22ND EDITION

IDAHO **MASTER GARDENER PROGRAM HANDBOOK**

IDAHO master GARDENER

A **UNIVERSITY OF IDAHO EXTENSION** PROGRAM

University of Idaho Extension

The *Idaho Master Gardener Program Handbook* was prepared by a committee of University of Idaho educators:

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For information about the Idaho Master Gardener Program, see the following website:
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- Pacific Northwest Plant Disease Management Handbook (revised annually) ..... (online only; in print from OSU)
- Pacific Northwest Weed Management Handbook (revised annually) (online only; in print from OSU)
- How to Reduce Bee Poisoning from Pesticides (PNW 591)..... (online only)

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- Managing Pocket Gophers in Idaho Lawns and Landscapes (CIS 1213)..... (online only)
- Managing Voles in Idaho Lawns and Landscapes (CIS 1214)..... (online only)

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- White Bryony (CIS 1203)..... (online only)

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- Idaho Plant Quarantines and the Home Garden: Understanding the Laws (CIS 1183).. (online only)

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CHAPTER **ONE**

INTRODUCTION AND POLICIES

University of Idaho Extension's Idaho Master Gardener Program

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1 INTRODUCTION AND **POLICIES**

Learning Objectives

- State the motto of University of Idaho Extension's Idaho Master Gardener Program
- Discuss the purpose of the Idaho Master Gardener Program
- Learn about the personnel and funding that support administration of the Idaho Master Gardener Program
- Review the minimum state-level Idaho Master Gardener training and certification policies
- Review county-level Idaho Master Gardener training and certification policies
- Follow relevant Idaho Master Gardener application and training procedures
- Describe the scope of responsibilities assigned to an Idaho Master Gardener
- Demonstrate an understanding of the guidelines for working with youth
- Demonstrate an understanding of the guidelines for making recommendations to clientele

Introduction

University of Idaho (UI) Extension's Idaho Master Gardener Program provides gardeners with opportunities to improve their horticultural knowledge and skills as well as to serve their communities. "Helping people grow" is the motto of the program. The program is conducted through participating UI Extension county offices under the direction of UI Extension educators.

Hundreds of Idaho Master Gardener volunteers give their time each year. Due to rapid urbanization in Idaho, training Master Gardeners is a critical element of Extension education in Idaho. Master Gardener volunteers give time and effort to provide quality learning experiences, thereby improving the quality of life for Idaho's citizens. Volunteers also provide the important service of problem-solving for issues related to

gardening and landscaping. Idaho Master Gardeners are the second-largest volunteer group with which UI Extension works in Idaho (4-H is the largest).

To help Idaho Master Gardeners prepare for these roles, the UI's College of Agricultural and Life Sciences provides credit and certificate courses to prospective and active Idaho Master Gardeners across the state.

Purpose

The Idaho Master Gardener Program serves as an educational and volunteer organization. The program's purpose is to provide technical assistance and information in the area of home horticulture to people in all Idaho communities through qualified volunteers. UI Extension educators and specialists, staff, and volunteers share vision, ideas, and responsibilities for the program. However, ultimate responsibility for the Idaho Master Gardener Program is with Extension educators, who are accountable for operation of the program.

Program Administration

UNIVERSITY OF IDAHO EXTENSION

The Idaho Master Gardener Program is part of UI Extension, an educational resource partnership that extends research and technology to the people of Idaho as part of the university's land-grant mission. UI Extension, in turn, is administered within the UI College of Agricultural and Life Sciences, which is funded in part by the Agricultural Research and Extension Service appropriation from the Idaho legislature.

UI Extension helps people help themselves by bridging gaps between research and everyday problems. Areas of expertise are agriculture, community development, family and consumer sciences, natural resources, and youth development.

All UI Extension programs, including the Idaho Master Gardener Program, are administered through three Extension districts in Idaho: northern, southern, and eastern. Many training events and volunteer opportunities are planned at the district level in collaboration with volunteers.

FUNDING

UI Extension is funded through a three-way partnership among local, state, and federal governments. In addition, volunteers, businesses, and private organizations contribute time, talent, and supplies.

PERSONNEL

Idaho Master Gardener educational programs are conducted at the county level by UI Extension educators. These educators are members of the UI faculty. Educational materials and events are developed in cooperation with the Department of Plant, Soil and Entomological Sciences and other departments within the UI College of Agricultural and Life Sciences.

Extension educators are based in UI Extension offices in nearly every Idaho county and at the Fort Hall, Nez Perce, and Coeur d'Alene Indian reservations. The educators are supported by subject-matter specialists and researchers, also university faculty members, located at UI research and Extension centers around the state and on the UI campus in Moscow.

Extension faculty and their support staff work with the people of Idaho to address agricultural, natural resource, youth, family, community, and environmental issues. Collaborative relationships with countless agencies, groups, and individuals make possible a vast array of innovative educational programs.

Training and Certification Policies

Requirements for becoming a certified Idaho Master Gardener and for maintaining certification are detailed below. The listed requirements are minimum statewide standards and it should be understood that Extension educators in some counties may have more stringent requirements for participation. This is a prerogative of the Extension educator.

INITIAL TRAINING AND CERTIFICATION

Idaho Master Gardeners

Becoming an Idaho Master Gardener involves a significant commitment of time and effort. Initially, applicants must receive at least 30 hours of basic education on a variety of topics related to plant science, landscaping, and urban horticulture.

Individuals must receive a satisfactory grade on exams or demonstrate competency in the course content to the satisfaction of the program coordinator.

Following the basic training course, and within a 6-month to 1-year period (timing may vary by county, course schedule, and Extension educator preference), an additional minimum of 30 hours of practicum/hands-on training and directed volunteer service must be completed. The type of hands-on training is based on a mutual decision between the supervising UI Extension educator and the Idaho Master Gardener trainee. At least part of the service hours must be spent in or arranged through the county Extension office.

The applicant will receive certification as an Idaho Master Gardener upon successful completion of the Idaho Master Gardener Program classroom instruction, examinations, and hands-on training, including completion of volunteer hours.

Certificates and identification badges that verify program status and satisfactory program completion are provided at the discretion of each responsible county Extension educator.

Certification as an Idaho Master Gardener is valid for 1 year only.

Advanced Idaho Master Gardeners

Many Idaho counties offer the opportunity to become an Advanced Idaho Master Gardener by participating in specific, advanced-level training. The process of qualifying as an Advanced Idaho Master Gardener can vary widely by county; volunteers should seek advice from the local coordinator to determine requirements. Certification as an Advanced Idaho Master Gardener is valid for 1 year and continuous recertification is required to maintain status.

CONTINUING CERTIFICATION

Idaho Master Gardeners

To maintain Idaho Master Gardener certification in years subsequent to initial training, a volunteer must complete a minimum 3 hours of education/training and 7 hours of service every 12 months. If these requirements for training and service are not met, recertification will not be issued. See "Time away from recertification" for policies on becoming recertified.

Advanced Idaho Master Gardeners

Individuals may retain Advanced Idaho Master Gardener status by completing a minimum of 10 hours training plus 10 hours volunteer service every 12 months. Extension educators at some locations may require more hours or have additional requirements.

TIME AWAY FROM RECERTIFICATION

Any person missing recertification for 1 or 2 years may again become a certified Idaho Master Gardener or Advanced Idaho Master Gardener by completing the annual recertification requirements without additional training or testing. Any person who misses recertification for 3 consecutive years must take a closed-book recertification exam and obtain a minimum score of 70 percent. The person may take the exam only once. If the person fails to attain a score of at least 70 percent, he/she must retake the 30-hour basic training course and complete the 30 hours of hands-on training and directed volunteer service to be certified as an Idaho Master Gardener.

TRANSFERRING MASTER GARDENER STATUS

From Another State

Individuals previously trained as a Master Gardener in another state may seek to become Idaho Master Gardeners. They must first provide a letter of recommendation from their previous county or state Master Gardener program coordinator. In addition, they must schedule an entrance interview with the UI Extension educator or program coordinator responsible for the Idaho Master Gardener Program in their county. In the interview they will mutually agree to the necessary training to be certified in the Idaho Master Gardener Program.

From Another Idaho County

Idaho Master Gardeners who move to a new county within the state will retain their certification but may be required by the Extension educator in the new location to participate in additional training before serving a volunteer within that county.

Advanced Idaho Master Gardeners must meet the training requirements of the new county before being granted active status.

IDAHO MASTER GARDENER EMERITUS

Purpose

The purpose of Idaho Master Gardener emeritus status is to recognize and keep exceptional volunteers involved in the program. Emeritus status

is intended to be awarded to an Idaho Master Gardener who has given exemplary service over the years, beyond the basic requirements to maintain certification, but is no longer able to meet all recertification requirements or participate fully in the program due to time constraints or health issues. Emeritus status may also be given posthumously to an exceptional Idaho Master Gardener Program volunteer.

Privileges

- Maintains Idaho Master Gardener certification by completing a minimum of 5 hours of hands-on service and/or education per year
- No longer is required to pay Idaho Master Gardener Program class fees but may attend any and all classes offered
- Has full use of resources in the UI Extension office
- Maintains membership in local Idaho Master Gardener associations with the payment of dues reduced or eliminated, at the discretion of the organization

Eligibility

- Has served for at least 10 years as an Idaho Master Gardener and volunteered for at least 500 hours
- Is an exemplary active participant in the local Idaho Master Gardener Program
- Has supervised a significant number of horticulture community projects or taught a significant number of horticulture classes to the general public and/or assisted in teaching Idaho Master Gardener Program classes
- Has been an active contributing Idaho Master Gardener in solving horticultural problems for the general public through Extension (for example, through a plant diagnostic clinic)

Nomination Process

- No more than two persons per year per county may receive emeritus status. Emeritus status does not have to be awarded every year, but only as needed.
- A letter of nomination is sent to the UI Emeritus Committee in the county by any active Idaho Master Gardener, Extension educator, or program coordinator. An emeritus committee member may also nominate an Idaho Master Gardener for emeritus status. No emeritus committee member may be nominated for the award during his or her term on the committee.
- A report summarizing all past work and hours completed by the nominee must be turned in to, or completed by, the emeritus committee as part of the nomination process.
- The decision to award emeritus status is made by the emeritus committee in the county. The committee will consist of an Extension educator coordinating the Idaho Master Gardener Program in the county and two or three active Idaho Master Gardeners chosen by the Extension educator. Membership on the emeritus committee may last no more than 3 years.

TRAINING OF TRADE-RELATED PROFESSIONALS

Industry professionals are welcome to extend or supplement their knowledge and credentials through UI classes and certification programs, including the Idaho Master Gardener Program. However, professionals must recognize that the Master Gardener course is specifically designed to train active volunteers. If a trade professional knows up front that providing volunteer service is not feasible, reimbursement for training and materials or in-kind support of the program will need to be negotiated with an Extension educator.

Also, because this is a volunteer training program, the supervising Extension educator may rightfully accept only a limited number of trade applicants in any one training session.

Upon completion of the course, trade applicants should exercise proper business ethics by not utilizing their Idaho Master Gardener status to directly enhance their business opportunities.

Additionally, it is considered inappropriate to solicit for personal or business purposes at or during UI Extension volunteer meetings, training sessions, or other functions.

Application and Training Procedures

APPLICATION AND VOLUNTEER POSITION DESCRIPTION

Before beginning training, each applicant must complete and sign an Idaho Master Gardener Program application and an opportunity contract (included at the end of this chapter). Before taking part in any volunteer service, either as a trainee or as a certified Idaho Master Gardener, each individual must also read and sign an Idaho Master Gardener Program authorized volunteer position description (included at the end of this chapter). The position description outlines the requirements of the volunteer position and the methods of supervision. The position description is also required to activate UI liability insurance for the volunteer. Position descriptions will be kept on file in the county Extension office.

FEES

Fees vary from county to county based on the needs of the local program. Fees may be used to cover the cost of the Idaho Master Gardener Program Handbook, materials and resources for the classes, lab supplies, tours, and field trips.

TRAINING DATES AND LOCATIONS

Contact your local UI Extension office for specific times, dates, and locations for Idaho Master Gardener training. In most counties training begins in January and ends in April or May. However, some counties offer summer or fall courses.

MASTER GARDENER TRAINING OUTSIDE THE COUNTY OF RESIDENCE

In any given year, Master Gardener training is offered in approximately 20 of the 44 Idaho counties. Many Extension educators serve multiple counties, including those that do not maintain Master Gardener volunteer programs. In the case of multicounty programs, Idaho Master Gardeners may be required to perform at least part of their volunteer service in the county wherein they were initially trained. The volunteer may discuss arrangements, prior to submitting an application for training, to serve partly or wholly in the county where they reside. It is important to recognize that each county program is unique and has different resources available to implement the Master Gardener program, and volunteer situations may not always be ideal.

COLLEGE CREDIT

Applicants accepted into the Idaho Master Gardener Program may, for an additional fee, obtain college credit from the UI College of Agricultural and Life Sciences. Up to three credits can be earned. Extra classwork and/or practicum work may be required for a satisfactory grade. Contact your local UI Extension office for more information about this opportunity.

Additional Program Policies

VOLUNTEER ACTIVITY RECORD

UI Extension requires an accounting of volunteer hours and tasks for all Idaho Master Gardeners and trainees. An activity log provides legal protection for the volunteer while in the course of service. It also allows the local coordinator to provide credit for volunteer service and measure the effectiveness of the program. Use the Volunteer Activity Record (available at the end of this chapter) to keep track of your volunteer hours, activities, and contacts. “Hours Earned” is the total number of hours a volunteer has spent on Idaho Master Gardener activities. “Contacts” refers to the number of people the volunteer assists.

IMPACT AND ACCOUNTABILITY

Master Gardeners plan and implement numerous countywide community projects. It is very important that they document the inputs, outputs, and outcomes of their projects, tasks, and assignments. Accountability should be one of the important factors in all phases of communication, planning, implementation, and evaluation of their projects.

REIMBURSEMENT FOR EXPENSES

Idaho Master Gardeners share their knowledge free of charge with individuals, groups, schools or in community service roles but may accept reimbursement for mileage and materials.

LIABILITY COVERAGE

For Trainees

Only authorized volunteers are entitled to the protection of the UI’s liability coverage program. As a rule, during the required 30 hours of coursework, a Master Gardener trainee is not an authorized volunteer and therefore not covered by the

university's liability insurance program. Prior to beginning coursework, applicants must read and sign an acknowledgment of risk and waiver of liability, which will be made available by their county Extension Master Gardener Coordinator. If a trainee desires to participate in authorized volunteer service before the completion of coursework, he or she must get the approval of the appropriate Extension educator and fill out an Idaho Master Gardener Program authorized volunteer position description.

For Authorized Volunteers

Prior to starting the 30 hours of hands-on training necessary for certification as an Idaho Master Gardener, each trainee's Master Gardener Coordinator must confirm that the trainee has been enrolled as an authorized volunteer. It should be recognized that becoming an authorized volunteer is not the same as becoming a certified Idaho Master Gardener. Authorized volunteers are persons who have been directed and given permission, in writing, to perform a specific function by a UI employee with the authority to recruit assistance. The volunteer is then protected while acting within the scope and course of this authorized volunteer service.

The liability coverage program will respond to a claim against a volunteer if the university is able to document that the person was an authorized volunteer acting within the scope and course of the requested service and during the time they were volunteering. Documentation for an authorized volunteer should include the following:

1. A completed authorized volunteer position description on file. The position description needs to specifically state the duties for which the volunteer is responsible. Each trainee's Master Gardener Coordinator must confirm that the trainee has been enrolled as an authorized volunteer.
2. A log of the volunteer's hours, based on the volunteer activity record that is maintained by a university employee at the local county office.

WORKERS' COMPENSATION COVERAGE

University of Idaho is self-insured for Worker's Compensation. Authorized volunteers, such as Idaho Master Gardeners, may be eligible for worker's compensation coverage, which is decided on a case-by-case basis by claims adjusters. To present a claim, it is vital that the university have on file a completed authorized volunteer position description and an up-to-date volunteer activity record. The claim adjudicator will want to establish that the volunteer's duties were authorized, that he or she was working within the established course and scope of his or her duties, and that he or she was "on the job" at the time of the potential workers' compensation incident.

VEHICLE COVERAGE

When an authorized volunteer uses a privately owned vehicle for official university business, the privately owned vehicle's liability and physical damage insurance is primary and the UI's liability insurance is secondary, up to the limits of the Idaho Tort Claims Act. Individuals should check with their own insurance agent to determine coverage on their privately owned vehicle when used for business purposes.

To become a qualified driver of a university vehicle, Master Gardeners must follow the university procedures for Vehicle Use and Coverage, Administrative Procedures Manual 05.08. Requirements include but are not limited to: drivers record check showing satisfactory driving performance, signing the Vehicle Use Agreement, and taking the Defensive Driving Course.

WORKING WITH YOUTH

Idaho Master Gardener volunteers may have opportunities to work with youth in school programs or in 4-H or other youth organizations. In order to work with youth, all UI Extension volunteers, including Idaho Master Gardeners, must first comply with the UI standards for Protection of Minors, including, but not limited to, background checks, interviews, reference checks, training and signing the Protection of Minors Code of Conduct. Until a volunteer has successfully completed the screening process, he or she should do no volunteer activities that involve working with youth unless a person authorized to supervise youth is present. For example, a volunteer may teach youth in a public school if the teacher of the class is present. Even if a volunteer is authorized to work with youth, it is still advisable that a second adult be present.

CIVIL RIGHTS AND DIVERSITY

The UI has the following nondiscrimination policy:

> "The University of Idaho has a policy of nondiscrimination on the basis of race, color, religion, national origin, sex, sexual orientation, gender identity/expression, age, disability or status as a Vietnam-era veteran. This policy applies to all programs, services, and facilities, and includes, but is not limited to, applications, admissions, access to programs and services, and employment."

In addition, discrimination is prohibited across the nationwide Cooperative Extension System in programs and with respect to individuals, audiences, groups, and organizations.

Idaho Master Gardeners, as representatives of UI Extension, are bound by this same policy. Idaho Master Gardener volunteers must make every effort to avoid discrimination in the form of either commission (purposefully excluding groups or individuals) or omission (adopting practices that inadvertently give preference) within the scope of their volunteer service. As a routine practice, Idaho Master Gardener volunteers should find creative ways to include underserved audiences.

MAKING RECOMMENDATIONS — PROVIDING ACCURATE INFORMATION

Whether through phone calls, home visits, plant clinics, presentations, newsletters, e-mails, websites, or other efforts, the information provided by Idaho Master Gardener volunteers must be unbiased and research-based. It must be accurate, current, and, when possible, taken from UI publications and research. Our mandated focus and emphasis is to extend to the people of Idaho the information being developed at the UI or other land-grant universities.

Idaho Master Gardener volunteers should use tact when advising clients. Your responsibility as a representative of the UI is to be an objective source of information rather than a subjective proponent for a particular approach.

It often is necessary to locate and interpret printed and online references to answer a client's question. Look first to resources from UI Extension or from Extension services of universities in neighboring states as well as to authoritative reference texts or research papers written by university experts. These sources have passed through a rigorous review process for technical accuracy so can be used with confidence.

UI publications can be obtained at the local UI Extension office; by writing to Extension Publishing, University of Idaho, 875 Perimeter Drive MS 2332, Moscow, ID 83844-2332; by calling (208) 885-7982; by faxing (208) 885-4648; or by e-mailing calspubs@uidaho.edu. Many publications are available to download from **http://www.uidaho.edu/extension/publications**.

As an Idaho Master Gardener, you may make recommendations about home horticulture, home vegetable and home fruit culture, ornamentals, turf, and tree and landscape care. Do not make recommendations in areas within which you lack knowledge or experience. Refer questions related to the commercial nursery industry or commercial farm crops to the UI Extension educator in your county or to the appropriate UI Extension specialist.

MAKING PEST MANAGEMENT RECOMMENDATIONS

When appropriate, provide clients with recommendations about pesticides and alternatives to pesticides so they can choose the best option for themselves. Often there is more than one solution to a pest problem; sometimes there is no simple solution. Pest problems not specifically covered by UI recommendations and that do not involve pesticide applications may be handled by suggesting treatments that an experienced Idaho Master Gardener considers appropriate.

Scope of Responsibilities

Idaho Master Gardeners are authorized to make pesticide recommendations only for yard and garden pests, including pests of indoor houseplants.

- Do not advise homeowners with questions about other household pest control, such as pantry insects, structural pests, or crawling invading insects.
- Never advise anyone about pesticides for any commercial agricultural, horticultural, or landscape planting; this restriction includes, but is not limited to, commercial field and row crops, landscape nurseries, forest lands, and public recreation sites. State law requires that people making pesticide recommendations for commercial operations be certified and licensed as a pesticide applicator by the State of Idaho.

- Do not answer questions about pesticide liability issues. Direct all such questions to the UI Extension educator for further referral and action.
- Do not make pesticide recommendations to clients on behalf of the UI until you have satisfied each of the following three steps:
    1. Successfully completed Idaho Master Gardener Program training.
    2. Successfully completed an additional training module specific to pesticides.
    3. Signed and filed the Pest Management Agreement form (located at the end of this chapter).

Master Gardener coordinators will ensure that all Idaho Master Gardeners working under their supervision complete steps 1 through 3 above, keeping the signed Pest Management Agreement form on file as a permanent record.

Recommending Registered Pesticides

When making pesticide recommendations as an Idaho Master Gardener, both you personally and the UI will be protected from potential liability issues if you satisfy these two conditions:

1. You recommend a pesticide legally registered and labeled for use in the yard or garden (or for indoor houseplants). The specific plant or site for application must be listed on the label. It violates federal and state law to apply a pesticide to a plant or site not listed on the label.[1]
2. The advice you give about how to use the pesticide is exactly as the pesticide label requires.

Be careful to note the directions for use, including application rates, timing, and frequency; preharvest and reentry waiting periods; personal protective equipment; and product and container disposal. As a general practice, the specific target pest also should be listed on the label, but this is not required by state and federal law.

Federal pesticide law[2] allows these three exceptions about using pesticides in ways not stated on the label:

1. It is legal to apply less than the rate stated on the label (for example, the label advises 1 lb, so it is legal to apply less than 1 lb).
2. It is legal to apply less frequently than stated on label (for example, the label says apply every 7 days, so it is legal to apply every 8th or 9th day or longer period, as long as the preharvest interval is followed).
3. It is legal to apply a pesticide for a pest not listed on the label as long as the plant or application site is listed on the label (for example, the label says the product can be used for beetles on cabbage, so it is legal to apply for caterpillars on cabbage even though the label does not mention caterpillars).

Idaho Master Gardeners may recommend any of these three exceptions but first must confer with the UI Extension educator or a UI Extension specialist to ensure the advice is technically sound. This requirement to confer with a UI expert is especially true when recommending pesticides for pests not cited on the label; your specific pest deliberately may have been excluded from the label because the product does not work against that species. So while these three exceptions are permitted, in general the best practice is to not deviate in any way from label directions. You never will make a mistake if your recommendation exactly agrees with the label.

As an Idaho Master Gardener volunteer, you should make good-faith pesticide recommendations that are based on information directly from the pesticide label or already recommended by UI research and Extension faculty or their peers at other regional universities, especially those in the Pacific Northwest and Intermountain West. Faculty expert recommendations appear in the annually updated, three-volume Pacific Northwest pest management handbooks as well as in Current Information Series publications and bulletins published by UI Extension.

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[1] Idaho State law, Title 22, Chapter 34 (pesticide law) specifically states:
No person shall:
(1) Use a pesticide in a manner inconsistent with its labeling except as provided for by rule.
(2) Make pesticide recommendations in a manner inconsistent with its labeling except as provided for by rule.
(3) Make false or misleading claims through any media relating to the effect of pesticides or application methods to be utilized.

[2] Federal Insecticide Fungicide Rodenticide Act section 2ee (FIFRA 2ee).

It is always a good practice to inform every client that the actual pesticide label always takes precedence over any oral or written recommendation.

Do not endorse any particular pesticide brand name, business, or service. Your mission as a representative of UI Extension is to be an objective source of information and knowledge that is not biased in any way. For example, rather than recommend a homeowner use Roundup weed killer, you instead would advise use of products containing the active ingredient glyphosate and then give commercial trade names (like Roundup, KleenUp, Eliminator Weed and Grass Killer) of locally available products. This approach does not imply endorsement.

Recommending Household Chemicals, Homemade Pesticides, and Related Tactics

Home chemicals. Never recommend any household cleaning product or other home chemical for pest control unless the product label specifically states it can be used to control or repel pests on your exact application site against your particular target pest. Only recommend pesticides specifically tested and approved by the Idaho State Department of Agriculture and/or the US Environmental Protection Agency for your particular pest situation.

Homemade pesticides. Never recommend any recipe for homemade pesticides, regardless of how low risk it might seem or the presumed authoritative knowledge of the reference. You might unwittingly recommend a compound that physiologically damages the plant rather than protect it from pests, or, even worse, the homemade mixture might pose a real health risk to the homeowner, pets, or wildlife.

Homemade devices. You may recommend use of homemade physical and mechanical devices such as sticky boards that trap aphids or slug traps baited with beer. Devices and related physical control actions, such as using a garden hose to forcefully spray off aphids from sturdy landscape plants or killing weeds with steaming-hot water, are not considered pesticides by state and federal law and so are not subject to the Idaho Master Gardener Program pesticide policy. But, as always, base your advice on trusted, research-documented reference materials as supplemented by the knowledge and observations of an experienced Idaho Master Gardener.

MAKING FERTILIZER RECOMMENDATIONS

Fertilizer recommendations do not require state certification or licensing. When making fertilizer recommendations, use UI recommendations or those on the label of the product being used. Cultural problems not specifically covered by UI recommendations and that do not involve pesticide applications may be handled by suggesting treatments that an experienced Idaho Master Gardener considers appropriate.

USE OF TITLE AND LOGO

The title Idaho Master Gardener™ and derivatives thereof are trademarked to the UI and are to be used only and exclusively in association with UI Extension's Idaho Master Gardener Program and not for commercial purposes. Idaho Master Gardeners should not display credentials or use their title to advance their business interests or a personal agenda. Persons are expected to identify themselves as participants in the Idaho Master Gardener Program only when performing volunteer work affiliated with the program. The training, experience, and certification gained in the Idaho Master Gardener Program may be used and listed as qualifications when seeking employment.

Additionally, the Idaho Master Gardener Program logo, letterhead, and other brand elements must not be used for advertising or any other purpose outside the activities of the program. All volunteers are expected to help maintain the integrity of the Idaho Master Gardener Program.

IDAHO MASTER GARDENER ASSOCIATIONS

Membership and Supervision

Idaho Master Gardener associations are county-based associations formed at the discretion of the UI Extension educator. People who are certified Idaho Master Gardeners may belong to a county-based Idaho Master Gardener association. Operation of the association is under the direct supervision of a UI Extension educator or Idaho Master Gardener Program coordinator.

Purpose

Following are the purposes of a county Idaho Master Gardener association:

- Enhance the overall benefits of the Idaho Master Gardener Program in local communities

- Provide ongoing education to help people maintain their Idaho Master Gardener certification
- Develop educational programs to be delivered to citizens in the county to supplement the UI home horticulture program
- Provide camaraderie for individuals with similar interests and purposes

Association Income, Bank Accounts

There may be a need to have a source of income to enhance the educational efforts of the Idaho Master Gardener association. The association may charge dues if so desired and/or raise money by other means such as plant sales. Money may be held in a local county UI Extension office account if allowed by the county or be deposited in a separate bank account with a unique taxpayer identification number. No money shall be held in the name of an individual (see *County Operations Handbook*, section B-3, for complete information on proper money-handling procedures). Idaho Master Gardener associations with 501(c)(3) status are still accountable to the UI, as the association funds are generated while individuals are volunteering under the supervision of the university.

Unaffiliated Associations

People who are currently certified as Idaho Master Gardeners or who have been certified are not prohibited from forming associations that are separate from the UI, but these associations will not be recognized by the UI and their members are prohibited from conducting educational programs under the auspices of the Idaho Master Gardener Program or the UI and must not refer to the independent association as an Idaho Master Gardener association. Furthermore, if such an association is formed, members must not use the title Idaho Master Gardener or derivatives thereof. If an association organized under the guidance of the university later separates from it, all funds in an account at the time of separation belong to the U of I.

Role of UI Extension Educator in Idaho Master Gardener Associations

A UI Extension educator is responsible for the Idaho Master Gardener Program within an assigned county or area and for the operation and function of its Idaho Master Gardener association. Duties of a UI Extension educator working with its county association include the following:

- Coordinate an Idaho Master Gardener volunteer training program to certify volunteers
- Preapprove all volunteer projects for noncertified volunteers who have completed the coursework and are seeking Idaho Master Gardener certification. A UI Extension educator will approve only those volunteer projects that contain an element of education for the recipients; the information presented must be from the UI, another university, or some other reliable research-based source.
- Assist certified Idaho Master Gardeners to develop projects, if needed
- Projects such as workshops, short courses, community gardens, etc., developed by certified Idaho Master Gardeners need to be preapproved by the Extension educator; however, a simple request for an educational presentation by a group does not need preapproval (for example, a request by a local garden club for a presentation on pruning roses). Projects must contain an element of education for the recipients, and the information presented must be from the UI, another university, or some other reliable research-based source.
- Approve or provide additional training needed by volunteers to maintain their Idaho Master Gardener certification
- Meet with association members on a regular basis
- Assist Idaho Master Gardener volunteers to develop educational projects that are beneficial to the citizens of their county

Responsibilities of Idaho Master Gardener Association Members

An Idaho Master Gardener association will be more successful if all members take an active role.

Just as a UI Extension educator has a responsibility to the association, its members should assume the following responsibilities:

- Help develop and deliver educational programs for citizens in the county to supplement the Idaho Master Gardener and home horticulture programs
- Assist in developing and delivering educational programs for members of the association

- Work to enhance the overall benefits of the Idaho Master Gardener Program to all citizens in the county
- Mentor individuals seeking to become Idaho Master Gardeners
- Work cooperatively with the UI Extension educator or program coordinator
- Be certain that all volunteer projects counting toward Idaho Master Gardener recertification contain an element of education for the recipients and that the information presented is from the UI, another university, or some other reliable research-based source
- Follow U of I nondiscrimination policies

Being an Idaho Master Gardener Volunteer

VOLUNTEER SERVICE OPPORTUNITIES

Idaho Master Gardeners assist in many areas of the community through demonstration gardens, horticulture classes, information booths, and UI Extension offices. Below is a list of some service opportunities in which Idaho Master Gardeners may be involved.

- Presenting educational programs/demonstrations on gardening to adults
- Helping at gardening education events: workshops, clinics, trade shows
- Presenting gardening classes to school youth
- Working at 4-H plant science events or training sessions
- Staffing information booths at fairs, field days, and horticultural education events
- Helping teach Idaho Master Gardener classes
- Reading gardening articles and summarizing them for Idaho Master Gardeners and Extension educators
- Writing newsletters and information sheets on gardening
- Maintaining a website for the county's Idaho Master Gardener Program
- Organizing Idaho Master Gardener plant clinics
- Making garden or landscape site visits
- Organizing community service projects related to gardening, including landscape design and maintenance
- Organizing an Idaho Master Gardener mentoring program for the county
- Answering garden calls at home or at the county's UI Extension office

VOLUNTEER SERVICE GUIDELINES

Idaho Master Gardeners represent the U of I. Accurate and quality work is expected.

These guidelines are basic for any professional, whether volunteer or paid:

- Be punctual, trustworthy, and reliable. Follow through with your commitments and responsibilities. Call if you will be delayed or cannot be there.
- Maintain a friendly, warm, courteous attitude toward the public.
- Communicate effectively with clients, staff, fellow volunteers, and UI faculty members. Be a capable and positive team member.
- Freely cooperate with the volunteers of other UI Extension volunteer programs. We are all on the same team.
- Learn as much as possible about your volunteer assignment and take the time to ask appropriate questions before beginning a task.
- Accuracy is important and greatly appreciated.
- Dress appropriately for the volunteer activity in which you are involved, paying particular attention to safety.
- Make childcare arrangements for the time you have committed to work as a volunteer. In some cases, it is not appropriate for safety or security reasons to bring children to certain events or activities.
- Follow UI Extension affirmative action policies, which forbid discrimination against anyone because of their race, color, gender, national origin, religion, age, sexual orientation, or disability.
- Enjoy your volunteer time. Volunteering is rewarding and satisfying.

TERMINATION OF VOLUNTEER SERVICES

As an Idaho Master Gardener volunteer, you are a representative of UI Extension and as such have agreed to abide by its policies and expectations. If your behavior is not acceptable or not in the best interests of UI Extension, the volunteer program, or our clientele, you may be reprimanded or asked to leave the program.

The following behaviors observed at or on the premises of any program or function, or while you are acting as a UI Extension volunteer, will not be tolerated:

- Criminal acts
- Profanity
- Illegal or inappropriate use of mind-altering substances (alcohol or drugs)
- Harassment
- Discrimination
- Abuse of any kind toward a fellow human

The above actions may constitute cause for disciplinary action or immediate dismissal.

VOLUNTEER BENEFITS

As an Idaho Master Gardener volunteer, you have many benefits. One major benefit is becoming part of a national volunteer network. You are part of the UI Extension network and have access to all of the information resources of that system. As a volunteer you will have the satisfaction of being a valuable resource to others.

Networking is another benefit that includes your fellow Idaho Master Gardeners and the faculty and staff of research facilities belonging to the UI. Tours of plant science facilities on campus and at any of the research and Extension centers can be arranged. This networking benefit also extends to other volunteers such as 4-H leaders or food-safety advisors. Another benefit is reduced prices or free admittance to seminars, classes, and workshops that need volunteer help.

Idaho Master Gardener volunteers benefit by increasing their leadership, organizational, decision-making, and problem-solving skills. As a testimony to the positive benefits of Master Gardener service, experienced volunteers report that they have made lasting friendships, increased their public relations skills, become more effective at work or home, and been well prepared for new employment or other volunteer opportunities.

UI Extension educators and staff benefit from association with Idaho Master Gardener volunteers by acquiring fresh, new ideas, acquiring an increased understanding of their community and clientele, and gaining the ability to reach a vastly increased audience. Given limited UI Extension resources and the increasingly urban population of the state, this last benefit is very important.

Every two years there is an international Master Gardener conference. You are eligible to join the national and international Master Gardener organizations as a certified Idaho Master Gardener. In most even years a western regional Master Gardener conference is held, which is a source of great ideas to bring back to your communities. A regional Idaho Master Gardener conference is held each year in one of the three regions of the state (northern, southern, and eastern). Take advantage of these opportunities and ask at your UI Extension office for conference information.

Last but not least, there are certain tax benefits to volunteers who itemize state and federal income tax returns. Since these may change annually, you will need to update which kinds of expenses are deductible and which are not. Consult your tax accountant for allowable deductions.

IMPORTANCE OF VOLUNTEERS

Each volunteer is vital to the success of our program, no matter what kind of volunteer work they do. There is no such thing as a small or unimportant job. Each individual brings skills that are unique and special, that really add to the educational effort. Each Idaho Master Gardener is a valuable part of our team.

Each year counties try to recognize the special things volunteers have done or accomplished in service to their communities. By itself, the Idaho Master Gardener name badge is recognition of your educational accomplishment. Wear it with pride.

You are important to us!

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

AUTHORIZED VOLUNTEER POSITION DESCRIPTION

PURPOSE OF THE IDAHO MASTER GARDENER PROGRAM

To extend horticultural education through trained and certified volunteers.

BRIEF DESCRIPTION OF MASTER GARDENER VOLUNTEER RESPONSIBILITIES

Volunteers are to provide education and assistance to Idaho residents in topic areas related to home horticulture. Activities may include, but are not limited to, answering questions in person and over the telephone about vegetable gardening, fruit trees, ornamentals, lawns, insects, and other related topics; assisting with public horticulture projects; assisting in the preparation of home horticulture classes; and organizing special seminars and conferences for homeowners and other Master Gardeners.

REQUIREMENTS FOR VOLUNTEER SERVICE

- Have an interest and/or knowledge or skills in basic gardening, ornamental horticulture, or general plant-related topics.
- Be able to communicate effectively with the public.
- Have completed or be enrolled in beginning Master Gardener classroom training (a minimum of 30 hours).
- Read and agree to the terms of the Idaho Master Gardener Program authorized volunteer position description and complete and sign the opportunity contract.
- Have completed or be enrolled in additional hands-on practicum training and volunteer service (a minimum of 30 hours) during the initial training to become a certified Idaho Master Gardener under the direction of a UI Extension educator.
- Be responsible to the Extension educator in charge of the Idaho Master Gardener Program. All outside projects must be preapproved, except that a simple request for delivery of an educational presentation by an Idaho Master Gardener to a group does not need preapproval. Outside projects must contain an element of education and follow all University of Idaho guidelines using information from the University of Idaho, another university, or some other reliable research-based source.
- Adhere to University of Idaho horticulture recommendations and cooperate with the county Extension staff.
- Be in the process to complete, or have completed, all statewide and local requirements for certification as an Idaho Master Gardener.
- Follow University of Idaho nondiscrimination policies.
- If required to operate a University of Idaho vehicle as part of volunteer duties, be trained as a qualified driver.

SUPERVISION OF VOLUNTEERS

- The University of Idaho Extension educator in charge of the Master Gardener program provides supervision and educational support to the volunteer Master Gardener.
- The Extension educator will assign, review, and assess hands-on practicum work for the Master Gardener trainee.
- The Extension educator will review and assess volunteer projects for certified Idaho Master Gardener and Advanced Idaho Master Gardener volunteers.
- The Extension educator will provide in-service training and furnish space and other needed support materials when the Master Gardener volunteer works in the Extension office.

Signed: Idaho Master Gardener Volunteer _____ Date _____

Signed: Idaho Master Gardener Supervisor _____ Date _____

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

APPLICATION

I would like to be considered for University of Idaho Extension's Idaho Master Gardener Program. I understand that, if accepted, I am required to complete a minimum of 60 hours of training (30 hours of basic education and 30 hours of hands-on training and directed volunteer service). The hands-on training must be completed within 6 months to 1 year of completing the classroom portion of the course (dependent on local county policy), unless prior arrangements are made with the UI Extension educator in charge.

All applicants should consider the expectations of Idaho Master Gardener service. Following certification, all Idaho Master Gardeners are committed to provide volunteer service for as long as they remain certified. Participants who are unable to participate in volunteer service after becoming certified should not sign up for the Idaho Master Gardener Program.

_____
Name (please print)

_____ _____
Address Zip Code

_____ _____
Phone (day) Phone (evening)

_____ _____
Signature Date

How did you learn about the Idaho Master Gardener Program?

How many years of gardening experience do you have? Where have you gardened before moving here?

Have you ever been in a Master Gardener program in Idaho or another state? If yes, indicate where and year(s).

☐ No ☐ Yes Where: _____ Years: _____

Please list all horticultural education you have received (school, topics, and dates, if possible).

Please list your areas of specilization or interest (vegetables, roses, greenhouse, herbs, etc.)

Are you affiliated with any gardening clubs or horticulture-related groups? If so, please list.

Why do you wish to be an Idaho Master Gardener?

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

APPLICATION — PAGE 2

What do you expect from this class?

How might you use your volunteer time to help others in the community?

How would you rate your "people skills" (ability to work with others)?

☐ Excellent ☐ Good ☐ Fair

How would you rate your gardening skills?

☐ Expert ☐ Intermediate ☐ Beginner

Are you knowledgeable in growing any of the following? Please check all that apply.

☐ House plants ☐ Herbs ☐ Turf
☐ Vegetables ☐ Annual flowers ☐ Shrubs
☐ Tree fruits ☐ Perennial flowers ☐ Ground covers
☐ Berries ☐ Ornamental trees ☐ Other (specify) _____

How do you receive gardening information? Please check all that apply.

☐ Garden magazines ☐ Nursery/garden center personnel ☐ Family/friends/neighbors
☐ Newspaper articles ☐ University/college professors ☐ Garden clubs
☐ Extension bulletins ☐ Extension office staff ☐ Master Gardeners at Extension office
☐ TV/cable stations ☐ Radio stations ☐ Internet

Are you employed now? ☐ No ☐ Yes ☐ Full-time ☐ Part-time

Are you retired? ☐ No ☐ Yes Semi-retired? ☐ No ☐ Yes

Do you speak a language other than English? ☐ No ☐ Yes (language) _____

If certified as an Idaho Master Gardener, do you give permission to UI Extension to publish your picture without additional permission and with or without accompanying personal identification (your name)?

☐ No ☐ Yes

Check the skills you are good at.

☐ Public speaking ☐ Artistic ☐ Computing/web design ☐ Marketing
☐ Writing ☐ Manual Labor ☐ Typing, filing ☐ Social media
☐ Other (specify) _____

☐ I would like to take this class for academic credit (an additional fee applies)

RETURN THIS FORM TO THE UNIVERSITY OF IDAHO EXTENSION OFFICE IN YOUR COUNTY.

At the University of Idaho we respect your right to privacy and we understand that participants need to be in control of their personal information. "Personal information" includes, but is not limited to, name, address, telephone number and e-mail address. The University of Idaho does not sell, rent, swap or otherwise disclose any of this information other than for the sole purpose of Civil Rights reporting.

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

OPPORTUNITY CONTRACT

I wish to become an Idaho Master Gardener. I understand I must complete the classroom instruction, finish all quizzes and exams, complete all lab work, and complete volunteer hands-on training to become certified. I realize that part of my hands-on training hours must be spent at, or arranged through, the UI Extension office where I complete my training. I also understand that I can sign up for more than one hands-on project and volunteer more than the required number of hours.

If I am accepted into the Idaho Master Gardener training program and/or become certified as an Idaho Master Gardener, I will abide by all regulations and policies of University of Idaho Extension.

As a certified Idaho Master Gardener, I agree to provide University of Idaho pest control recommendations even if they include synthetic chemical pesticides. I also agree to become, or work under, a person licensed as an Idaho pesticide applicator.

I understand that as an Idaho Master Gardener, I am considered a volunteer representative of the University of Idaho. Therefore, the University of Idaho will assume liability for my pest control recommendations, but only if my recommendations are in accordance with the University of Idaho pesticide policies found in chapter 1 of the *Idaho Master Gardener Program Handbook*.

Name (please print)

Address

Zip Code

Phone (day)

Phone (evening)

Signature

Date

All certified Idaho Master Gardeners are required to provide volunteer service. One important function is to assist the local county UI Extension educator in the office, answering horticulture-related inquiries in the spring and summer. Time commitments vary by county. Indicate the days and months that are convenient for you. You will be contacted for specific dates.

MONTH	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
APRIL						
MAY						
JUNE						
JULY						
AUGUST						
SEPTEMBER						
OCTOBER						

☐ My schedule is flexible. I can be available almost anytime with advance notice.

(continued)

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

OPPORTUNITY CONTRACT — PAGE 2

Do you speak a language other than English? ☐ No ☐ Yes (language) _____

SELECT SEVERAL PROJECT AREAS OF INTEREST TO YOU.

Plant Clinic

- ☐ Plant clinic (identifying plant problems)

Garden Projects

- ☐ City beautificaion
- ☐ 4-H/youth garden projects
- ☐ Weed/insect collection
- ☐ Demonstration garden
- ☐ Senior citizen garden project

Support Activities

- ☐ Artwork, calligraphy
- ☐ Photo album, photography

Communications/Writing

- ☐ Garden newsletter articles
- ☐ Newspaper articles
- ☐ Publicity for Idaho Master Gardener Program

Landscape Design/Maintenance

- ☐ Extension office landscape
- ☐ Other landscapes (must be approve by the Master Gardener coordinator)

Speaker's Bureau

- ☐ Speaker/presenter (topic) _____

  _____
  - ☐ For youth groups only
  - ☐ For adult groups only
  - ☐ Audience makeup is not crucial

Special Events

- ☐ Information booths
- ☐ Fundraising events
- ☐ Garden tours

Office Assistance

- ☐ Filing/organizing paperwork
- ☐ Typing, mailing, stapling, collating
- ☐ Telephone answering

Other

- ☐ Special project (topic) _____

  _____

  _____

RETURN THIS FORM TO THE UNIVERSITY OF IDAHO EXTENSION OFFICE IN YOUR COUNTY.

At the University of Idaho we respect your right to privacy and we understand that participants need to be in control of their personal information. "Personal information" includes, but is not limited to, name, address, telephone number and e-mail address. The University of Idaho does not sell, rent, swap or otherwise disclose any of this information other than for the sole purpose of Civil Rights reporting.

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

VOLUNTEER ACTIVITY RECORD

Name (please print) _____ Date _____

For program year _____ Ending _____

Please complete this volunteer activity record each year of volunteer service and turn it in to your University of Idaho Extension office as directed by your program coordinator or Extension educator. Please record specific accomplishments that you are most proud of on the back of this sheet. Let us know what you have done for your community!

If you need help filling out this form, please ask.

WHAT YOU DID AND WHEN			NUMBER OF CONTACTS MADE									
DATE	SUMMARY OF ACTIVITY	HOURS EARNED	MALE	FEMALE	ADULT	YOUTH	A	B	H	N	W	HC

Codes: A=Asian B=Black H=Hispanic N=Native American W=Caucasian HC=Handicapped

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

TAX RECORDS FOR VOLUNTEER SERVICE

Directions for claiming deductions: List the amount you claim as a deduction in Schedule A under "Contributions" (other than cash). This statement certifies that you have performed volunteer service. File this statement with your records. You should also keep a record of when and where your service was performed. Keep a record of mileage (read tax instructions to determine how many cents per mile are allowed). You may also list supplies you purchased and used within the Idaho Master Gardener Program. Keep this information with your records to verify your deductions in case your tax return is audited. Consult a tax accountant for advice as needed.

IDAHO master GARDENER

A **UNIVERSITY OF IDAHO EXTENSION** PROGRAM

THIS CERTIFIES RECOGNITION OF VOLUNTEER SERVICE PERFORMED WITHIN THE UNIVERSITY OF IDAHO'S IDAHO MASTER GARDENER PROGRAM.

Idaho Master Gardeners receive training from University of Idaho Extension educators in solving and giving advice on yard, garden, and houseplant problems. Volunteer service within this program is performed by Idaho Master Gardeners in various ways (e.g., participating in Master Gardener clinics, assisting in a county UI Extension office, speaking to groups, consulting on plant problems by telephone, and other methods arranged with UI Extension staff members).

Idaho Master Gardener

Barbara Petty

Barbara Petty, Director
University of Idaho Extension

University of Idaho Extension

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

EMERGENCY CONTACT FORM

College/Department

Activity Name | Date | Location

Name (First) | (Last)

Address

City | State | Zip Code

Phone (Cell) | Phone (Home)

Primary Emergency Contact Name | Relationship

Phone (Cell) | Phone (Home) | Phone (Work)

Secondary Emergency Contact Name | Relationship

Phone (Cell) | Phone (Home) | Phone (Work)

PLEASE NOTE: Hospitals and clinics require Social Security numbers before providing treatment and suggest that participants bring a copy of their insurance card. **THE PARTICIPANT IS RESPONSIBLE FOR ALL MEDICAL EXPENSES.**

The contact information provided will be shared only in the case of an emergency.

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

PEST MANAGEMENT AGREEMENT

The role of pesticides is important for home yard and garden pest management recommendations. All pesticide use in Idaho is regulated by state and federal laws. In order to promote the safe and effective use of pesticides and reduce the misuse of pesticides, all University of Idaho volunteer Master Gardeners are required to follow the terms of this agreement, as listed below.

1. I must be a certified Idaho Master Gardener to give pest control advice to clients. Certification requires both successful completion of county Master Gardener training and requirements and successful completion of a pesticide online training course.
2. I can only advise homeowners about pesticide use around home yards, gardens and landscapes. Questions regarding commercial crop production, nursery management, forestry, public area landscape maintenance, aquatic weed management, and pesticide liability are to be referred to the county Extension educator.
3. I will provide both chemical and nonchemical pest management recommendations allowing the client a choice of strategies.
4. I can only give pest management recommendations, both chemical and nonchemical, published in current University of Idaho or Pacific Northwest Extension publications, in other university publications, or in some other reliable research-based source. Remember that the actual pesticide label always takes precedence over any oral or written recommendation.
5. I can only recommend pesticides that are registered for home and garden use. I must follow all label directions and precautions, including but not limited to: preharvest intervals, reentry waiting periods, personal protective equipment, and product and container disposal.
6. I must never recommend any household product or chemical as a pesticide unless the product label states it can be used to control pests on the specific site of interest. I must never recommend any "homemade recipe" as a pesticide without proper labeling. Homemade insect or slug traps baited with food products are considered devices and under state law are not regulated as pesticides. If an Idaho Master Gardener has credible, published information from a university source on devices (for example, sticky boards that trap aphids or slug traps), they may be recommended.
7. I understand that as an Idaho Master Gardener, I am not required to have an Idaho pesticide license to recommend pesticides registered for home and garden use only.
8. I understand that as an Idaho Master Gardener, I am considered a volunteer representative of the University of Idaho. The university will assume liability for my pest management recommendations only if: (1) the pesticide is a legally registered product for home and garden use, (2) appropriate pesticide label directions and precautions are followed, (3) the management recommendations are made directly from the pesticide label or from current University of Idaho, Pacific Northwest Extension, or other regional university publications, and (4) no household chemicals and/or homemade recipes are recommended unless they are labeled as pesticides.

Signed: Idaho Master Gardener Volunteer

Date

Print Name

UNIVERSITY OF IDAHO EXTENSION

IDAHO MASTER GARDENER PROGRAM

ACKNOWLEDGMENT OF RISK AND WAIVER OF LIABILITY

Master Gardeners will be expected to sign an Acknowledgment of Risk and Waiver of Liability ("Waiver"). Master Gardener Coordinators will request the Waiver of Liability from all participants in the Master Gardener program.

CHAPTER **TWO**

INTRODUCTION TO HORTICULTURE AND PLANT PHYSIOLOGY

JoAnn Robbins
Former Extension Educator,
Jerome County, Jerome

Susan Bell
Extension Educator
Ada County

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Light Quality
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FURTHER READING AND RESOURCES 8

2 INTRODUCTION TO **HORTICULTURE** AND PLANT PHYSIOLOGY

Learning Objectives

- Define horticulture and the different areas of horticulture
- Describe macroclimates and microclimates and discuss how they affect gardens and landscapes
- Explain the role of temperature in horticulture
- Understand how to calculate heat units and their relation to plant growth
- Describe techniques to modify low temperatures in a garden
- Explain the role of light in horticulture
- Understand how light quality, intensity, and duration affect plant growth

Horticulture Defined

Horticulture is defined by Webster's dictionary as "the science and art of growing fruits, vegetables, and flowers." It is the intensive commercial production of high-value and high-yielding plants. But it also includes the cultivation of garden crops and landscape ornamentals and the interaction of science and art.

Horticulture contributes to the economy, provides good nutrition, and is a valuable spiritual and psychological therapy. Horticulture beautifies and enhances the environment. Areas of horticulture include the following:

- **Pomology**. Fruit culture, including pome fruits (apple, pear, quince), stone fruits (peach, cherry, plum, nectarine, apricot), small fruits (blueberry, raspberry, grape, strawberry), and nut tree fruits.
- **Vegetable production**. Culture of food crops from vegetable plants including roots, fruits, and seeds.

- **Floriculture**. Growing of cut flowers, potted plants, bedding plants, and bulbs and floral design.
- **Environmental horticulture**. Nursery production of herbaceous and woody plants for landscape design and management.
- **Postharvest physiology**. Harvest, handling, and storage of horticultural crops including flowers, fruits, and vegetables.

Climate in Horticulture

MACROCLIMATE

The term "climate" refers to the long-term weather patterns of a large geographical area and is used interchangeably with "macroclimate." Macroclimate is determined mainly by an area's latitude, elevation, nearness to large bodies of water, nearby ocean and wind currents, relation to nearby forests and irrigated areas, and location in relation to topographic features such as mountains.

Temperature and light are two fundamental features of climate that profoundly affect gardening. Rainfall, wind, hail, clouds, snow, and humidity also create the climate of a region. Short-term variations in rain, wind, snow, and other climatic characteristics are the weather.

Climatologists have calculated the statistical probabilities of certain climatic occurrences that are likely to affect plant growth. The United States Department of Agriculture hardiness zone map, for example, is based on an area's average minimum temperatures. The Arbor Day Foundation has produced an updated version of the climate zone map based on the last fifteen years of warmer temperatures (1990–2005) (Figure 1).

MICROCLIMATE

Microclimates are variations in climate within a community, yard, or other restricted area and result from topographic features, soil types, aspect, or location of buildings, fences, and/or plantings. Different microclimates will be more or less conducive to differ-

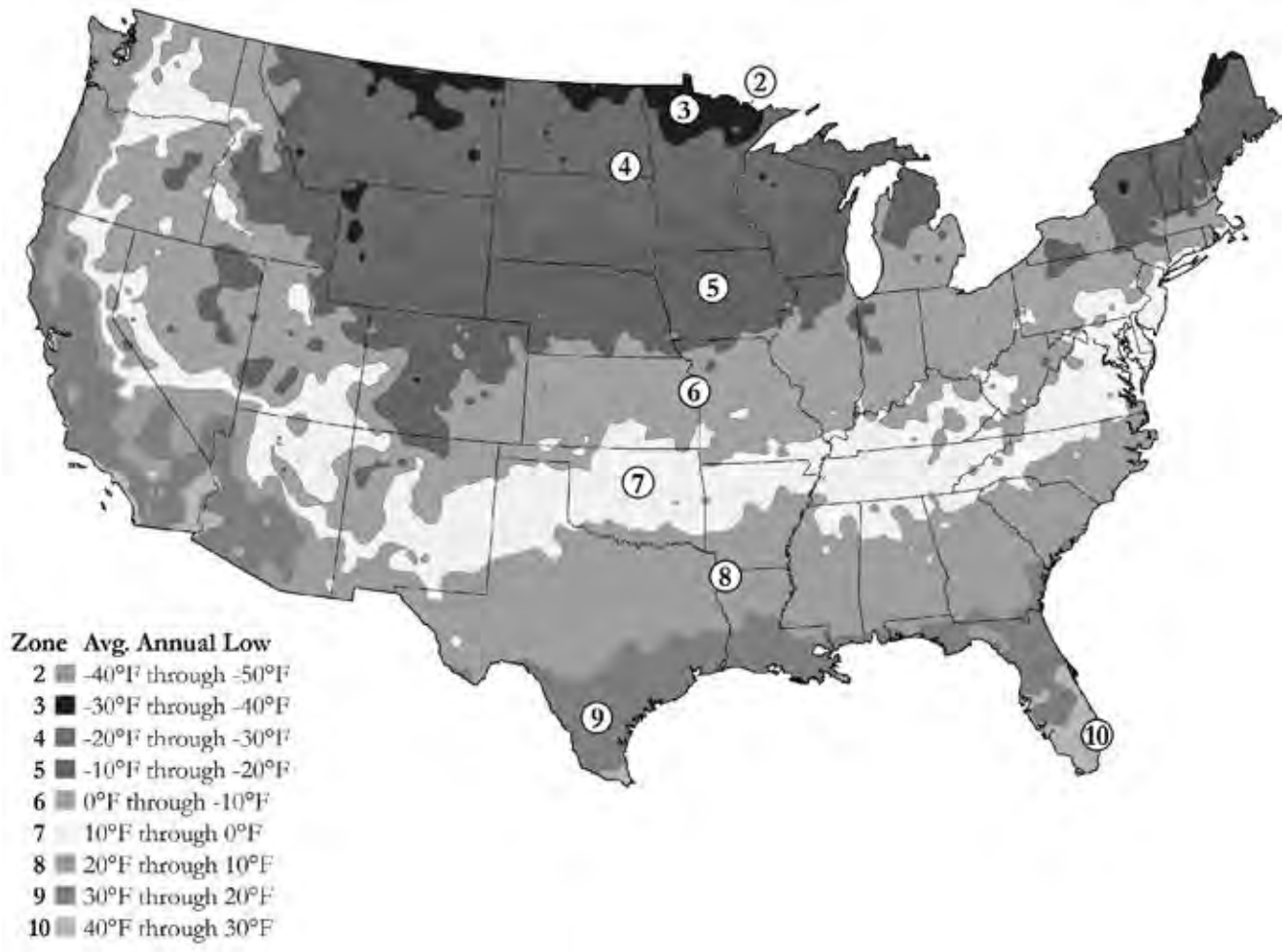

Figure 1. Hardiness zone map of the continental United States. Courtesy of the Arbor Day Foundation.

ent outdoor activities and will limit or enhance the success of plantings. For example, a shady northern exposure may make a better summer patio space than the sunny south side.

Gardeners can create or modify microclimates to increase livability and diversify planting conditions on their property. Landscape features that produce microclimates include the following:

- **Hills and low areas**. Hillside locations are less subject to frost since cold air is denser than warm air and will flow downhill to settle in low areas. A south-facing slope warms earlier in the spring than a north-facing slope, but will be hotter and dryer during summer. The leeward side of a ridge is less subject to wind or breeze than the windward side.
- **Structures**. Structures such as buildings, fences, driveways, or sidewalks serve as heat sinks for solar radiation. Planting areas around them will be warmer, especially on their southern sides or next to pavement. Northern sides of buildings and fences are shady and will remain cooler and moister.
- **Bodies of water**. Water has a moderating effect on air temperature. A lot more energy is required to raise the temperature of water than the temperature of air. Likewise, water releases large amounts of heat energy when it cools. Thus, water acts as a buffer to heat or cold.

Air blowing over cool water will cause adjacent land to warm up slower in the spring, thus delaying bloom and growth. This can protect plants from spring frosts. In the fall, air moving over warm water keeps the surrounding land warmer longer than areas farther away.

- **Elevation**. The higher the elevation, the cooler the temperature; there is less atmosphere to retain the heat from solar radiation at high elevations. Each 300-foot gain in elevation results in an average 1°F drop in temperature.
- **Raised beds**. Raised beds heat quicker than surrounding flat soil surfaces, but plants in raised beds may dry out faster and suffer root damage due to freezing in winter.
- **Plants**. Large plants create microclimates by reducing wind speed, creating shade, and raising the humidity beneath them.

Figure 2. Soil, large objects, bodies of water, and large plants all create microclimates.

- **Soil**. Sandy soil will warm more rapidly in the spring than clay soil and can be planted earlier, resulting in a crop that will mature more rapidly.

By identifying and using microclimates to your advantage, you can maximize the conditions for individual plants or strategically locate garden beds, patios, and other outdoor spaces. The right microclimate often will make the difference between failure and survival for some landscape plants (Figure 2).

Role of Temperature in Horticulture

Temperature is the climatic factor that, more than any other, determines the kinds of plants that will grow in an area. Photosynthesis, transpiration, and respiration increase with rising temperature. Many horticultural crops thrive in warm climates such as California's and Florida's, but are challenged in northern climates like Idaho's. Cold temperatures restrict plant growth, freeze plants in midwinter, and damage plants during fall and spring frosts.

Surviving cold temperatures requires well-adapted plants. Hardiness is especially important for permanent landscape plants such as woody ornamentals and fruit trees.

Each plant type has an optimal temperature needed for growth. Some plants prefer cooler nights or days, whereas others prefer warmer nights or days. Temperate zone vegetables and annual flowers are classified as cool-season or warm-season crops.

Cool-season crops (sweet peas, pansies, garden peas, onions, carrots, potatoes, lettuce, cabbage, and broccoli) grow best in the northern portions of the United States, at higher elevations, or during the spring and fall in warm-climate areas.

Warm-season crops (sweet corn, tomatoes, peppers, melons, zinnias, and marigolds) do best during the warmth of summer in the north but are ideally suited for growth over a longer season in warmer parts of the country. Seeds of warm-season crops require a soil temperature of 60°F or higher to germinate, whereas seeds of cool-season crops will germinate at a soil temperature of just 40°F.

HIGH TEMPERATURES

Plant growth is measured by the food energy produced thorough photosynthesis above that used for respiration. Plants generally grow best at the higher end of their optimal temperature range. In the temperate zone, the minimum temperature for growth is about 40°F. Photosynthesis and respiration increase as temperatures rise until the energy used in respiration equals photosynthetic capacity, when growth ceases. For most plants, this temperature is around 96°F. For many cool-season crops, growth may cease at temperatures considerably lower than 96°F.

Warm temperatures cause stored carbohydrate reserves to be used up thorough respiration or to be converted to starch. This affects the sweetness of crops such as sweet corn and peas and thus their quality.

Very high temperatures can cause physiological damage to plants resulting in burnt leaves and slowed growth. Other high-temperature considerations in plant growth are discussed below.

Overcoming Dormancy

Most temperate zone perennials need a cold period to overcome their physiological dormancy, or rest period, for either the entire plant or only for their flower and vegetative buds. Temperatures that are not cold enough during the winter will keep these plants from forming normal leaves and buds in the spring. For example, peach cultivars for northern climates require 700–1,000 hours below 45°F and above 32°F before they break their rest period and begin growth. If grown in the southern part of the United States, these peaches will not thrive because this requirement is not met.

Vernalization

Some plants require a chilling treatment to induce flowering. This is especially common in biennials and spring-flowering bulbs.

Plant Pests

Plant diseases often grow well at 96°F or higher, increasing the chance of infection. Similarly, insect pests reproduce more rapidly during periods of high temperatures, with resultant high pressure on plants.

Heat Units

Plants have a base temperature below which they grow very little. Average temperatures above a threshold "base" temperature (40°F–50°F, depending on plant type) accumulate on a seasonal basis and are called "heat units" (or "degree days") for that season (Figure 3). Heat units are useful in estimating time of maturity, predicting the latest feasible date for fall planting, and deciding if long-season fruit cultivars will mature in a specific locality.

To calculate heat units, use the following equation:

$$\left(\frac{\text{High temp for day} + \text{Low temp for day}}{2}\right) - \text{Base temp} = \text{Heat units for that day}$$

Add heat units for each day to those of the previous days to calculate the season's total heat units thus far. A negative number for daily heat units does not

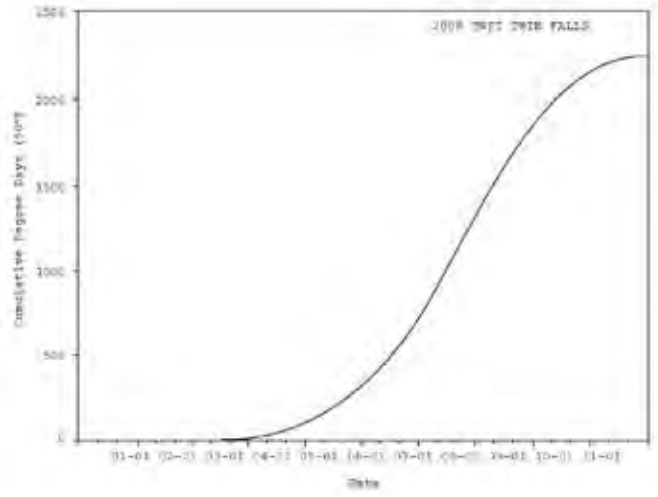

Figure 3. Calculation of accumulated heat units (degree days) in Twin Falls, Idaho, given a base temperature of 50°F (the base temperature for corn). Calculated using the Oregon State University Degree-Day Calculator (**http:pnwpest.org/cgi-bin/ddmodel.pl**)

decrease seasonal heat units, but rather leaves it unchanged.

Certain sweet corn cultivars mature at 1,500 heat units (degree days). Cool nights like we have in Idaho will slow the accumulation of heat units in comparison with areas of the country that have warm nights. This is why corn labeled "matures in 65 days" can take much longer to mature in a cooler climate!

LOW TEMPERATURES

Many plants are susceptible to frost and cold temperatures. If temperatures are too cool, there will be a lack of plant growth, a failure of seed germination, and some plants will not set fruit. Species originating in the tropics, for example, are injured by temperatures below 40°F.

Plants have a minimum survival temperature below which they will be severely injured or killed. The amount of plant damage depends on many variables such as the kind of plant, the plant part, the nutrients and moisture in the plant tissues, the season of the year, the temperature during the freeze, the temperature after the freeze, the amount of air movement, and the moisture level in the soil. Other low-temperature considerations in plant growth are discussed below.

Premature Flower Stalk Formation (Bolting)

Premature flowering in plants is related to the weather and other environmental conditions. Many biennials will bloom in the first year if cool temperatures follow shortly after planting. Since many biennial plants are grown for their roots, petioles, or leaves rather than for seed, flowering and seed formation make the plant inedible. (Other temperature conditions that will cause plants to bloom early are summer heat and fluctuating temperatures.)

Development of Winter Hardiness or Dormancy

Perennial plants become more cold tolerant in the fall after they shed their leaves. This is part of the "hardening" process brought on by cooler temperatures and shorter days. Freezing temperatures are necessary for most plants to increase their resistance to cold damage, while sustained freezing temperatures are necessary for maximum cold tolerance.

If temperatures rise for any length of time, plants lose their tolerance to the cold. Cold tolerance will return with colder temperatures, but not if the buds have broken dormancy. Buds will break dormancy during a warm spell if they have already been exposed to chilling temperatures for the period required for bud break. This type of damage is common in northern climates like Idaho's.

Carbohydrate Reserves

Plant tissues well supplied with carbohydrates will reach deeper dormancy and be less susceptible to winter cold. Make fertilizer applications and prune well in advance of cool fall temperatures. Plants that are stress free and without new growth will move carbohydrates to the roots and other storage tissues in the fall. Stress from insects, diseases, or other sources will lessen carbohydrate production and storage.

Water Status of Plant Tissue

Winter damage can occur due to a lack of moisture in the plant or plant part. If the plant goes into the winter with little moisture in the root zone, or if dehydration occurs while the soil is frozen, the plant will be injured due to water stress. This is called "physiological drought." This type of damage is particularly detrimental to evergreen trees and will show up as browning needles that dry from the tips down.

The windward and sunny, southwest sides of trees are particularly at risk for browning needles and for bark injury called "sunscald." The windy conditions that are common in many parts of Idaho will intensify injury due to cold temperatures and physiological drought.

To prevent this damage, supply ample moisture during the growing season. However, it is advisable to cut back on moisture in late August and early September in order to allow the plant to enter its dormancy. Water well again in late October or early November after the plant has become completely dormant. Plant roots are still active up until the ground freezes and soil temperatures drop below 40°F.

Frost Heaving

Alternate freezing and thawing can force some plants completely out of the soil. This is called "heaving" and young plants without a well-established root system are particularly susceptible to this type of damage, especially when planted in the fall.

Spring Frosts

Cold temperatures will freeze tender transplants, emerging seedlings, and opening buds in the spring. Fruit buds are easily frozen once they begin to expand and bloom. Even expanding leaf buds can freeze when unusually cold spring temperatures occur. On still nights, when temperatures hover near freezing, cold air, which is heavier than warm air, will settle to the bottom of valleys and depressions. These cold spots are called "frost pockets" and may result in cold damage to plants in that area.

TEMPERATURE MODIFICATION

Modifying High Temperatures

You can modify high temperatures by shading plants with larger plants or with structures such as lath houses. Shade cloth suspended over plants will also moderate temperature. Cooler conditions exist on the shady side of a building and under trees.

Plants poorly adapted to high temperatures are not good choices in hot, dry areas because extreme measures must be taken to ensure their survival.

Modifying Low Temperatures

There are many ways to avoid or modify cold temperatures. The most obvious are planting frost-susceptible annual crops after all frost danger is past and selecting perennial plants that are adapted to the cold temperatures in your area. Other methods of modifying cold temperatures include the following:

- **Using covers or heat sinks.** Surround the plants with medium-to large-sized rocks to absorb heat or cover them with fabric row covers, plastic sheeting, or waxed paper cloches in early spring or when frosts are predicted. These techniques reduce outgoing stored solar radiation from soil, rocks, and plants. Depending on the type of cover, you can gain 2°F–6°F of nighttime warmth. Remember that during sunny days it may be 20°F–25°F warmer under the cover, which may require venting to keep plants from becoming too hot.
- **Mulching**. Use a covering of mulch to modify soil temperature. Applied soon after the ground freezes in early winter, mulch will keep the soil frozen and the covered plant crowns at a consistent cold temperature to prevent winter damage. Applied in the spring after the soil warms, mulch moderates soil temperature extremes during the growing season. Certain dark or colored mulches can warm the soil early and maintain warmer temperatures when the weather is still cool. To be most effective, an organic mulch layer should be 3–4 inches deep. Small stones can be used as mulch to gather heat around plants.
- **Using heaters or fans**. Protecting tree fruits from early spring frosts is done in orchards using heaters or large fans. This equipment stirs the air and prevents an air "inversion," when cooler air is trapped under a layer of warm air.
- **Sprinkling**. When liquid water changes to solid ice, it releases heat. When water is sprinkled on plants as they cool, the heat of freezing will keep the plant surface at or near 32°F. This technique is often used in orchards during bloom time when frost or cold temperatures are predicted.

Role of Light in Horticulture

Light is the part of the sun's energy visible to the human eye. Solar radiation reaching the earth includes some light near and on either side of the visible light spectrum. Plants use mostly those light rays that can be seen (Figure 4).

LIGHT QUALITY

Water vapor in the air acts as a prism to separate light into its various wavelength components. The human eye interprets these wavelengths as color. Beginning with the longest visible wavelength, the rays become shorter through the rainbow color spectrum: red, orange, yellow, green, blue, indigo, and violet. Violet rays are the shortest and are slightly longer than ultraviolet rays, which cause sunburn.

The following rays are used by plants in physiological processes (Figure 4):

- **Violet.** These are important for the development of red pigments in plants like apples. At higher elevation, there is less atmosphere to screen out the violet and ultraviolet, resulting in well-colored apples (and maybe sunburn on our skin!). Indigo and violet rays are also responsible for bending flower heads and other plant parts toward the sun (phototropism).
- **Blue-violet and orange-red**. These rays provide the light energy for photosynthesis. In fact, plants appear green to the human eye simply

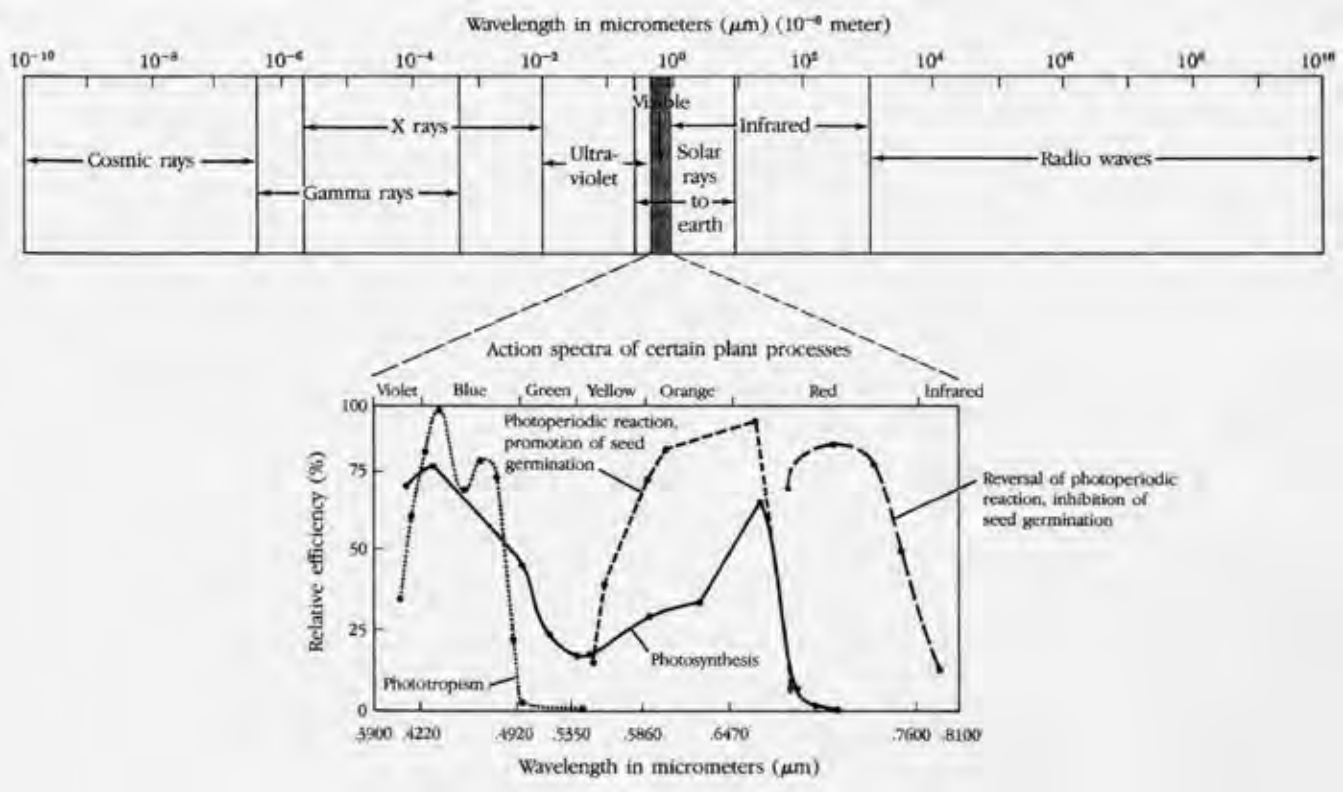

Figure 4. Wavelengths and the responses of plants to the visible rays. (Reprinted from Bienz, D.R. 1980. *The Why and How of Home Horticulture*. San Francisco: WH Freeman.)

because plant pigments in leaves do not absorb and use green light for photosynthesis; instead, it is reflected back to our eyes.

- **Orange-red and far-red (longer than red)**. This part of the spectrum is absorbed by plants and produces the day-length response (photoperiodism).

Supplemental light varies in quality, with fluorescent or cool white bulbs emitting wavelengths in the blue range. Incandescent light is high in the red and orange ranges but also emits the longer heat waves and is too warm to be useful for plant growth. The light bulbs specifically designed for plants are balanced in the wavelengths used by plants.

LIGHT INTENSITY

Gardeners generally use foot-candles to measure intensity or concentration of light, even though the foot-candle is an older unit based on English measurements (amount of light falling on 1 square foot from a candle burning 1 foot away). You will also hear the term *lux* to indicate the amount of light that falls on a surface. Lux is a metric unit equal to 1 lumen per square meter. One foot-candle is 10.76 lux. Physicists use a more precise mathematical measure (millimoles per square meter per second). Gardeners use foot-candles because many existing light meters are calibrated in foot-candles.

In full sunlight at noon on a summer day in the desert, light intensity measures about 12,000–15,000 foot-candles, possibly as high as 20,000 foot-candles. Light intensity is less in the morning and late afternoon because light from the sun reaches the earth at an oblique angle, filtered through more layers of atmosphere before reaching the surface. For the same reason, light intensity is much lower in winter in the Northern Hemisphere. On a heavily overcast winter day at noon, light intensity may be as low as 600–900 foot-candles in northern latitudes. The interior of a well-lighted home will measure from 50–300 foot-candles.

Tropical plants, like many of our houseplants, thrive in nature under a jungle canopy that provides very low light intensity. Plants not from the jungle are able to grow in and use very bright or intense light. Most crop plants use about 1,200 foot-candles of light, but they will grow better in light up to 4,000 foot-candles because of the shading from surrounding leaves.

Plants and leaves adapted to low light intensity will sunburn, wither, or die if they are suddenly exposed to higher light intensity. Light intensity can be decreased through shading or increased with supplemental lights, reflective material, or white backgrounds.

Insufficient light will cause plants to stretch and become "gangly" or unusually long. Nodes will be far apart, leaves broad and thin, and the plants will have a loose, open structure. Reduced light intensity can also induce succulence.

LIGHT DURATION

Plants respond to particular day lengths. Actually, processes that occur during an uninterrupted dark period bring about the plant's response, not processes that occur during the day, but we use day length as the measure. How plants respond to day length is modified somewhat by temperature. Depending on the plant type, blooming, for example, may be delayed or sped up by warm or cool weather. The bloom period can be intentionally altered with specific light treatments or unintentionally altered by lights coming from streetlights or other artificial sources.

Long-Day Plants

Long-day plants respond to day lengths longer than a certain minimum (usually about 12 hours). Spinach, for example, is a long-day plant and, if planted late in the spring, it will make a flower stalk before producing leaves.

Onion bulbing is a long-day response. Onions produce bulbs during long days, and onion types that do well in northern latitudes require longer days (16 hours) compared with those adapted to more southern locations (11–12 hours). Northern-type onions will not produce bulbs in southerly locations because the days never get long enough! Southern types, when grown in the north, produce bulbs before the plant reaches a size adequate to develop a good-sized onion bulb.

Short-Day Plants

Short-day plants respond to day lengths shorter than a certain maximum (less than about 12 hours). Chrysanthemums are short-day plants and will bloom when day lengths range from 16 hours down to 7 hours depending on the cultivar. They grow and develop plant tissue and carbohydrate reserves during the spring and summer to support fall flowering. Poinsettia is another short-day plant.

Day-Neutral Plants

Day-neutral plants do not respond to day length, but must have sufficient growth to support flowering. Temperatures must also be acceptable, roughly above 32°F and below 96°F. Geraniums and certain strawberry cultivars are examples of day-neutral plants.

Further Reading and Resources

BOOKS

Benz, D. R. 1980. "Climate, Temperature and Light." Chapter 7 in *The Why and How of Home Horticulture*. San Francisco: WH Freeman.

BOOKLETS AND PAMPHLETS

University of Idaho Extension

PNW 497 *Short-Season Vegetable Gardening.*

Websites

National Weather Service, Climate Prediction Center. **http://www.cpc.ncep.noaa.gov.**

National Oceanic and Atmospheric Administration, US Department of Commerce. **https://www.noaa.gov/climate.**

Idaho Climate Summaries, Western Regional Climate Center. **http://www.wrcc.dri.edu/summary/climsmid.html.**

Frost and Freeze Information, National Climatic Data Center, NOAA Satellite and Information Service. **https://www.weather.gov/iwx/fallfrostinfo.**

Online Phenology and Degree-day Models, Integrated Plant Protection Center, Oregon State University. **http://ippc2.orst.edu/cgi-bin/ddmodel.pl.**

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CHAPTER **THREE**

BASIC BOTANY

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3 BASIC BOTANY

Learning Objectives

- Describe plant nomenclature, including common and scientific names
- Understand horticulture-related plant classification and define others, including line, landrace, open-pollinated, heirloom, and hybrid
- Describe plant life cycles
- Understand plant parts and their functions
- Describe leaf parts, structure, and arrangement
- Discuss the function of leaves
- Describe the parts and types of stems and root growth and function
- Discuss the function of the vascular system
- Define flower parts and their functions
- Discuss the role of fruit in seed development and dispersal
- Describe seed viability and how it is affected by seed storage conditions
- Understand the seed germination process, the vegetative growth stage, and the reproductive stage of plant development

Introduction

Botany is the study of plants. To become a knowledgeable plant person, it is essential to understand basic plant science. It is important to understand how plants grow, how their various parts function, how they are identified and named, and how they interact with their environment. Learning the language of botany means learning many new words. Making the effort to learn this material will prove extremely valuable and will create excitement as you learn to unravel the mysteries of the plant world.

Like all living organisms, plants are complex, and there is far more to know about them than can be learned in an introductory Master Gardener course. Nonetheless, this chapter is designed to provide the Master Gardener student with a brief, but broad, introduction to many aspects of botany.

Plant Nomenclature and Classification

Plant classification and the scientific naming of plants are important for correct and precise identification. Plant classification can be useful for Master Gardeners involved in identifying plants, germinating seeds, growing a garden, diagnosing plant problems, or controlling pests.

Plants generally have a common name and a scientific name. Common names are usually simple and easy to remember for the general public. They often are descriptive of the plant; for example, burning bush, bleeding heart, or paper birch.

There are problems, however, with using common names. The same species of plant may have two or more common names, with names varying from country to country, region to region, and sometimes even within a local area. This makes it difficult to communicate about a plant. For example, the state flower of Idaho is *Philadelphus lewisii*, commonly called syringa in Idaho. In other parts of the country, however, the same plant is known as mock orange. To add to the confusion, *Syringa* is the genus for lilac shrubs. Another example of confusing common names is *Malva parviflora*, which is called little mallow, round leaf mallow, cheeseweed, or sometimes buttonweed. The same common name may also be used for several plants. An example is the common name geranium, which can refer to plants in either the genus *Geranium* or the genus *Pelargonium*.

With scientific names, a plant has only one name. Scientific names use the Latin language and often are descriptive of some characteristic of the plant. A dictionary on plant names can help with pronunciation and clarify the meaning of Latin words.

Plants are named using a **binomial** (two-part) naming system. A binomial name includes the plant's genus name (capitalized and italicized) plus the specific epithet name (lowercased and italicized). The name may be followed by the initial of the person credited with originally describing and naming the plant. For example, *Solanum tuberosum* L. indicates that Carl von Linne (Linnaeus), a Swedish physician, described and named the white (Irish) potato.

Plant classification groups plants with similar characteristics, first in a broad sense, then through a series of subgroups, using progressively more specific flower and plant traits. This process continues until a single, unique plant form remains.

This plant is given a binomial species name. Ranked from general to specific, the plant classification groups are as follows: kingdom, division or phylum, class, order, family, genus, species, and variety or cultivar. Each species is assigned to a genus, each genus to a family, and so on. Refer to Table 1 for examples of plant classification.

Understanding plant classification is useful for maintaining a successful garden. For example, vegetable crops should be rotated each year, and rotation can be simplified by grouping plants from the same family. To do so, you need to know which

Table 1. Examples of plant classification.

Common name	Black chokecherry	Siskiyou blue Idaho fescue	Western white pine
Kingdom	Planta	Planta	Planta
Division or phylum	Magnoliophyta	Magnoliophyta	Pinophyta
Subdivision	Angiospermae	Angiospermae	Gymnospermae
Class	Magnoliopsida (dicots)	Liliopsida (monocots)	Pinopsida
Order	Rosales	Poales	Pinales
Family	Rosaceae	Poaceae	Pinaceae
Genus	*Prunus*	*Festuca*	*Pinus*
Species	*Prunus virginiana*	*Festuca idahoensis*	*Pinus monticola*
Variety or cultivar	var. *melanocarpa*	'Siskiyou Blue'	

plants belong in which family. A second example: when using the internet to research solutions to a plant problem, it is absolutely essential to enter the correct scientific name. The more you study plants, the more you likely will appreciate the usefulness of the scientific nomenclature system.

An important distinction among plants at the Division level is between those with seedlings having one seed leaf (**monocots**, such as grasses and lilies) and those with seedlings having two seed leaves (**dicots**, such as beans). Monocot and dicot seeds germinate differently. The distinction between monocots and dicots becomes very important when using herbicides. For example, common lawn herbicides for broadleaf weeds (for example, 2,4-D) will kill only dicot plants, leaving the grass plants (monocots) unharmed.

FAMILY

Master Gardeners usually work with the classification of plants at the family level and below. Plant families are important in gardening because members of the same family often have similar cultural requirements and similar insect and disease problems.

In a family of plants, similarities occur primarily with reproductive parts (flowers, fruit, and seed), although leaves and other plant parts may also be similar. Table 2 includes some common families and some of their characteristics.

GENUS

Genus is a subdivision of a plant family. Plants of the same genus share similarities mostly in flower characteristics and genetics. Plants in one genus usually cannot breed with plants in another, but species within a genus will often intercross. The first letter of the genus name is capitalized and the entire name is italicized or underlined.

SPECIES

Species is a group of individual plants that freely interbreed and have many (or all) characteristics in common. Species names use the binomial naming system of genus and specific epithet.

VARIETY AND CULTIVAR

Variety

Variety is a word commonly used to describe cultivated and hybridized plant types. This is a misnomer; used in its proper context, a variety is a botanical division of a species. It is a subgrouping of plants within a species that differs in some particular way from other members of that species. In the wild, variety may be used to describe a particular regional variant of a species with unique plant size, flower color, or other visible trait. In cultivated plants, variety may be used to designate a particular useful form of a species. For example, cauliflower (*Brassica oleracea* var. *botrytis*) and cabbage (*Brassica oleracea* var. *capitata*) are varieties of the same species. The variety name follows the abbreviation "var." It is written in lower case and is italicized or underlined.

Cultivar

This word is a contraction of the term "cultivated variety." A cultivar is a very specific, human-bred, cultivated form of a useful crop species. If propagated asexually (vegetatively), cultivars can be termed **clones**. When vegetatively propagated, cultivars maintain their characteristics from generation to generation, thus preserving desirable traits. However, seeds of clones will not produce plants with the same desirable characteristics as the cultivar. If propagated by seeds, cultivars can be termed **lines**.

Cultivar names are indicated by placing the term in single quotation marks or by preceding the cultivar name with the abbreviation cv. (do not use both). The first letter of the cultivar name is capitalized, but the name is not italicized or underlined. An example is the tomato cultivar Early Girl, expressed as *Solanum lycopersicum* 'Early Girl' or cv. Early Girl.

Both ancient practices of plant domestication and modern processes of plant breeding have contributed to the vast pool of plants we have available for food, industry, and beautification.

Understanding the titles used to describe these plants will help in making decisions as to which cultivars are suitable for specific uses.

Landrace. This term is used to describe a locally domesticated and utilized form of a plant species that was developed through a long process of selection without the use of modern genetics.

Landraces typically have ancient origins and their production was historically limited to a very small geographical area. They often are specifically adapted to production conditions typical of their point of origin. One example is Palomero Toluqueño,

Table 2. Common plant families.

Scientific family name	Common family name	Common plants in family	Family traits
Apiaceae	Carrot family	Carrot (*Daucus carota*) Parsnip (*Pastinaca sativa*) Dill (*Anethum graveolens*) Poison hemlock (*Conium maculatum*)	Flowers usually in simple or compound, flat-topped clusters called umbels; stems often hollow.
Asteraceae or Compositae	Sunflower family	Lettuce (*Lactuca sativa*) Sunflower (*Helianthus annuus*) Zinnia (*Zinnia elegans*) Spotted knapweed (*Centaurea stoebe*)	Flowers organized as heads with ray and disk flowers. One of the largest families: 20,000 species.
Brassicaceae or Cruciferae	Mustard family	Broccoli (*Brassica oleracea* var. *botrytis*) Kale (*Brassica oleracea* var. *acephala*) Cabbage (*Brassica oleracea* var. *capitata*) Radish (*Raphanus sativus*) Shepherd's-purse (*Capsella bursa-pastoris*)	Flowers have four petals that are not joined; there usually are six stamens (four long, two short).
Fabaceae or Leguminosae	Pea or bean family	Common pea (*Pisum sativum*) Common bean (*Phaseolus vulgaris*) Lupine (*Lupinus argenteus*) Hairy vetch (*Vicia villosa*)	Flowers with a distinct upper "flag" petal, arranged in heads or spikes.
Lamiaceae or Labiatae	Mint family	Peppermint (*Mentha* x *piperita*) Sweet basil (*Ocimum basilicum*) English lavender (*Lavendula angustifolia*) Henbit (*Lamium amplexicaule*)	Leaves usually opposite; flowers tubular; stems square.
Poaceae	Grass family	Corn (*Zea mays*) Kentucky bluegrass (*Poa pratensis*) Blue fescue (*Festuca glauca*) Quackgrass (*Elytrigia repens*)	Leaves simple and strap-like; inflorescence usually a long spike. Large family of between 7,500 and 10,000 species.
Ranunculaceae	Buttercup family	Columbine (*Aquilegia vulgaris*) Larkspur (*Delphinium elatum*) Lenten rose (*Helleborus orientalis*) Creeping buttercup (*Ranunculus repens*)	Large and variable family with variable flower form; most species have showy sepals rather than petals.
Rosaceae	Rose family	Apple (*Malus pumila*) Garden strawberry (*Fragaria* x *ananassa*) Rose (*Rosa* spp.) Sulfur cinquefoil (*Potentilla recta*)	Flowers with five (or multiples of five) petals and many stamens.
Solanaceae	Nightshade or potato family	Tomato (*Lycopersicon esculentum*) Pepper (*Capsicum annuum* var. *annuum*) Potato (*Solanum tuberosum*) Black henbane (*Hyoscyamus niger*)	Leaves alternate; flowers have five petals fused at the base; stamens attached to the petals and form a column around the pistil.

a type of popcorn that was historically grown in the highlands of Mexico.

Landraces typically have improved traits that make them valuable for human use in comparison with the original wild species. At the same time, individual plants within a landrace often vary in appearance, quality, and resistance traits.

Open-pollinated. These cultivars are developed through modern breeding practices, genetically stabilized to ensure uniformity, and then seed propagated using methods that allow uncontrolled distribution of pollen within the crop. They differ from hybrids, which are produced through a process that completely controls pollen transfer. Open-pollinated

cultivars will grow true-to-type if seed is collected from parental plants that are isolated from other cultivars of the same species. Most lettuce, bean, and pea varieties for home gardeners are examples of open-pollinated plants.

Heirloom. No universally accepted definition of heirloom exists. Some people consider varieties to be heirlooms only if they are at least one hundred years old. Other people feel the proper cutoff date is 1951, the year recognized as the time when modern hybrid cultivars became available. Nonetheless, there are two fairly common characteristics attributed to heirloom cultivars: (1) they are relatively old and (2) they are not currently planted in large-scale production agriculture.

Cultivars designated as heirloom have recently become very popular in home garden and small agriculture production. They provide unique appearance and quality characteristics. However, they also tend to be narrowly adapted and lack the pest resistance that is common in modern cultivars.

The terms "open-pollinated" and "heirloom" are often used synonymously. By any standard used to define heirloom, this is incorrect. Open-pollinated refers to any cultivar developed through modern (traditional) breeding methods that is not a controlled-pollination hybrid. Every year, modern breeding programs release new open-pollinated cultivars of many crops and landscape species. Cultivars designated as heirloom, however, include many of the older, lesser known open-pollinated cultivars, clonal cultivars, and, in some cases, landraces.

Hybrid. Hybrid cultivars are often referred to as F1 hybrids. This means that the seed we purchase and the resulting plants grown are the first-generation offspring of two open-pollinated parents. (The abbreviation F1 stands for the term "first filial" generation.) Hybrid cultivars are limited almost exclusively to food plants, with a few exceptions. In production agriculture, hybrid cultivars can provide many important advantages, including higher yield, greater plant uniformity, more consistent quality, and the combination of the superior traits of two outstanding parents.

The main difference between hybrid and open-pollinated cultivars is that subsequent generations grown from the seed of a hybrid do not breed true to type. Thus, growers cannot collect and use their own seed, but must purchase new seed each year. For this reason, many people do not consider hybrid cultivars sustainable in small-scale agricultural production.

Clonal. Many plant cultivars are not propagated from seed. They are propagated using vegetative parts. Some familiar plants propagated in this manner include potatoes, rhubarb, asparagus, bulb flowers, and most types of fruit trees. Types of plant material used to establish a new generation include tubers, bulbs, root cuttings, stolons or runners, rhizome pieces, and stem cuttings. Many clonally produced cultivars can trace their origins to a single plant discovered many hundreds of years ago.

GMO. Short for "genetically modified organism," GMO cultivars are radically different from the cultivar types discussed previously, all of which have their basis in traditional breeding and/or selection. Biotechnologists have discovered ways to isolate and remove specific genes from one organism and attach them to the chromosomes of a different organism. This makes it possible to give plants traits that nature did not provide.

This technology is widely used in production agriculture to address critical production and nutrition issues. Examples include insect-resistant corn and cotton cultivars (greatly reducing the need for insecticide use), herbicide-resistant soybeans and sugar beets (minimizing the need for expensive hand weeding), and rice cultivars with high levels of vitamin A (reducing the incidence of blindness in many developing countries). Currently, there are no GMO cultivars available for home food production. Many people oppose the use of GMO cultivars, limiting their value for use in small-scale farming or home production of food crops.

Plant Life Cycles

A plant is classified by its life cycle, specifically how long it lives and how long it takes to complete reproductive processes and develop seed.

ANNUALS

Annuals grow, mature, flower, produce seed, and die in one season. An annual may be a summer annual or a winter annual. For summer annuals, the seed germinates in the spring, and a plant develops, matures, and produces seed by the end of the growing season. Summer annuals include zinnias, corn, and beans. Winter annual seed germinates in

the fall, producing a plant that overwinters, matures, and produces seed the following growing season. Winter wheat and downy bromegrass (a weed) are winter annuals.

BIENNIALS

Biennials take two years or at least part of a second year to complete their life cycle. During the first season, they grow a hardy rosette of basal leaves that will overwinter. During the second season, the plant flowers, produces seeds, and then dies. Parsley and table beets are examples of biennial plants.

PERENNIALS

Perennials live for more than two years. **Herbaceous perennials** have soft, nonwoody stems. Herbaceous perennials die back each winter, and a new plant grows from the crown or roots the following spring. Herbaceous perennials may live for 3–25 years, or even longer under ideal growing conditions. Many herbaceous plants, such as tomatoes or lantana (a flowering shrub), are perennial in warmer climates, but are grown as annuals in temperate climates.

Woody perennials such as trees or shrubs have a woody stem or trunk. Those that lose their leaves every fall and grow new leaves in the spring are called **deciduous**.

Trees or shrubs that keep their leaves (needles or broad leaves) through the winter are called **evergreens**. Sometimes, the term evergreen may be somewhat of a misnomer because the older needles (those closer to the tree trunk) fall off. For example, a spruce tree will hold its needles for 7–10 years, while a pine tree will hold needles for about 3 years.

Woody perennials have a wide range of life spans, ranging from 10–12 years for aspens in a home landscape to more than 1,000 years for some conifers. Life expectancy is often linked to growth rates. (Slower growing plants such as bristlecone pines tend to live longer.)

Plant Parts and Their Function

VEGETATIVE PARTS: LEAVES, STEMS, AND ROOTS

Understanding plant part terminology (Figure 1) and the functions of plant parts will help you identify plants and diagnose plant problems.

Leaves

Leaves are the main structures produced on plant stems. Leaves come in many different shapes, sizes, and arrangements and are used for plant identification. They also serve many vital roles, the most important being the harvest of light energy. The leaf is the primary site of photosynthesis, respiration, and transpiration, all important growth processes for plants.

Leaf parts and structure. There are two main parts to a leaf: the **blade** (flat, thin portion) and the **petiole**. The petiole attaches the blade to the stem and contains conducting tissues between the leaf and the stem.

The outer cell layers on the top and bottom of the leaf blade are the **epidermis**; they serve to protect the inner leaf tissue. Specialized epidermal cells on the undersides, and sometimes upper sides, of leaves form openings called **stomata.** (The singular of stomata is **stomate**.) Open stomata keep water and nutrients moving through the plant and

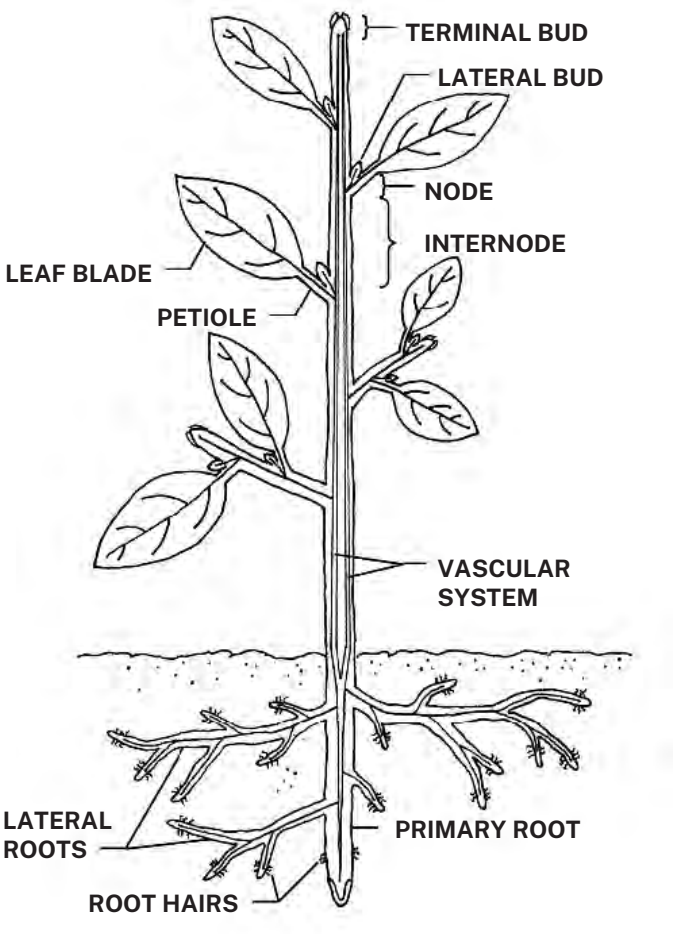

Figure 1. Parts of a vascular plant.

allow the exchange of carbon dioxide and oxygen between the air inside and outside the leaf, a process that is critical for photosynthesis. Conditions that cause plants to lose a lot of water (high temperature, wind, low humidity) cause the stomata to close. Consequently, it is important to keep plants adequately watered to allow air exchange for photosynthesis.

Some plant leaves have a waxy layer on the epidermis called the **cuticle**. The cuticle protects the leaf from dehydration and prevents penetration of some disease-causing organisms.

The leaf blade texture (smooth, hairy, waxy, etc.) is often important to consider when applying pesticides. For example, herbicides may not make good contact on hairy or waxy leaves; consequently they are less effective. Also, some pesticides may remove a desired waxy leaf texture. When this happens on Colorado spruce needles, for example, the color of the needles may change from blue to green.

Leaf arrangement and shape. Leaves are attached to a stem in one of three patterns: **opposite**, **alternate**, and **whorled**. Opposite arrangement means two leaves attach at the same point, but on opposite sides of the stem. With alternate arrangement, leaves are attached at alternating points from one side of the stem to the other. In a whorled arrangement, three or more leaves are attached at the same point. Leaf arrangement is often used for plant identification. For example, maple trees have opposite leaf arrangement, and birch and willow trees have alternate leaf arrangement.

Leaves are most often thought of as being flat blades of various shapes. Examples include the leaves of maple trees or green beans. However, a leaf blade may be needle-like, such as in conifers. Spruce trees have about 1-inch-long needles, and pine trees 2–3-inch-long needles. Leaves can also be scale-like, such as in red cedar and arborvitae, or flat and strap-shaped as in grass plants. Leaf shapes are also helpful for identification.

Photosynthesis in leaves. Plants are able to take solar energy and turn it into chemical energy through the process of photosynthesis. Without photosynthesis, life on earth would not exist. All other life forms depend on the oxygen and food that photosynthesis provides.

Inputs for photosynthesis include carbon dioxide, water, and light. Carbon dioxide enters the leaf through the stomata, water enters through the roots, and light energy comes from natural or artificial light. Outputs of photosynthesis are oxygen and carbohydrates.

Gardeners are basically managing a living plant factory. The goal is to maintain plant health and manage the environment so plants can produce the most carbohydrates possible. Anything that damages the leaves (diseases or insect feeding) or reduces their ability to absorb sunlight (too much shade) or take in carbon dioxide will limit the photosynthetic capability of a plant.

Respiration in leaves. Respiration is essentially the reverse of photosynthesis. It is the process by which carbohydrates are converted into energy. With the production of energy, sugars and oxygen are converted to carbon dioxide, water, and a small amount of heat. Respiration releases energy to build new tissues, maintain chemical processes, and produce growth within the plant. Respiration occurs in all cells at night as well as during the day, a key point that is discussed below.

Relationship between photosynthesis and respiration. The rates of photosynthesis and respiration depend on temperature. Plants have an optimum temperature range and a maximum temperature for photosynthesis. The rate of photosynthesis will increase with increasing temperature up to a certain point and then decrease at higher temperatures. Likewise, higher temperatures will increase respiration. Unlike photosynthesis, however, respiration continues to rise with increasing temperature.

Photosynthesis does not occur at night, but respiration does. If nighttime temperatures are too warm, the plant will use all of the energy produced by photosynthesis during the day for metabolic processes at night just to stay alive, rather than converting the carbohydrates into new plant cells. This can affect the portions that we eat, such as potato tubers and cucumbers. If days are hot and nights are warm, plant growth will be reduced and yields may decrease. Grasping this relationship between photosynthesis and respiration will help you understand plant growth and yield variability from year to year.

Transpiration in leaves. The loss of water through leaf stomata is called **transpiration**. Transpiration pulls water containing dissolved nutrients from the soil through the roots and the rest of the plant. It also provides evaporative cooling for leaf tissue. About 90% of the water entering roots is used in transpiration, and the remainder is used for photosynthesis.

The amount of water used depends on temperature. As temperatures rise, the amount of water needed increases. Consequently, it is critical to irrigate more frequently during warm weather. Also, plants growing in a dry climate need more water than those growing in a more humid environment.

Stems

The stem is the main aboveground support structure of a plant. It contains the vascular system that allows water, nutrients, and carbohydrates to move within a plant.

Parts of a stem. All stems have **nodes**, where leaf attachments occur. Nodes contain buds that may develop into leaves, flowers, or lateral branches. The areas between nodes are called **internodes**. Plants that grow in reduced light conditions may have very long internodes.

It is important to be able to recognize nodes when pruning. For example, it is often necessary to remove a tree branch back to a node that will produce a new stem. Also, when plants are propagated asexually via vegetative cuttings, new roots most often form at nodes.

Types of stems. Most stems grow aboveground and many grow erect (for example, trees, corn and sunflowers). Some aboveground stems can also grow along the ground, such as cucumbers and pumpkins. There are also several other types of stems that gardeners need to understand because plants with these modified stems may need to be managed differently.

Crowns are compressed, aboveground stems with very short internodes. Examples of plants with crowns include dandelions, strawberries, rhubarb, asparagus, and many grasses such as Kentucky bluegrass. Rhubarb and asparagus are propagated by planting crowns. Crown identification is especially important when planting strawberries, as covering the crown with soil is detrimental to their growth.

Spurs are short, stubby stems commonly found on fruit trees such as apple and pear. Spurs produce fruiting buds. If a severe pruning cut is made close to a spur, the spur may produce a stem rather than the intended fruit.

Stolons, also called runners, are horizontal stems, either fleshy or semiwoody, that grow on top of the soil surface. For example, stolons attach a strawberry plant to its plantlets. Some types of grass, such as creeping bentgrass, form stolons. This species often is planted on golf course putting greens.

Rhizomes are stems that grow belowground. A very popular lawn grass, Kentucky bluegrass, spreads by rhizomes. Another grass that spreads by rhizomes is quackgrass, which is considered a difficult-to-control weed.

There are several other types of modified stems, such as tubers (the edible part of potatoes) and bulbs (tulips and onions). These topics are covered in more detail in the chapter titled “Herbaceous Ornamentals.”

VASCULAR SYSTEM

Plants need a system to transport water and nutrients from the roots to the leaves and to move photosynthetic sugars to stems, roots, and other plant parts. You could think of this vascular system as being similar to the vessels and veins in vertebrate animals. There are two types of vessels in plants. **Xylem vessels** conduct water and minerals up from the roots, while **phloem tubes** carry sugars and other compounds from the leaves to the rest of the plant.

The xylem and phloem are grouped in vascular bundles. In dicots, the vascular bundles are arranged in a continuous ring in the outer perimeter of the stem. In woody plants (trees and shrubs), these vascular bundles are located just under the bark. Thus, they can be easily damaged by lawn mowers, string trimmers, or stems rubbing against each other. In monocots, the vascular bundles are scattered throughout the stem and are not as easily damaged.

Buds

A **bud** is a fully formed but undeveloped shoot or flower. If a bud is at the tip of a shoot, it is called a **terminal bud**. Regardless of location, buds that form shoots or leaves are **vegetative buds**. **Flower buds** produce one or more flowers. Mixed buds produce both shoots and flowers.

Buds may grow immediately after they are formed or stop growing and remain **dormant** until the following spring. Buds on many plants, such as fruit trees, require a specified duration of cold temperature below a critical level before they will grow in the spring. This cold period is easily accomplished in Idaho, but may not be achieved in warmer states such as Florida or California.

During dormancy, buds can tolerate very low temperatures without damage. However, once the plant has had enough cold temperature to satisfy the requirement for growth, a new bud can easily be damaged by subsequent cold temperatures.

Roots

Roots are often neglected or forgotten while caring for plants because they are not visible. However, roots are a critical plant part that gardeners need to understand to properly care for plants. Roots make up a large proportion of the total plant — about 20%–30% of the total volume. Small feeder roots are so numerous that the total amount of roots can account for up to 90% of the surface area of a plant!

Establishing a healthy root system is one key to growing attractive and productive plants. The importance of roots is evident when transplanting trees. Transplanted trees often suffer from "transplant shock" and do not seem to grow well the first two or three years. The problem is the amount of root system that was removed during the transplanting process. Bare-root or balled and burlapped trees have less than about 5% of their original root system and cannot grow normally until a complete new root system has developed.

Root functions. Roots absorb nutrients and moisture from the soil or growth medium (potting soil), anchor the plant, physically support the stem, and move water and minerals to the stem. In some cases, roots serve as food storage organs. Roots profoundly affect the size and vigor of the plant, the method of propagation, adaptation to soil types, and responses to cultural practices and irrigation.

Types of root systems. After the primary root emerges from the seed, it may continue to grow straight down and become a **taproot** or it may branch and form a **fibrous** root system with many side (lateral) roots.

Root growth. There is a common misconception that tree roots penetrate the soil to several feet. In fact, most of the functional feeder roots of woody plants — those that absorb water and nutrients — are located in the upper 18 inches of soil. Many plants have even more shallow root systems. The depth to which roots penetrate depends on the plant type, soil texture and structure, and water status. A dense, compacted soil layer or a high water table will restrict or terminate root growth.

Another misunderstanding about roots is that they will grow to "find" water. Roots will not grow into dry soil, so unless soil is moist, roots will not grow to their maximum length.

The roots of most plants are far more extensive than the aboveground area beneath the plant. Tree roots extend several feet beyond the drip-line of the tree. Disturbing the soil by, for example, digging a trench or compacting the soil via vehicular or foot traffic will have an adverse effect on the tree's health.

REPRODUCTIVE PARTS: FLOWERS, FRUITS, AND SEEDS

Flowers

Flowers are the sexual reproductive organs of seed-bearing plants, designed to produce and distribute pollen, accept pollen, provide a way to fertilize the ovary, and nourish and protect the developing seed (Figure 2). This makes flowers critical to the survival, adaptation, evolution, and distribution of plant species.

Angiosperms produce the reproductive structures we recognize as flowers and are the group of plants discussed in this section. **Gymnosperms** (conifers) produce pollen and seeds, but don't have structures recognizable as flowers. Some plants, such as ferns, do not produce flowers or seeds and instead reproduce using spores.

Parts of the flower. A typical flower has four major parts: **sepals**, **petals**, **stamens**, and **pistils**. However, not all flowers have all four parts. Flowers lacking one or more of these basic parts are called **incomplete** flowers. In nature, any combination of flower parts can occur. The shape and visibility of flower parts also vary widely among plant species.

Sepals are the outer covering of the flower when it is in the bud stage. They are usually green and leaf-like in appearance. In some plants, they have the form and color of petals (for example, in tulips). Collectively, all of the sepals form the **calyx**.

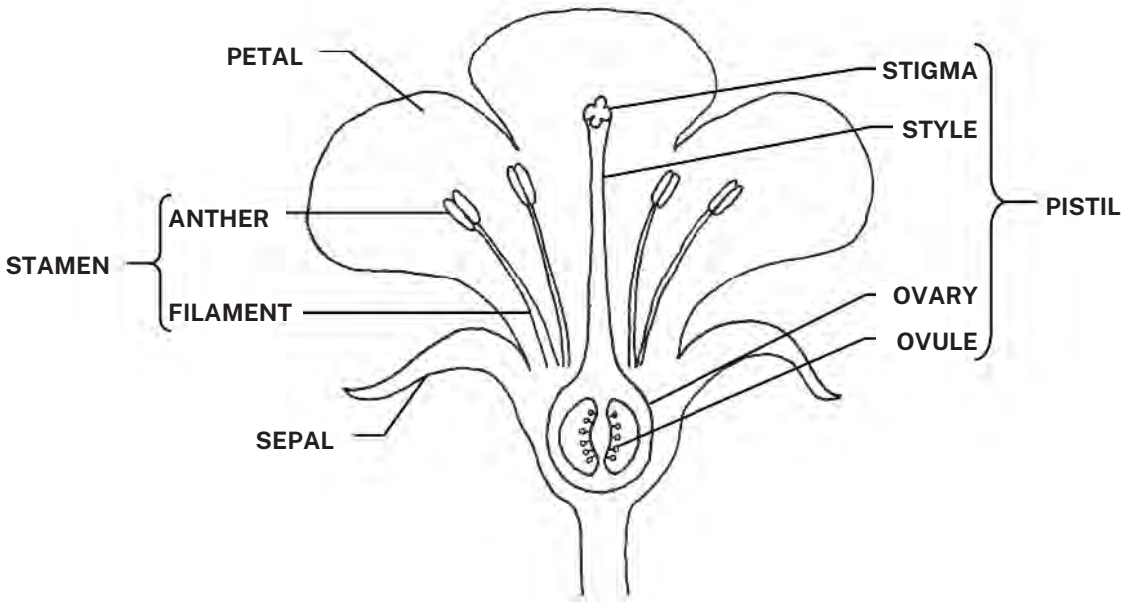

Figure 2. Parts of a flower.

Petals are usually the largest and most visible feature of a flower and are commonly brightly colored. The color helps attract insects to pollinate the flower. As a group, the petals form the **corolla**.

Stamens are the male parts of the flower and are usually found near the center of the flower. Each flower contains multiple stamens — in some cases very large numbers. At the top of each stamen is an anther sac in which pollen is produced.

The **pistil** is the female component of the flower. The upper part of the pistil, called the **stigma**, usually has some type of sticky surface designed to trap and accept pollen. The base of the pistil contains one or more **ovules** (eggs) that develop into seeds after pollination and fertilization.

Arrangement of male and female flowers. Many species of plants produce flowers lacking one or more of the sexual parts and are referred to as **imperfect**. Flowers with no pistils are male flowers (**staminate**). Flowers with no stamens are female flowers (**pistillate**).

Depending on species, imperfect flowers may be arranged within and among plants in a number of ways. Individual plants may produce separate male and female flowers on the same plant. The term for this arrangement is **monoecious** (a Latin term meaning "one house"). Cucumbers are an example of this type of plant; the male flowers (the ones lacking tiny fruit under the corolla) and female flowers (the ones with a tiny cucumber under the corolla) alternate along the vines (see Table 3 for additional examples of common monoecious species).

Other species may have separate male and female plants, with flowers of only one sex on any single plant. The term for this arrangement is **dioecious** (a Latin term meaning "two houses"). Holly is an example of a dioecious plant. Only the female plants produce berries, and only if a male plant is nearby to supply pollen (see Table 3 for additional examples of dioecious plants).

Pollination of flowers. For seed to develop, pollen must be transferred from the anthers to the pistil, where it can fertilize the ovules. Some plants require a pollinator to transfer pollen from flower to flower. Pollinators can include many types of animals, most commonly insects or birds. Honeybees are an example of common pollinating insects.

Plants that require a pollinator (such as an apple tree) produce sticky pollen that adheres to animal visitors. Other plants, such as corn, utilize the wind for pollination. They release large amounts of small, light, nonsticky pollen grains into the air and rely on chance to carry them to the pistil of a nearby plant. As a rule, plants that require pollinators have large and/or showy flowers. Wind-pollinated plants tend to have inconspicuous flowers.

Table 3. Examples of plants with a monoecious or dioecious flower arrangement.

	Scientific name	Common name
Monoecious species	*Betula alba* *Curcurbita pepo* *Juglans nigra* *Musa acuminata* *Quercus macrocarpa* *Salix matsudana* *Zea mays*	European white birch Pumpkin Black walnut Banana Bur oak Globe willow Corn
Dioecious species	*Acer negundo* *Asparagus officinalis* *Fraxinus pennsylvanica* *Juniperus horizontalis* *Populus alba* *Spinacia oleracea* *Taxus cuspidate*	Box elder Asparagus Green ash Carpet juniper White poplar Spinach Japanese yew

Fruits

After pollination, the embryo starts to develop, fruit forms, and seeds enlarge within the fruit. Fruits come in many sizes and forms. They may be fleshy (peach) or dry (elm). They can be single (avocado) or aggregated (raspberry; the crumbles of a raspberry are actually individual fruits). They can have a hard coat (a nut) or soft, fragile skin (tomato). They can hold one seed (plum) or many (cantaloupe).

The fruit serves to protect the developing seed. Once the seed is mature, the fruit can be important in seed dissemination. Sweet, edible fruits, such as serviceberries, are often consumed by animals, and the seed is then deposited elsewhere in their droppings. Other types of fruit may dry and break open violently (dehiscence), flinging the seed some distance from the mother plant. An example of a plant using this dissemination mechanism is chickpea. Still other fruits may have "wings" (**samaras** in maples) or "umbrellas" (the parachute-like **pappus** of dandelions) that allow them to "ride the wind" to a new location. Cockleburs have a barbed fruit that attaches itself to clothing or animal fur, providing the seed with transportation. Small animals gather, transport, and bury nuts, not only moving the seeds but planting them as well.

Fruits are also important for human nutrition, and many garden plants are produced for their edible fruits. Some fruits, such as cucumbers and peas, are picked and eaten at a botanically immature stage. Others reach full maturity before being picked, meaning growth is complete and the seed is capable of germination. Examples are apples and pumpkins.

Seeds

Seeds form when ovules are fertilized after pollination. Thus, they contain genes from both the female and male parents. Each seed is an encapsulated embryo, in essence a miniature but fully formed plant within a protective coat. Once the embryo is formed, it usually goes into a state of arrested development until the seed is separated from the mother plant and is exposed to proper growing conditions.

Seeds, in addition to fruits, are important sources of food for humans. We grow many plants for their edible seeds, including nuts, legumes, and grain.

Seed viability. In order for seeds to grow, the embryo must be **viable**, or alive. Factors such as improper pollination, less-than-ideal growing conditions during seed development, or competition within a plant for resources can lead to **nonviable** seed. Nonviable seeds may look normal, but will not grow, even when planted in optimal conditions. In nature, nonviable seeds affect the ability of plants to propagate themselves. In the garden, nonviable seeds have a negative impact on plant stands and productivity. Nonviable seeds should not be confused with dormant seeds, which are discussed below.

Seeds enable plants to bridge periods of time when growing conditions are not favorable (winter, dry periods, etc.). Consequently, if conditions are appropriate, seeds of most plant species can remain viable for extended periods of time. Germination and growth may be delayed until suitable growing conditions occur. Having seeds of desirable plants remain viable for many years is beneficial, but when weed seeds remain viable for many years, it creates a need for ongoing weed management.

There are exceptions to the rule of extended seed viability. The seeds of some plant species are capable of growth for only a few days and then only if kept constantly moist. Species of plants with short periods of viability usually live in warm, or at least moist, conditions and often produce seeds that develop within wet, pulpy fruits.

Recently purchased seed has usually gone through a certification process, meaning the germination percentage has been tested in a laboratory and acceptable levels of seed viability ensured. Older seed or seed that has not been certified can be tested at home to make sure it is viable. Before testing germination, make sure the seed is not dormant (see a discussion of dormancy below).

A quick, simple way to test the viability of most seeds is to float the seed in a container of water. Seeds that float are usually not viable; live seeds sink. However, the most reliable method for assessing viability is a germination test. Place a known quantity of seeds on a moist paper towel and seal it in a plastic bag. After a week to 10 days, inspect the seed to determine the percentage that has sprouted.

Seed storage. Due to the tendency of seed to remain viable over extended periods of time, seed can often be stored for one to several years, depending on species and storage conditions (Table 4). Even under ideal conditions, however, seeds of some plants (such as onions, leeks, and parsnips) may remain viable for only one year. Seeds of other plant species (such as radishes, tomatoes, grains, and many grass species) may remain viable at least six and sometimes more than twenty years.

Successful seed storage requires proper conditions. The keys to long storage are temperature and humidity, with cool, dry conditions being best. The "rule of 90" can help you determine a suitable storage site. Measure the temperature and relative humidity of the intended storage location and add the two values together. If the sum is less than 90, extended seed storage should be successful. Low humidity is the most critical factor for seed storage, but generally, lowering either humidity or temperature will extend the storage period. Long-term viability of seeds can be ensured by placing the seed in a sealed container with a desiccation gel packet and placing the container in a freezer.

Seed dormancy. Some seeds, although viable and planted under correct conditions, fail to grow. These seeds are exhibiting a natural survival characteristic termed **dormancy**. Dormancy is an adaptation of some plants to keep seeds from germinating until conditions favor seedling survival. Most of our common food crops and annual flowers lack dormancy, meaning the seed will grow as soon as it is planted into warm, moist soil. However, many perennial flower species (such as monkshood, alliums, columbines, and penstemons) and most hardy shrubs and trees produce seed with some form of dormancy. In these cases, dormancy must be broken before seedling establishment can be successful.

Table 4. Examples of longevity and minimum germination (percentage of live seed required to ensure successful production).

Kind of seed	Longevity (years)	Minimum germination (percent)
Bean	3	70
Beet	4	65
Carrot	3	55
Corn, sweet	2	75
Cucumber	5	80
Lettuce	1	80
Muskmelon	5	75
Pea	3	80
Pumpkin	4	75
Radish	4	75
Spinach	3	60
Squash	4	75
Watermelon	4	70

*Source: J.E. Ells, L.N. Bass, and D. Whiting. 2020 (revision). *Storing Vegetable and Flower Seeds*. Colorado State University Extension, 7.221. **https://extension.colostate.edu/topic-areas/yard-garden/storing-vegetable-and-flower-seeds-7-221/**.

The most common mechanisms of dormancy are **seed coat impermeability** and **embryo dormancy**. Seed coat dormancy is caused by the presence of a thick, hard seed coat that is impermeable to water. In nature, weathering, soil abrasion, the action of microorganisms, or passage through the digestive tract of an animal can soften the seed covering, thus allowing the seed to take up water and begin growing.

For garden production, an artificial method known as **scarification** can be used to break or soften the seed coat. The simplest scarification method is mechanical; simply scratch the seed coat with sandpaper or nick it with a knife. Heat treatments

using boiling water can also disrupt the seed coat enough to allow germination. With this method, it is important to use caution to avoid personal injury. Also, be sure you know the proper length of treatment to avoid damaging or killing the seed.

Embryo dormancy is a chemical/physiological condition that prevents growth, usually associated with the balance of growth hormones in the seed. In nature, this type of dormancy ensures that seedlings will emerge in the spring, rather than in the fall. The hormonal balance of the seed changes toward a status favoring growth during exposure to cold, moist soil conditions. This type of dormancy can be overcome by **stratification**, a process of artificially chilling seeds under moist conditions. Place the seed in moist potting soil in a small plastic bag and place the bag in a refrigerator for 1–3 months.

Seed dormancy attributes and the methods required to overcome dormancy vary widely among plant species. Success with many plants depends on understanding dormancy characteristics and finding the best ways to satisfy dormancy requirements. Good reference materials are available to determine the necessary conditions for germinating seed of difficult species.

Plant Development

Plants go through definable stages of life, beginning with germination (sprouting) and ending with senescence and death. Some annuals complete this entire process within a few months, while some tree species live for thousands of years.

SEED GERMINATION

Plant development begins with the germination of a seed. First, the seed swells as it absorbs water. The first root (**radicle**) emerges from the seed coat and grows downward. In proper soil moisture conditions, the new roots and root hairs grow down into the soil to anchor the plant and acquire water and minerals. Meanwhile, the shoot portion of the stem emerges from the seed and begins extending toward the soil surface.

During germination and seedling establishment, young plants are vulnerable to damage from conditions that may not damage an established plant. Lack of moisture, excessive heat or cold, pests, and diseases can all kill or seriously damage an emerging seedling. For example, an established plant may be hardy to −25°F, while a tender young plant of the same species may be hardy to only 32°F. As the fragile new shoot moves up through the soil, it may also be damaged by the inability to penetrate heavy or compacted soil.

Because of this extreme vulnerability, germinating seedlings require that we pay careful attention to cultural details. We must adequately prepare the soil, plant seed to the proper depth, maintain proper moisture conditions, minimize exposure to pests, and control temperature as much as possible.

VEGETATIVE GROWTH STAGE

Once a seedling is established, the size and complexity of the plant increases as the first true leaves are formed. Stems elongate and produce additional leaves. The leaf surface increases, thereby enhancing the plant's ability to capture and utilize light. During this stage of development, growth is rapid and plant parts tend to be large and succulent. Also, the growing plant begins to display characteristic branching and rooting patterns. For example, carrots will produce fern-like leaves and a long taproot, while blue fescue will develop long, narrow leaves from a crown and a dense, fibrous root system.

New growth on all plants develops from localized **meristems**—specific regions of rapidly dividing cells. Meristematic tissues within any plant include those providing both **apical** and **lateral** growth. The apical meristems are found at the tips of stems and roots and produce cells resulting in longer stems and branches. Lateral meristems are located along the interior of the stem and roots and serve to increase the diameter of stems, trunks, branches, and roots. Lateral meristems are especially important in the expansion (increase in diameter) of woody tissues in trees and shrubs.

Grass plants have a unique form of apical meristem called the **intercalary meristem**, located at the base of the leaves. Intercalary meristem cells divide and produce new growth from the leaf base, giving grasses the unique ability to regrow after mowing or grazing. Scalping grass with a mower (cutting to a very short length) or overgrazing may damage or remove this meristem and cause a bald spot (no grass) in the lawn or pasture.

REPRODUCTIVE GROWTH STAGE

Upon achieving adequate size and storing sufficient energy, flowering plants go through a process of physiological change that favors the development of reproductive organs at the expense of vegetative growth. Among angiosperms, this means producing flowers and fruits. Once flowering is induced, particularly with annuals and herbaceous perennials, leaf growth usually slows and the plants become more fibrous and stout. For annuals, the reproductive process occurs only once before the plant senesces and dies. For long-lived perennial and woody species, the reproductive cycle may be repeated many times during the life span of a single plant.

Flowering is influenced by many external and internal factors, including genetics, plant mass, plant health, hormone balance, temperature, and day length. Cold or warm temperatures at a specific stage of growth can trigger the flowering process. For example, consistent cold weather will cause young broccoli plants to bloom early instead of growing large heads. Another important trigger for some plants is the length of the light period. Onions, for example, require increasingly long early summer days to trigger bulb growth. These triggering mechanisms ensure that the plants produce flowers during the optimal time of the year so that flowering and fruit development can be unhindered.

During fruit set — the next phase of reproductive growth — the ovary develops into a fruit with seed. Fruit and seed development take a great deal of energy. For this reason, it may be beneficial to prevent fruit from developing when plants are just getting established. Deadheading is another example of preventing fruit development, in this case to promote more flowering. Any stress that reduces photosynthesis — drought, nutrient deficiencies, insects, or diseases — will negatively affect fruit development.

SENESCENCE

For annuals and biennials, death is the next and final stage following fruit development. **Senescence** is a series of steps that lead to the death of a plant. The plant ceases to metabolize and nutrients are moved from the vegetative structures to the fruits.

Perennial plants do not die after fruit production. On herbaceous perennials, however, fruiting may signal an annual dieback of foliage. In woody species, fruiting may or may not be associated with fall leaf drop and annual dormancy.

For all plants, the stages of development associated with maturation and senescence are accompanied by a lack of response to outside influences. In other words, the plants are programmed to naturally decline and no inputs of nutrients, moisture, or any form of tender loving care will extend their life. During this stage of development, plants also become more prone to diseases and insect feeding. Luckily, pests do little lasting damage to plants at this stage of their lives and efforts to control pest issues during senescence are usually unwarranted.

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CHAPTER **FOUR**

PLANT PROPAGATION

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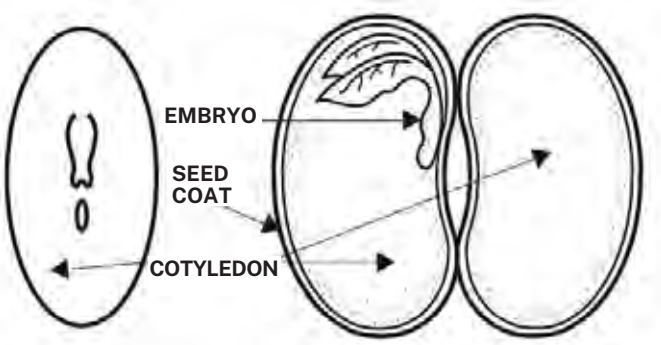
4 PLANT PROPAGATION

Learning Objectives

- Define sexual propagation
- Describe the role of water, light, oxygen, and heat in germination
- Describe methods of breaking seed dormancy
- Discuss the role of media, containers, and timing in seed starting
- Describe seed tape
- Describe the method of pregermination in seed starting
- Describe how to transplant and handle seedlings
- Describe how to harden off plants
- Define asexual propagation
- Describe the methods for propagating with cuttings and those by layering
- Describe the method of propagating by divisions and that by graft

Sexual Propagation

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm (cotyledon), which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate (begin active growth). In the following section, seed germination and transplantation of seeds will be discussed.



Bean seed with interior parts indicated

SEED

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to

provide the size, color, and habit of growth desired. Choose varieties adapted to your area that will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than nonhybrids and sometimes have specific disease resistance or other unique cultural characteristics. Disadvantages of hybrids: seed cannot be saved as they do not breed true and they may have a higher fertility requirement.

Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Good seed will not contain seed of any other crop, weed seeds, or other debris. The seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, germination percentage you may typically expect, and notes of any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Do not freeze seed. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly closed containers and maintained near 40°F in low humidity.

Some gardeners save seed from their own gardens; however, such seed is the result of random pollination by insects or other natural agents and may or may not produce plants typical of the parents. Open-pollinated varieties are best for seed saving. Vegetable seeds are discussed in chapter 20.

GERMINATION

Four environmental factors affect germination: water, light, oxygen, and heat.

Water

The first step in the germination process is absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process begins, a dry period will cause the death of the embryo.

Light

Light is known to stimulate or to inhibit germination of some seed. The light reaction involved here is a complex process. Some crops that have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, centaurea, annual phlox, verbena, and vinca will germinate best in the dark (Table 1). Many other plant seeds are not specific in their light or dark requirements.

Table 1. Seed requirements.

Plant	Approximate time to seed before last spring frost	Approximate germination time (days)	Optimum germination temperature (°F)	Germination in light (L) or dark (D)
Begonia	12 weeks or more	10–15	70	L
Browallia		15–20	70	L
Geranium		10–20	70	D
Larkspur		5–10	55	D
Pansy (Viola)		5–10	65	D
Vinca		10–15	70	D
Dianthus	10 weeks	5–10	70	—
Impatiens		15–20	70	L
Petunia		5–10	70	L
Portulaca		5–10	70	D
Snapdragon		5–10	65	L
Stock		10–15	70	—
Verbena		15–20	65	D
Ageratum	8 weeks	5–10	70	L
Alyssum		5–10	70	—
Broccoli		5–10	70	—
Cabbage		5–10	70	—
Cauliflower		5–10	70	—
Celosia		5–10	70	—
Coleus		5–10	65	L
Dahlia		5–10	70	—
Eggplant		5–10	70	—
Head lettuce		5–10	70	L
Nicotiana		10–15	70	L
Pepper		5–10	80	—
Phiox		5–10	65	D
Aster	6 weeks	5–10	70	—
Balsam		5–10	70	—
Centaurea		5–10	65	D
Marigold		5–10	70	—
Tomato		5–10	80	—
Zinnia		5–10	70	—
Cucumber	4 weeks or less	5–10	85	—
Cosmos		5–10	70	—
Muskmelon		5–10	85	—
Squash		5–10	85	—
Watermelon		5–10	85	—

(—) means no specific light or dark requirements.

Seed catalogs and seed packets often list germination or cultural tips for individual varieties. When sowing light-requiring seed, do as nature does and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6–12 inches above the seeds for 16 hours a day.

Oxygen

In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.

Heat

A favorable temperature is another important requirement of germination (Table 1). It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperatures, whereas others require a narrow range. Many seeds have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50°F and a maximum temperature of 95°F, but an optimum germination temperature of about 80°F. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65°F–75°F is best for most plants. This often means the germination flats may have to be placed on radiators, heating cables, or heating mats to maintain optimum temperature. The importance of maintaining proper soil temperature to achieve maximum germination percentages cannot be overemphasized.

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones or auxins to initiate the process.

METHODS OF BREAKING DORMANCY

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

Seed Scarification

Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds.

- **Acid scarification.** Put seeds in a glass container and cover them with concentrated sulfuric acid. Gently stir the seeds and soak them anywhere from 10 minutes to several hours depending on the hardness of the seed coat. When the seed coat thins, remove, wash, and plant the seeds.
- **Mechanical scarification.** File seeds with a metal file, rub them with sandpaper, or crack them with a hammer to weaken the seed coat.
- **Hot water scarification.** This involves putting the seed into hot water (170°F–212°F). The seeds are allowed to soak in the water, as it cools, for 12–24 hours and then planted.
- **Warm, moist scarification.** In this case, seeds are stored in nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.

Seed Stratification

Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they overwinter. This “afterripening” may be accomplished artificially by a practice called stratification.

The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with ½ inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator (not freezer). Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10–12 weeks, remove the bag and pot from the refrigerator. Remove the bag and set the pot in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 2 inches tall, transplant them into pots to grow until it is time to set them outside.

Another procedure for starting seeds uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will be successful. After 10–12 weeks, remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off.

Temperatures in the range of 35°F–45°F are effective for stratification. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

STARTING SEEDS

Media

A wide range of materials can be used to start seeds, from plain vermiculite or mixtures of soilless media to the various amended soil mixes. With experience, you will learn to determine what works best under your conditions. However, keep in mind what makes a good germinating medium. It should be rather fine and uniform, yet well aerated and loose. It should be free of insects, disease organisms, and weed seeds. It should also be of low fertility or total soluble salts and capable of holding and moving moisture by capillary action. One mixture that supplies these factors is a combination of ⅓ sterilized soil, ⅓ sand or vermiculite or perlite, and ⅓ peat moss. Do not use garden soil by itself to start seedlings; it is not sterile, it is often too heavy, and it will not drain well.

The importance of using a sterile medium and container cannot be overemphasized. The home gardener can treat a small quantity of soil in an oven. Place the slightly moist soil in a heat-resistant container in an oven set at about 250°F. Use a candy or meat thermometer to ensure that the mix reaches a temperature of 180°F for 30 minutes. Avoid overheating as this can be extremely damaging to the soil. Be aware that the soil will release very unpleasant odors in the process of sterilization. This treatment should prevent damping-off and other plant diseases, as well as eliminate potential plant pests.

An artificial, soilless mix also provides the desired qualities of a good germination medium. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, lightweight, and produce uniform plant growth. “Peat-lite” mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge.

Containers

Flats and trays can be purchased or you can make your own from scrap lumber. A convenient size to handle would be about 12–18 inches long and 12 inches wide with a depth of about 2 inches. Leave cracks of about 1/8 inch between the boards in the bottom or drill a series of holes to ensure good drainage.

You can also make your own containers for starting seeds by recycling such things as cottage cheese containers, the bottoms of milk cartons, or bleach containers and pie pans, as long as good drainage is provided. Wash growing containers and implements to remove any debris, then rinse in a solution of one part chlorine bleach to nine parts water. At least one company has developed a form for shaping newspaper into pots and another has developed a method for the consumer to make and use compressed blocks of soil mix instead of pots.

Clay or plastic pots can be used and numerous types of pots made of compressed peat are also on the market. Plant bands and plastic cell packs are also available. Each cell or minipot holds a single plant that reduces the risk of root injury when transplanting. Peat pellets, peat or fiber-based blocks, and expanded foam cubes can also be used for sowing.

Seeding

The proper time for sowing seeds for transplants depends upon when plants may safely be moved out-of-doors in your area. This period may range from 4–12 weeks before transplanting, depending upon

the speed of germination, the rate of growth, and the cultural conditions provided. A common mistake is to sow the seeds too early and then attempt to hold the seedlings back under poor light or improper temperature ranges. This usually results in tall, weak, spindly plants that do not perform well in the garden.

After selecting a container, fill it to within 3/4 inch of the top with moistened growing medium. For very small seeds, at least the top 1/4 inch should be a fine, screened mix or a layer of vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.

For medium and large seeds, make furrows 1–2 inches apart and ⅛- to ¼-inches deep across the surface of the container using a narrow board or pot label. By sowing in rows, good light and air movement results, and if damping-off fungus does appear, there is less chance of it spreading. Seedlings in rows are easier to label and handle at transplanting time than those that have been sown in a broadcast manner. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if it requires darkness for germination. A suitable planting depth is usually about two to three times the diameter of the seed.

Do not plant seeds too deeply. Extremely fine seeds such as petunia, begonia, and snapdragon are not covered, but lightly pressed into the medium or watered in with a fine mist. If these seeds are broadcast, strive for a uniform stand by sowing half the seeds in one direction, then sowing the remaining seed in the other direction to form a crossed pattern.

Large seeds are frequently sown into a small container or cell pack that eliminates the need for early transplanting. Usually two or three seeds are sown per unit and later thinned to allow the strongest seedling to grow.

Seed Tape

Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-to-handle seeds. However, tapes are much more expensive per seed. Seed tapes allow uniform emergence, eliminate overcrowding, and permit sowing in perfectly straight rows. The tapes can be cut at any point for multiple-row plantings and thinning is rarely necessary.

A homemade “seed tape” can be fashioned from two-ply toilet paper and paste made with flour and water. Separate the two paper layers, then use a toothpick with a dab of flour paste on it to pick up and place seeds on one of the paper layers. Once all seeds are placed, put the two layers back together while the paste is still wet and roll the “tape” up for later use. The toilet paper, once covered with soil, will rapidly decay, leaving no trace.

Pregermination

Another method of starting seeds is pregermination. This method involves sprouting the seeds before they are planted in pots or in the garden. This reduces the time to germination, as the temperature and moisture are easy to control. A high percentage of germination is achieved since environmental factors are optimum.

Lay seeds between two paper towels or on a layer of vermiculite in a shallow pan. Keep them moist and in a warm place. When roots begin to show, place the seeds in containers or plant them directly into the garden. While transplanting seedlings, be careful not to break off tender roots. Continued attention to watering is critical.

When planting seeds in a container that will be set out in the garden later, place one seed in a 2- to 3-inch container. Plant the seeds at only one-half the recommended depth. Gently press a little soil over the sprouted seed and then add about 1/4 inch of milled sphagnum peat or sand to the soil surface. These materials will keep the surface uniformly moist and are easy for the shoot to push through. Keep the seedlings in a warm place and care for them as for any other newly transplanted seedlings.

A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. You can make a gel by blending cornstarch with boiling water to a consistency that is thick enough so the seeds will stay suspended. Be sure to cool thoroughly before adding seeds. Place the gel with seedlings in a plastic bag with a hole in it. Squeeze the gel through the hole along a premarked garden row. Spacing of seeds is determined by the number of seeds in the gel. If the spacing is too dense, add more gel; if too wide, add more seeds. The gel will keep the germinating seeds moist until they establish themselves in the garden soil.

Watering

After the seed has been sown, moisten the planting mix thoroughly. Use a fine mist or place the containers in a pan or tray that contains about 1 inch of warm water. Avoid splashing or excessive flooding, which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.

Ideally, seed flats should remain sufficiently moist during the germination period without having to add water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering.

The plastic should be at least 1 inch from the soil. Placing a popsicle stick or pencil in the middle of the flat will hold the plastic off the soil and plants. Keep the container out of direct sunlight, otherwise the temperature may rise to the point where the seeds will be harmed. Many home gardeners cover their flats with panes of glass instead of using a plastic bag. Be sure to remove the plastic or glass cover as soon as the first seedlings appear. Surface watering can then be practiced.

Lack of uniformity, overwatering, or drying out are problems related to manual watering. Excellent germination and moisture uniformity can be obtained with a low-pressure misting system or subirrigation (watering from below). Flats or pots must not sit in water constantly as the soil may absorb too much water and the seeds will rot due to lack of oxygen.

Temperature and Light

Several factors for good germination have already been mentioned. The last item, and by no means the least important, is temperature. Since most seeds will germinate best at an optimum temperature that is usually higher than most home night temperatures, special warm areas must be provided. The use of thermostatically controlled heating cables is an excellent method of providing constant heat (see Germination section on page 4-2).

After germination and seedling establishment, move the flats to a light, airy, cooler location, at a 55°F–60°F night temperature and a 65°F–70°F day reading. This will prevent soft, leggy growth and minimize disease. Some crops, of course, may germinate or grow best at a different constant temperature and must be handled separately from the rest of the plants. Read as much as you can about the plants you are trying to grow.

Seedlings must receive bright light after germination. Place them in a window facing south, if possible. If a large, bright window is not available, place the seedlings under a fluorescent light. Use two 40-watt, cool-white fluorescent tubes or special plant growth lamps. Position the plants 6–8 inches from the tubes and keep the lights on for 14–16 hours each day. As the seedlings grow, the lights should be raised.

TRANSPLANTING AND HANDLING

If the plants have not been seeded in individual containers, they must be transplated to give them proper growing space. One of the most common mistakes made is leaving the seedlings in the seed flat too long. The ideal time to transplant young seedlings is when they are small as there is less danger from transplant shock. This is usually about the time the first true leaves appear above or between the cotyledons (the cotyledons sometimes called “seed leaves” are not true leaves). Avoid letting plants get hard, stunted, or tall and leggy.

Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble houseplant fertilizer at the rate recommended by the manufacturer, about every 2–3 weeks after the seedlings are established. Remember that young seedlings can easily be damaged by too much fertilizer, especially if they are under moisture stress.

To transplant, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Gently ease them apart in small groups that will make it easier to separate individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not by their delicate stems. Punch a hole in the medium into which the seedling will be planted. Make it deep enough so that the seedling can be put at the same depth it was growing at in the seed flat.

After planting, firm the soil and water gently. Keep newly transplanted seedlings in the shade for a few days, or place them under fluorescent lights. Keep them away from direct heat sources. Continue watering and fertilizing as in the seed flats.

Most plants transplant well and can be started indoors, but a few plants are difficult to transplant. These are generally directly seeded outdoors or sown directly into individual containers indoors. Examples include zinnias and cucurbits, such as melons and squash.

Containers for Transplanting

There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Small plastic pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.

Many types of containers are available commercially. Those made out of pressed peat can be purchased in varying sizes. Individual pots are inexpensive and can be planted directly into the garden. When setting out plants grown in peat pots, be sure to cover the pot completely. If the top edge of the peat pot extends above the soil level, it may act as a wick and draw water away from the soil and roots. To avoid this, tear off the top lip of the pot and then plant.

Compressed peat pellets, when soaked in water, expand to form compact, individual pots. They waste no space, don't fall apart as badly as peat pots, and can be set directly out in the garden.

In addition, many homeowners find a variety of materials from around the house to use for containers. These homemade containers should be deep enough to provide adequate soil and have plenty of drainage holes in the bottom.

Hardening Plants

Hardening off is the process of altering the quality of plant growth to withstand the change in environmental conditions that occurs when plants are transferred from a greenhouse to the garden. Severe sunscald or a stoppage in growth may occur if plants produced in the home are planted outdoors without a transition period. Hardening off is most critical with early crops, when adverse climatic conditions can be expected.

Hardening off can be accomplished by gradually lowering temperature and relative humidity and reducing water. This procedure results in an accumulation of carbohydrates and a thickening of cell walls. A change from a soft, succulent type of growth to a firmer, harder type occurs.

This process should be started at least 2 weeks before planting in the garden. If possible, plants should be moved to a 45°F–50°F temperature either indoors or outdoors in a shady location. A cold frame is excellent for this purpose. When put outdoors, plants should be shaded, then gradually moved into sunlight. Start with a 15- to 20-minute exposure. Each day, gradually increase the length of exposure time to outside temperatures. Don't put tender seedlings outdoors on windy days or when temperatures are below 45°F.

Reduce the frequency of watering to slow their growth, but don't allow plants to wilt. Even cold-hardy plants will be hurt if exposed to freezing temperatures before they are hardened. After proper hardening, however, they can be planted outdoors and light frosts will not damage them.

The hardening-off process is intended to slow plant growth. If carried to the extreme of actually stopping plant growth, significant damage can be done to certain crops. For example, cucumbers and melons will stop all growth, while cauliflower will make thumb-size heads and fail to develop further if hardened too severely.

Asexual Propagation

Asexual propagation is the best way to maintain some species, particularly an individual that best represents that species. Clones are groups of plants that are identical to their parent or mother plant. The Bartlett pear (1770) and the Delicious apple (1870) are two examples of clones that have been asexually propagated for many years. The major methods of asexual propagation are cuttings, layering, division, and budding/grafting. Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent plant and then severing it later; and budding and grafting is joining two plant parts from different varieties.

CUTTINGS

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part that is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.

Take cuttings with a sharp blade to reduce injury to the parent plant. Before using the knife to cut, dip the cutting tool into rubbing alcohol and allow it to dry or use a mixture of one part bleach to nine parts water to disinfect the blade and to prevent transmitting diseases. Remove flowers and flower buds from cuttings to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production.

To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting a small amount in a separate container for immediate use. Do not dip cuttings directly into the original container.

If hormone powder is used, only a very light coating is necessary. Tap off any excess onto a sheet of paper.

Insert cuttings into a rooting medium such as coarse sand, vermiculite, sterilized soil, water, or a mixture of peat and perlite. A pencil can be used to make a hole in the medium for easier insertion and to prevent the removal of hormone powder from the cut surface.

It is important to choose the correct rooting medium to get optimum rooting in the shortest time. In general, the rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress. Moisten the medium before inserting cuttings and keep it evenly moist while cuttings are rooting and forming new shoots. Place stem and leaf cuttings in indirect light. Root cuttings can be kept in the dark until new shoots appear.

Stem Cuttings

Numerous plant species are propagated by stem cuttings (Table 2). Some can be taken at any time of the year, but stem cuttings of many woody plants must be taken during the fall or in the dormant season. Tip, medial, cane, single and double eye, and heel are all examples of stem cuttings.

Tip cuttings. Detach a 2-to 4-inch piece of stem with two or three nodes, including the terminal bud. Make the bottom cut 1/4 inch below a node. Remove lower leaves from the cutting that would be in contact with the medium. Dip the stem in rooting hormone if desired. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deeply enough into the media to support itself (about halfway). At least one node must be below the surface.

Medial cuttings. Make the first cut just above a node, and the second cut just below another node 2–4 inches down the stem. The terminal bud is not necessary for this kind of stem cutting. Prepare and insert the cutting as you would a tip cutting. Be sure to position right side up. Axial buds are always above leaves.

TIP CUTTING MEDIAL CUTTINGS

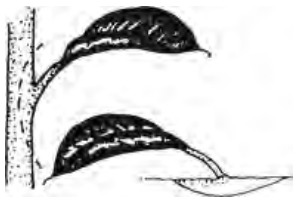
Cane cuttings. Cut cane-like stems into sections containing one or two “eyes” or nodes. Dust ends with fungicide or activated charcoal. Allow to dry several hours. Lay horizontally with about half of the cutting below the media surface, eye facing upward. Cane cuttings are usually potted when roots and new shoots appear. This method is used with dumb cane (*Dieffenbachia*).

Single eye cuttings. The eye refers to the node. This is used for plants with alternate leaves when space or stock material are limited. Cut the stem about ½ inch above and ½ inch below a node. Place cutting horizontally or vertically in the medium.

Double eye cuttings. This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about ½ inch above and ½ inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

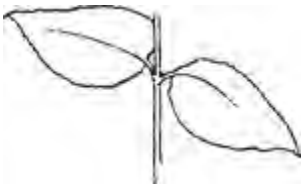
Heel cuttings. This method uses plant material with woody stems. Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.

CANE CUTTING



HEEL CUTTING

SINGLE EYE CUTTING



DOUBLE EYE CUTTING

Table 2. Selected herbaceous plants that can be propagated from cuttings.

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	**Scientific name**		
African violet	*Saintpaulia* spp.	leaf	3–4
Aluminum plant	*Pilea* spp.	stem	2–3
Aloe	*Aloe* spp.	leaf	4–6
Aphelandra	*Aphelandra* sp.	stem	2–3
Arrowhead plant	*Syngonium podophyllum*	stem	2–3
Begonia	*Begonia* spp.	stem	2
		(fibrous rooted) whole leaf or leaf section (Rex)	4–5
Cactus	*Cephalocereus senilis*	stem	3–4
	Opuntia microdasys	stem	3–4
Chrysanthemum	*Chrysanthemum* spp.	stem	1–2
Carnation	*Dianthus* spp.	stem	2–3
Coleus	*Coleus blumei*	stem	1–2
Crown of thorns	*Euphorbia splendens*	stem	4–5
Dahlia	*Dahlia* spp.	stem or leaf bud	3–4
Dieffenbachia (dumb cane)	*Dieffenbachia* spp.	stem	4–6
Dracaena	*Dracaena* spp.	stem	3–4
Echeveria	*Euphorbia* spp.	stem	4–6
Fittonia	*Fittonia* spp.	stem	2–3
Fuchsia	*Fuchsia* spp. (also hybrids)	stem	1–2
Geranium	*Pelargonium* spp.	stem	1–2
Hoya	*Hoya* spp.	stem	3–4
Hydrangea	*Hydrangea* spp.	stem	2–3
Impatiens	*Impatiens* spp.	stem	2–3
Ivy	several genera and species	stem	2–3
Jade	*Crassula* spp.	stem or leaf	4–5
Kalanchoe (*bryophyllum*)	*Kalanchoe* spp.	stem or leaf	4–5
Lantana	*Lantana* sp.	stem	3–4
Monstera (Swiss cheese plant)	*Monstera deliciosa*	stem	4–5
Mint	*Mentha* spp.	stem	2–3
Peperomia	*Peperomia* sp.	leaf, leaf bud or stem	4–6
	P. obtusifolia	leaf bud or stem	4–6
	P. obtusifolia variegata	leaf bud or stem	4–6

Table 2. (cont'd).

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	Scientific name		
Periwinkle (myrtle)	*Vinca* spp.	stem	3–4
Petunia	*Petunia hybrids*	stem	2–3
Philodendron	*Philodendron* spp.	stem	2–4
Piggyback plant	*Tolmiea menziesii*	leaf with plantlet	3–4
Pothos	*Scindapsus aureus*	stem	2–3
Poinsettia	*Euphorbia pulcherrima*	stem	2–3
Sansevieria (snake plant)	*Sansevieria* spp.	leaf, leaf section	4–6
Velvet plant	*Gynura* spp.	stem	1–2
Wandering jew	*Tradescantia* spp. *Zebrina* spp.	stem	2–3

*The indicated time for rooting is only approximate and may be longer under some conditions. Where new shoots must develop in addition to roots, the time required for shoot development is often longer. Source: *Propagating Herbaceous Plants from Cuttings*, PNW 151.

Leaf Cuttings

Leaf cuttings are used almost exclusively for a few indoor houseplants. Leaves of most other plants will either produce a few roots but no plant, or they just decay. Covering leaf cuttings with a plastic bag will maintain moisture in the medium and humidity around the cutting.

Whole leaf with petiole. Detach the leaf and up to 1½ inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be severed from the new plants when they have their own roots and the petiole reused. This method is used for African violets.

Whole leaf without petiole. This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will form from the axillary buds. The leaf may be removed when the new plant has its own roots. This method is used with jade plants.

Split vein. Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay and pin the cutting, lower side down, on the medium. New plants will form at each cut. If the leaf tends to curl up, hold it in place by covering the margins with the rooting medium. This method is used with Rex begonias. A plastic bag around the container and leaf will help keep the leaf from drying out.

Leaf sections. This method is frequently used with snake plant (*Sansevieria*) and Rex begonias. Cut begonia leaves into wedges with at least one main vein. Lay leaves flat on the medium. A new plant will arise at the vein.

Cut snake plant leaves into 2-inch sections. Consistently make the lower cut slanted and the upper cut straight so you can tell which is the top. Insert the cuttings vertically into the medium. Eventually a new plant will appear at the base of the cutting. These and other succulent cuttings will rot if kept too moist. No plastic bag is needed around succulents.

WHOLE LEAF WITH PETIOLE

WHOLE LEAF WITHOUT PETIOLE

SPLIT VEIN

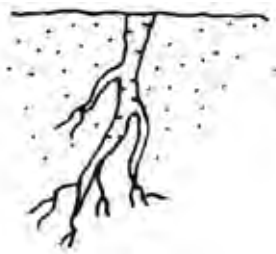
LEAF SECTION

Root Cuttings

Root cuttings are usually taken from 2- to 3-year-old plants during their dormant season when they have a large carbohydrate supply. Root cuttings of some species produce new shoots, which then form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

Plants with large roots. Make a straight top cut and a slanted cut 2–6 inches below the first cut. This will help you determine what portion is the top. Store about 3 weeks in moist sawdust, peat moss, or sand at 40°F. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often used outdoors.

Plants with small roots. Take a 2- to 3-inch section of root. Insert the cutting horizontally about ½ inch below the medium surface. This method is usually used indoors or in a hotbed.



PLANTS WITH LARGE ROOTS

PLANTS WITH SMALL ROOTS

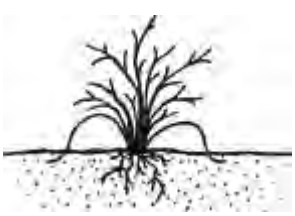
LAYERING

Stems still attached to their parent plants may form roots where they touch a rooting medium. Severed from the parent plant later, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents water stress and the loss of carbohydrate shortage that plagues cuttings.

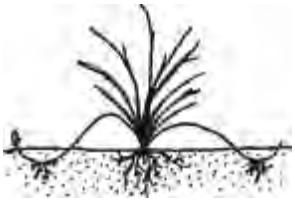
Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering is enhanced by wounding one side of the stem or by bending it very sharply.

Tip Layering

Dig a hole 3–4 inches deep. Insert the shoot tip and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the tip layer from the mother plant and plant it in early spring or fall. Examples: purple and black raspberries and trailing blackberries.



TIP LAYERING



SIMPLE LAYERING

Simple Layering

Bend the stem to the ground. Cover part of it with soil, leaving the last 6–12 inches exposed. Bend the tip into a vertical position and stake it in place. The sharp bend will often induce rooting, but wounding the lower side of the branch may help. Examples: rhododendron and honeysuckle.

Compound Layering

This method works for plants with flexible stems. Bend the stem to the rooting medium as for simple layering, but alternately cover and expose stem sections. Wound the lower side of stem sections to be covered. Examples: heartleaf philodendron and pothos.

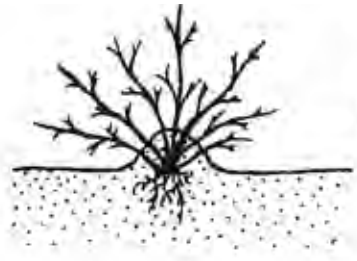
Mound (Stool) Layering

Cut the plant back to 1 inch above the ground during the dormant season. Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries and apple rootstocks.

Air Layering

Air layering is used to propagate some indoor plants with thick stems or to rejuvenate them when they become leggy. Make an upward slanting cut one-half way through the stem just below a node. Hold the slit open with a toothpick laid sideways or a bit of sphagnum moss. Surround the wound with wet, unmilled

COMPOUND LAYERING



MOUND LAYERING

AIR LAYERING

sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie it in place above and below the wound. When roots pervade the moss, cut the plant off below the root ball. Examples: dumb cane and rubber tree.

NOTE

The following propagation methods can all be considered types of layering, as the new plants form before they are detached from their parent plants.

Stolons and Runners

A stolon is a horizontal, often fleshy stem that can root and produce new shoots where it touches the medium. A runner is a slender stem that originates in a leaf axil and grows along the ground or downward from a hanging basket, producing a new plant at its tip. Plants that produce stolons or runners are propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent or detached and placed in a rooting medium. Examples: strawberry and spider plant.

STOLONS AND RUNNERS

OFFSETS

Offsets

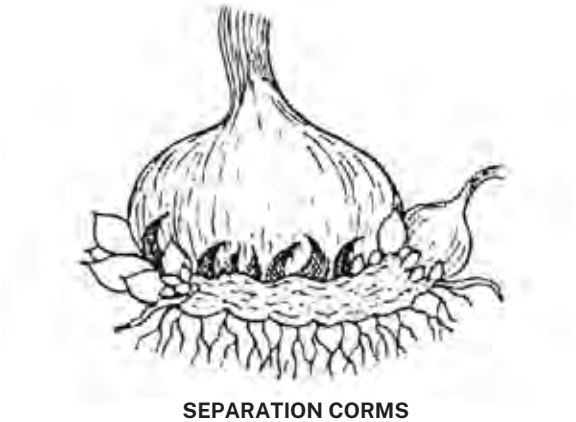
Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, while others may simply be lifted off of the parent stem. Examples: date palm, haworthia, bromeliads, and many cacti.

Separation

Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.

Bulbs. New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3–5 years for largest blooms and to increase bulb number. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replace them immediately so that their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Examples: tulip and narcissus.

Corms. A large new corm forms on top of the old corm and tiny cormels form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting time. Examples: crocus and gladiolus.



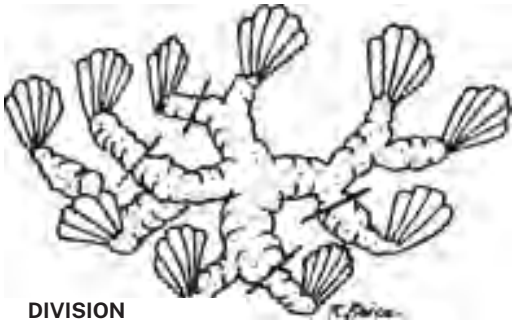
SEPARATION CORMS

DIVISION

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not jointed, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: snake plant, iris, prayer plant, and day lilies.

Most perennials left in the same place for more than 3 years are likely to be overgrown, overcrowded, have dead or unsightly centers, and in need of basic feeding and soil amendment. The center of the clump will grow poorly, if at all, and the flowers will be sparse. The clump will deplete the fertility of the soil as the plant crowds itself.

To divide mature clumps of perennials, select only vigorous side shoots from the outer part of



DIVISION

the clump. Discard the center of the clump. Divide the plant into sections of three to five shoots each. Be careful not to overdivide; too small a section will not give much color the first year after replanting.

Divide perennials when the plants are dormant, just before a new season of growth, or in the fall so they can become established before the ground freezes.

GRAFTING

Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant. These techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate. One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.

The portion of the cultivar that is to be propagated is called the scion. It consists of a piece of shoot with dormant buds that will produce the stem and branches. The rootstock or stock provides the new plant's root system and sometimes the lower part of the stem. The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate.

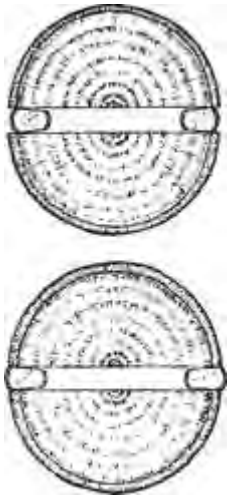
Four conditions must be met for grafting to be successful:

1. The scion and rootstock must be compatible.
2. Each must be at the proper physiological stage.
3. The cambial layers of the scion and stock must meet.
4. The graft union must be kept moist until the wound has healed.

Cleft grafting. Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree (usually a seedling). It is especially successful if done in the early spring. Collect scion wood ⅜–⅝ inch in diameter. Cut the limb or small tree trunk off at the area that it is to be reworked. Make a 2-inch vertical cut through the center of the limb or trunk. Be careful not to tear the bark. Keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3–4 inches long. Insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.

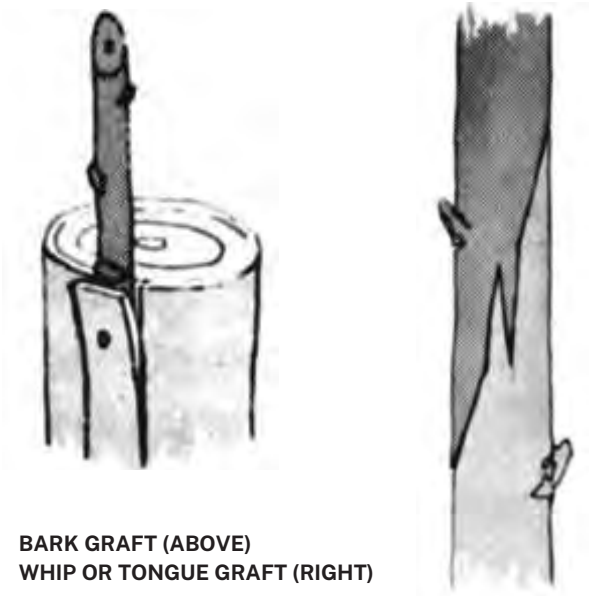
Veneer or bark grafting. Unlike most grafting methods, bark grafting can be used on large limbs, although these are often infected before the wound can completely heal. Collect scion wood ⅜- to ½-inches in diameter when the plant is dormant and store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock to be worked. In the spring, when the bark easily separates from the wood, make a 1- to 2-inch diagonal cut on one side of the scion, and a 1 ½-inch diagonal cut on the other side. Leave two buds above the longer cut. Slice through the bark of the stock cutting a little wider than the scion. Insert the scion between the bark and wood with the longer cut against the wood. Nail the graft in place with flat-headed wire nails. Cover all wounds with grafting wax.

Whip or tongue grafting. This method is often used for material ¼–½ inch in diameter. The scion and rootstock are usually of the same diameter, but the scion may be narrower than the stock. This strong

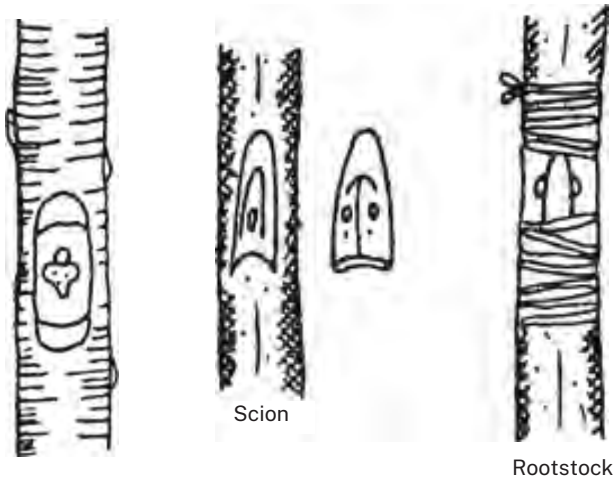


CLEFT GRAFT (CORRECT METHOD ON TOP; INCORRECT METHOD BELOW)

CLEFT GRAFT WITH BOTH SCIONS INSERTED AT SLIGHT ANGLES. ALL CUT SURFACES SHOULD BE WAXED OVER.



BARK GRAFT (ABOVE)
WHIP OR TONGUE GRAFT (RIGHT)



PATCH BUD CHIP BUD

graft heals quickly and provides excellent cambial contact. Make one 2½-inch sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface, slice downward into the stock and up into the scion so the pieces will interlock. Fit the pieces together, then tie and wax the union.

Care of the Graft

Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts to prevent girdling. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut, as they deteriorate and break after a short time. It is also an excellent idea to inspect the grafts after 2 or 3 weeks to see if the wax has cracked, and if necessary, rewax the exposed areas. After this, the union will probably be strong enough and no more waxing will be necessary.

Limbs of the old variety that are not selected for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually reduced as the new grafted variety increases until at the end of 1 or 2 years, when the new variety has completely taken over. Completely removing all the limbs of the old variety at the time of grafting will increase the shock to the tree and cause excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

BUDDING

Budding or bud grafting is the union of one bud (attached to a small piece of bark) from the scion to the rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.

Patch Budding

Plants with thick bark should be patch budded. This is done while the plants are actively growing, so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cut a matching rectangular piece with a bud and piece of bark from the scion to cover this wound. If the rootstock's bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped, the patch will be held firmly in place.

Chip Budding

This budding method can be used when the bark is not slipping. A downward cut is made at a 45° angle about one quarter through the rootstock. About 1 inch above the first cut, a second cut is made slicing downward and inward until it connects with the first cut. The cuts removing the bud from the bud stick are made just as those in the rootstock, except the lower cut is made about ¼ inch below a bud. Fit the bud chip to the stock and wrap the union.

T-Budding

This is the most commonly used budding technique. When the bark is slipping, make a vertical cut through the bark of the rootstock, avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, bark, and a thin section of wood. Push the shield under the loosened stock bark. Wrap the union, leaving the bud exposed.

T-BUD

Care of Buds

Place the bud in the rootstock in August. Force the bud to develop the following spring by cutting the stock off 3–4 inches above the bud. The new shoot may be tied to the resulting stub to prevent damage from the wind. After the shoot has made a strong union with the stock, cut the stub off close to the budded area.

PLANT TISSUE CULTURE

Tissue culture is a mass of undifferentiated callus tissue growing on an artificial medium, separately from the plant from which it originated. Size increases by cell division. After about 4–6 weeks, the mass of cells is large enough to divide into sections and reculture to produce additional tissue cultures. This procedure is usually done in a laboratory or under laboratory conditions.

A tissue culture can be started from a variety of plant parts that have cells capable of dividing. Usually tissues near the vascular area of stems and roots proliferate best, but cultures have been started from fruits, en-dosperm, pollen, and embryos. To read more about this exciting method of propagation, refer to books in your local library.

Further Reading

BOOKS

The Virginia Master Gardener Handbook, Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The Nevada Master Gardener Handbook, University of Nevada Cooperative Extension, phone 702-784-4848.

Wilkins, H. M. 1988. *Plantwatching: How Plants Live, Feel, and Work*. New York: MacMillan.

Wilkins, H. M. 1988. *Plantwatching: How Plants Remember, Tell Time, Form Partnerships, and Move*. New York: Facts on File.

BOOKLETS AND PAMPHLETS

University of Idaho Extension

PNW 496 *Propagation of Plants by Grafting*

PNW 164 *Propagation of Plants from Specialized Structures*

PNW 151 *Propagating Herbaceous Plants from Cuttings*

PNW 152 *Propagating Deciduous and Evergreen Shrubs, Trees, Vines with Stem Cuttings*

PNW 496 *Propagation of Plants by Grafting and Budding*

PNW 170 *Propagating Plants from Seed*

PNW 400 *Training and Pruning Your Home Orchard*

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CHAPTER **FIVE**

SOILS AND FERTILIZERS

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Former Extension Educator
Benewah County

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5 SOILS AND FERTILIZERS

Learning Objectives

- Understand what soil is and how it's formed
- Understand texture and structure and how they influence management
- Understand the importance of organic matter
- Understand aggregation and soil pores
- Understand the role of soil life and soil health
- Understand how to incorporate soil health principles in the garden
- Understand pH
- Understand plant nutrients, their functions and mobility
- Understand how to take a soil sample
- Understand different fertilizer sources
- Understand how to read a fertilizer label
- Understand fertilizer application and timing

The Five Soil-Forming Factors

What is soil? Soil is basically weathered rock, the decaying remains of living organisms — plants and animals — and microorganisms. Soil is also commonly described as a medium for plant growth because it provides physical support and nutrients for plants.

Have you ever noticed how soils can vary within a short distance as well as regionally? Five soil-forming factors are at work on all soils and determine their physical and chemical properties. Where all five factors are the same we can expect the soils will be very similar. The following is a description of the soil-forming factors: parent material, climate, topography, living organisms, and time.

PARENT MATERIAL

The term **parent material** refers to where the soil came from. The source of the soil has a large influence on soil texture (particle size) and minerals present. Soil surveys

include the parent materials in the soil descriptions; therefore, it is important to learn the common terms.

There are six basic types of parent material:

1. **Alluvium** — Parent material that has been transported by water, such as in floodplains and washes.
2. **Colluvium** — Parent material that has been transported by gravity (talus), such as in toeslopes or debris at the base of a cliff.
3. **Eolian** — Parent material composed of sand-sized particles that have been transported by the wind.
4. **Loess** (pronounced "luss") — Parent material composed of silt-sized particles that have been transported by the wind. The Palouse area of northern Idaho and eastern Washington is a good example of a loess deposit.
5. **Lacustrine and marine sediments** — Parent material that has been deposited by streams into freshwater lakes or ponds is lacustrine. Parent material that has been deposited by oceans or seas, sometimes found in saltwater basins, is marine.
6. **Residual/residuum** — Parent material that has weathered, in place, from the bedrock below. These materials have not been transported.

CLIMATE

Temperature and precipitation are major factors influencing the rate of weathering of a soil. They also control the rate of chemical and physical processes. Water is the medium by which things are moved into and through a soil profile.

Less annual precipitation means that soluble components, such as calcium carbonate (lime), will accumulate, which is why soils in arid regions are more alkaline. Conversely, soils in high-moisture areas will have faster rates of leaching (removal) of soluble components, which is why soils in humid regions are more acidic.

TOPOGRAPHY

Topography includes both the gradient (steepness) and the aspect (direction) of a slope. The gradient influences how quickly water enters the soil or runs off, which directly influences the amount of soil loss or erosion. The aspect of the slope influences the amount of solar radiation and temperature fluctuations in the soil, which directly influences the type of plants that will grow in the soil.

LIVING ORGANISMS (BIOTA)

Living organisms include plants, animals, and microorganisms that live in and on the soil. Biota have a significant impact on soil formation due to factors such as nutrient cycling, production of organic matter, and vegetative cover of the soil surface. Human activities such as farming and construction also impact the soil.

TIME

How "old" a soil is makes a difference in its development. Soils are dynamic in that they are "a work in progress," constantly under the influence of soil-forming factors. The older a soil is, the more "developed" it is. Therefore, "young" soils are very different from "old" soils chemically and physically. An example of a young soil is new soil deposits from a flood.

Each of the five soil-forming factors has a powerful influence on the characteristics of a soil. This helps explain why soils a very short distance apart can be different. It takes a change in only one of the five soil-forming factors to differentiate the classification of one soil from another.

The consistency of the soil-forming factors is demonstrated in a soil survey. Most soil surveys are done by a county and they are a good source of general soils information, including information on climate and land-use suitability.

The first step in developing a soil survey is to gather topographic data on the area to be surveyed. Lines are drawn to delineate areas of similar slope and major changes in vegetation are noted. Each delineated area or mapping unit is then given a soil-classification designation or name. A soil scientist will do fieldwork to verify a few of these mapping units. Extrapolations can be made without field verification because the soil-forming factors have such consistent effects on soil characteristics.

Major Components of a Mineral Soil

Only 48% of the soil is made up of minerals; the other 52% is organic matter and pore space filled with water or air (Figure 1). Water is the medium of transport for nutrients to reach the plant roots. Air is required for chemical processes in the plant roots as well as for the microorganisms that live in the

soil. Too much water can not only cause plants to die but can kill microorganisms as well. Generally, the mineral soils in Idaho have about 2% organic matter, plus or minus 2%–3% in some areas of the state. That 2% organic matter affects the soil's water-holding capacity, soil structure, and fertility. Every bit of organic matter counts.

There is a vast array of microorganisms living in the soil. Microorganisms play a major role in nutrient cycling — the retention and release of nutrients in the soil. The main categories of microorganisms are listed below, with a conservative estimate of their concentration in soil:

- Bacteria — 500 million per gram of soil
- Actinomycetes — 1–20 million per gram of soil
- Fungi — large variation up to 1 million per gram of soil
- Algae — up to 500,000 per gram of soil
- Protozoa — up to 500,000 per gram of soil
- Nematodes — 50 or more per gram of soil

Have you ever noticed the smell of freshly tilled soil? That is the smell of microorganisms at work!

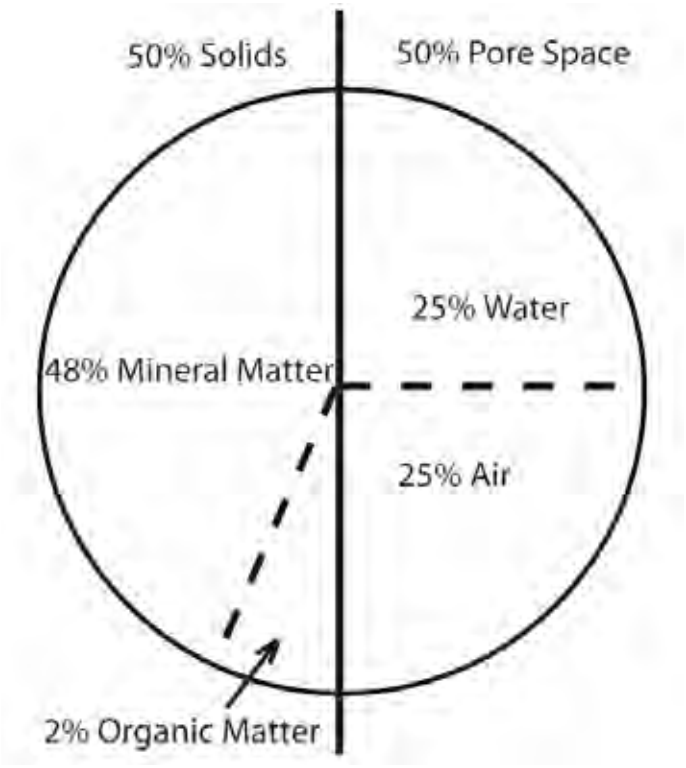


Figure 1. Major components of a mineral soil. The percentage will vary depending on the soil. Under wet conditions, there is less air. Under dry conditions there is less water.

Soil Texture

The texture (particle size distribution) of a soil is determined by the relative amounts of sand, silt, and clay present. There are many possible combinations of these particles and distinct textural classes to describe all possible particle-size combinations or distributions. See the soil texture triangle (Figure 2) to determine the textural class of a particular soil. The three major particle size classes are sand, silt, and clay.

SAND

Sand particles range in size from 2.0 to 0.02 millimeters (mm). Sand particles are the largest particles in the soil. Any particle larger than the sand particle (>2 mm) is considered part of the rock fraction (gravel, stone, cobble, etc.), not part of the soil. Sand particles provide the most stable medium for engineering purposes. Sand particles are relatively inactive chemically. The large spaces between the particles (pore space) mean that water and some nutrients cannot be retained very long and readily move out of the soil profile. This is why sandy soil is often referred to as a "droughty" soil.

SILT

Silt particles range in size from 0.02 to 0.002 mm. Silt particles carry a very weak negative charge and are capable of holding small amounts of plant nutrients. Silty soils hold more water than sand and water movement through silty soils is generally slower. A good example of silt is talcum powder.

CLAY

Clay particles are smaller than 0.002 mm and there are many types of clays. Clay particles carry negative charges capable of attracting all positively charged ions in the soil; as a consequence, clays attract positively charged plant nutrients. The very tiny, flat clay particles lead to high water-holding capacity and can result in slow movement of water through the soil. Although there may be more total pore space in a given volume of clay soil than in sandy soil, most of the pore space in a clay soil will hold water. In contrast, most of the pore space in sand is large so water moves through rapidly rather than being held. Compaction can be a problem in clay soils more so than in sandy soils.

TEXTURE AND SOIL MANAGEMENT

By knowing the texture of a soil and understanding the influences of sand, silt, and clay on the soil, you

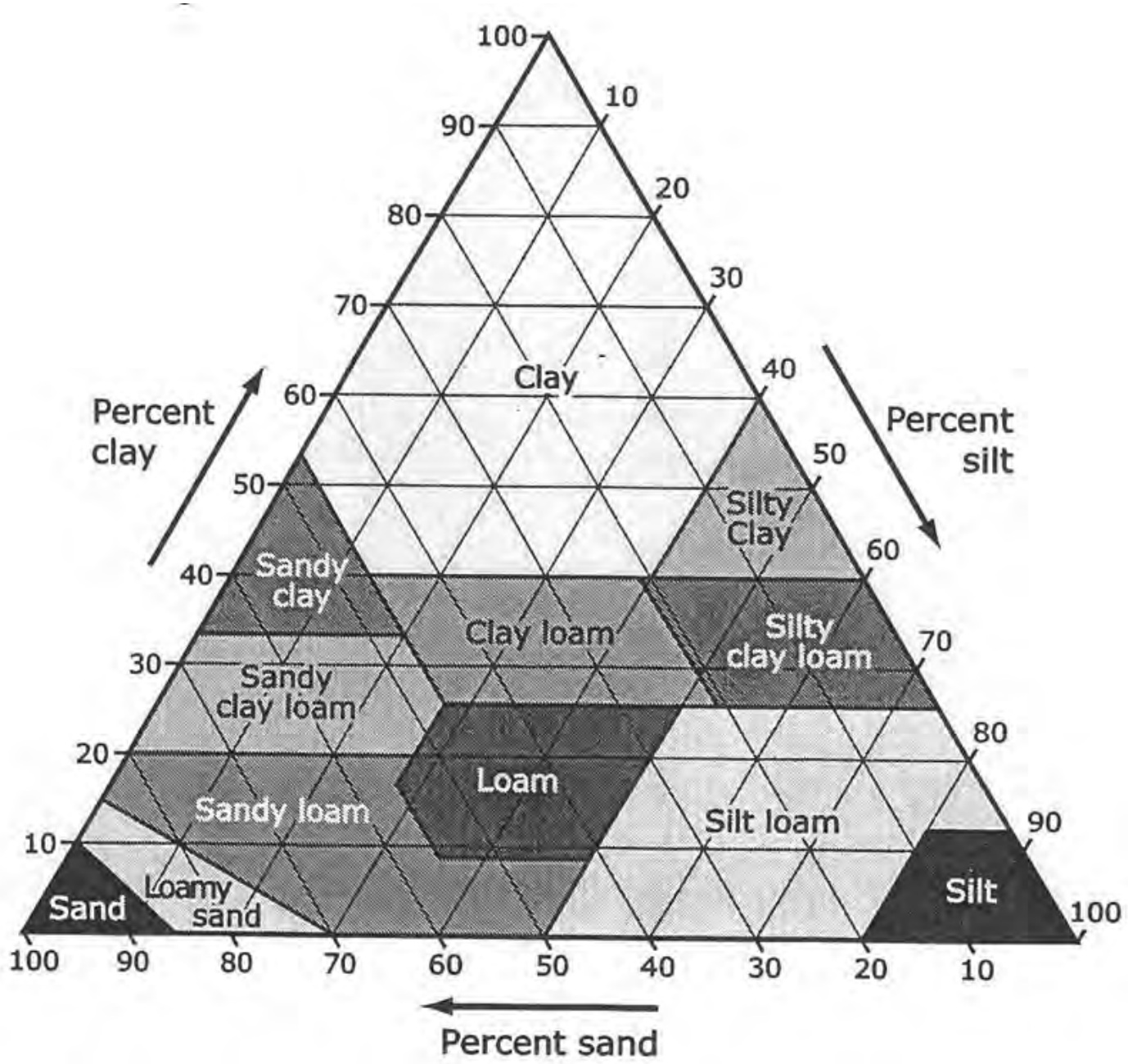


Figure 2. Soil texture triangle.

can make inferences about the management of that soil. Soils with a high sand content will need to be watered more often than soils with a high clay content. Soils with a high clay content have to be watered less often or there is a risk of waterlogging the soil.

A loam does not have equal percentages of the three soil separates (sand, silt, and clay) but is influenced by them equally. A loam has the characteristics of a clay for water- and nutrient-holding capacities, while the sand and silt provide pore space for air and water movement. Notice that a small amount of clay can strongly influence the soil texture class (Figure 2).

SOIL STRUCTURE

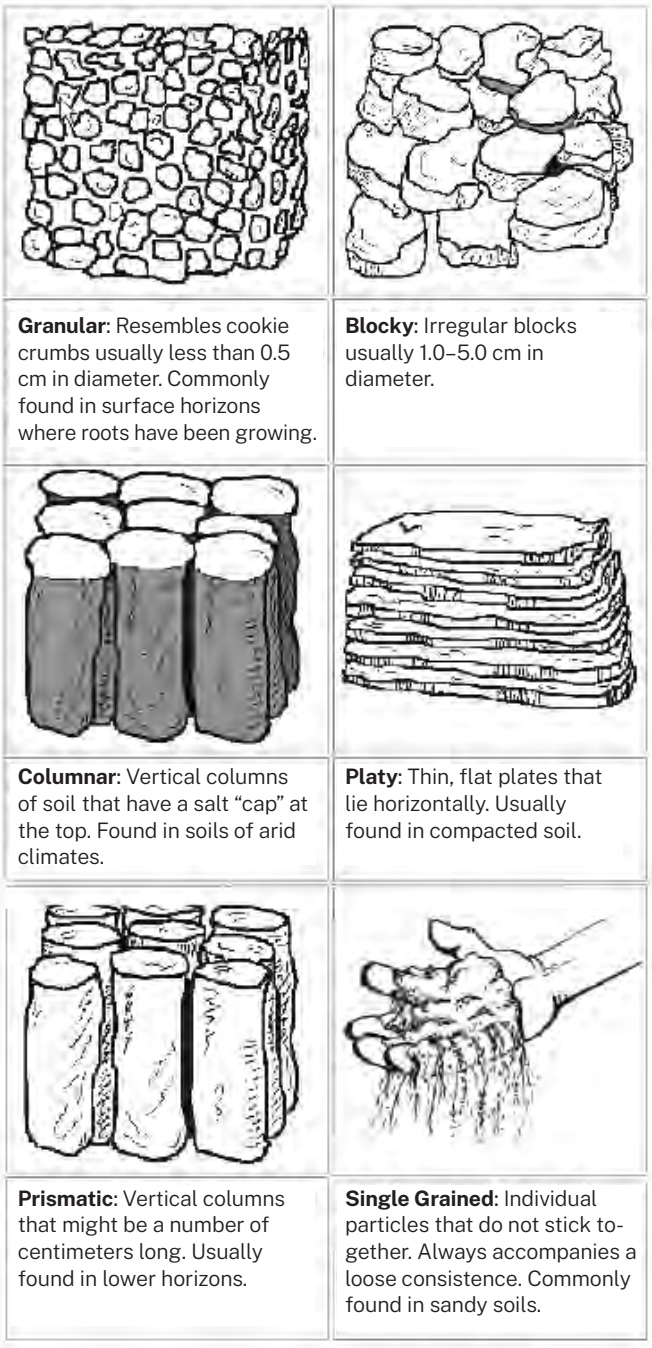
The arrangement of soil particles or aggregates is referred to as soil structure. Soil structure is the aggregation of sand, silt, and clay into shapes with distinct sizes and strengths (Figure 3). Soil structure provides additional pore space and open channels for movement of water, nutrients, air, and plant roots. Soil structure can give an indication of the age of the soil, parent material, vegetation, and land use.

Soils that have organic matter and are properly managed will have good soil structure. If soils are cultivated when they are too wet, they can become very compacted and lose structure until

reaggregation occurs. Plant roots and the addition of organic matter to the soil will help improve soil structure or tilth (soil workability).

Organic Matter

Organic matter in soil is made up of the remains of plants and animals. Residue from previous crops must be broken down to provide soil fertility and structure benefits. Moist and warm soil is ideal for microbes to work at breaking down plant tissue.



Granular: Resembles cookie crumbs usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

Blocky: Irregular blocks usually 1.0–5.0 cm in diameter.

Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.

Platy: Thin, flat plates that lie horizontally. Usually found in compacted soil.

Prismatic: Vertical columns that might be a number of centimeters long. Usually found in lower horizons.

Single Grained: Individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Figure 3. Various types of soil structures.

The organic matter content of a soil is an important factor related to overall productivity for the following reasons:

- Contributes to well-structured soil
- Is a source of three nutrients — nitrogen, phosphorus, and sulfur
- Increases water-holding capacity
- Increases soil aeration
- Provides an energy source for soil microorganisms (plants and animals)

Carbon:Nitrogen (C:N) Ratio

The carbon:nitrogen (C:N) ratio is an important consideration whenever you add organic material to your production system (Table 1). Plant residues and manures are made up largely of the following:

- Sugars, starches, and simple proteins that decompose rapidly
- Crude proteins
- Hemicelluloses
- Celluloses
- Lignin, fats, waxes, etc. that decompose slowly

Their rates of decay and release of nutrients to the soil vary greatly, as do the demands of living soil microorganisms as they "break down" plant residue.

In order to break down the carbon compounds in the plant tissue, microorganisms consume N. If the C:N ratio in the organic material is too high, greater than 25:1, there will be a net loss of N available for plant growth in the short term because the microorganisms will consume any N added with the organic material. However, if the C:N ratio is low, less than 20:1, sufficient N will be available to meet the microorganism's needs with some left over for plant growth. Thus organic material such as straw (C:N = 80:1) added to the soil will need to have N added or the plants will suffer.

Table 1. Carbon:Nitrogen ratio of common organic materials.

Material	C:N
Wheat straw	80:1
Pine needles	90:1
Sawdust	625:1

Soil/Water Relationships

WATER-HOLDING CAPACITY

One of the main functions of soil is to store moisture and supply it to plants between rainfalls or irrigations. Water in the soil is held in pores, the spaces between soil particles. If the soil's water content becomes too low, plants become stressed.

The water-holding capacity of a soil and the amount of water available for plants to use are dependent on the number and size of its pore spaces, which is directly related to soil texture and organic matter content. Water is held by the soil in various ways and not all water in the soil is available to plants (Table 2).

Capillary water is held in pores that are small enough to hold water against gravity but not so tightly that roots cannot absorb it. This water occurs as a film around soil particles and in the pores between them and is the main source of moisture for plants. As this water is withdrawn, the larger pores drain first. The finer the pores, the more resistant they are to removal of water. Capillary water can move in all directions for several feet as the particles and pores of the soil act like a wick.

When soil is saturated, all the pores are full of water and the water that drains out of the soil in the first few hours is called **gravitational water**. Gravitational water is available to plants only for a short time. When the gravitational water is gone, the soil is at **field capacity**. Plants then draw water out of the capillary pores until no more can be withdrawn and the only water left is in the micropores. The soil is then at the **wilting point** and if water is not added to the soil the plants will die.

Table 2. Water-holding capacity of main soil texture groups (inches per foot).

Texture	Field capacity	Wilting point	Available water
Sand	1.3	0.6	0.7
Sandy Loam	2.5	1.3	1.2
Loam	3.6	1.8	1.8
Silt Loam	4.4	2.3	2.1
Clay Loam	4.6	2.6	2.0
Clay	4.7	2.8	1.9

Note: Figures are averages and vary with structure and organic matter.

A soil dominated by large particles (sand) has a lower water-holding capacity than a soil dominated by small particles (clay). Although a soil dominated by fine particles can hold more water, that water is not necessarily available (wilting point) because it takes more energy for plants to remove the water from the tiny pores.

WATER INFILTRATION RATE

Infiltration specifically refers to water movement into the soil from the surface. The rate of infiltration is measured in inches (or cm) per hour. The finer the soil texture (more clay), the slower the infiltration rate and vice versa. The infiltration rate of a soil will determine how much and how often to apply water. The infiltration rate also affects how much rainfall or irrigation water will enter the soil or run off, which relates to erosion hazard.

PERMEABILITY RATE

Permeability specifically refers to water movement within and through the soil profile (after infiltration). The permeability rate is the speed at which water moves in the soil profile and like infiltration is measured in inches (or cm) per hour. Soil compaction, plow layers, hardpans, clay layers, rock, or changes in soil texture all can influence the permeability rate of the soil. When a homeowner seeks a permit to have an on-site septic leach field, a "perc test" is required. This is a test of the permeability rate of the soil. If the rate is too slow then the site is not suitable for a septic leach field.

SOIL COMPACTION

Compacted soils have low water infiltration/ permeability rates. When the soil air spaces are compacted there is less space for air and water. Compacted soils also make root penetration and plant growth more difficult. Compaction can best be avoided by keeping heavy equipment off the soil when it has a high moisture content. Soil compaction can be remedied mechanically with deep tillage equipment.

WATER AND AIR

Under irrigated conditions, regulating the soil water (moisture level) is an important management consideration. Excessive soil moisture or saturated conditions can be as harmful as limited-water conditions. Soil pore space and soil temperature are directly related to soil water content. For

instance, a wet soil takes longer to warm up and will have a greater incidence of fungal and bacterial plant diseases.

Plant roots need oxygen and get it from the air in the soil pore space. When a soil is saturated, water displaces all the air in the pore space. If the wet condition persists, plant roots will die from lack of oxygen.

NUTRIENT LEACHING

Leaching can best be described as the "flushing" of water and soluble nutrients out of the soil profile, specifically, out of the plant root zone. Factors that affect the rate of leaching in soils include:

- Amount of rainfall/irrigation
- Intensity (rate) of rainfall/irrigation
- Soil texture
- Quantity and type of clay minerals present
- Amount of organic matter

SOLUBLE SALTS

Soluble salts are described in terms of soil salinity and are measured by determining the electrical conductivity of a soil extract. Salinity problems can occur where there are excessive applications of fertilizer, fresh manure, wood ash, or irrigation water or in areas with high water evaporation. High soil salinity is detrimental to plant growth.

pH

The term pH refers to the concentration of hydrogen ions (H+) present in the soil. As the concentration of H+ increases, the soil becomes more acidic. As the concentration decreases, the soil becomes more basic (alkaline). The pH scale is 0 (acidic) to 14 (alkaline). A pH of 7 is considered neutral. The pH scale is logarithmic:

- pH 8 — 10 times more alkaline than pH 7
- pH 7 — Neutral
- pH 6 — 10 times more acidic than pH 7
- pH 5 — 100 times more acidic than pH 7
- pH 4 — 1,000 times more acidic than pH 7

Plant species have various adaptations to specific acidic, neutral, or alkaline soil conditions. When plants fail to thrive, even after a fertilizer application, it may be an indication that there is a pH problem.

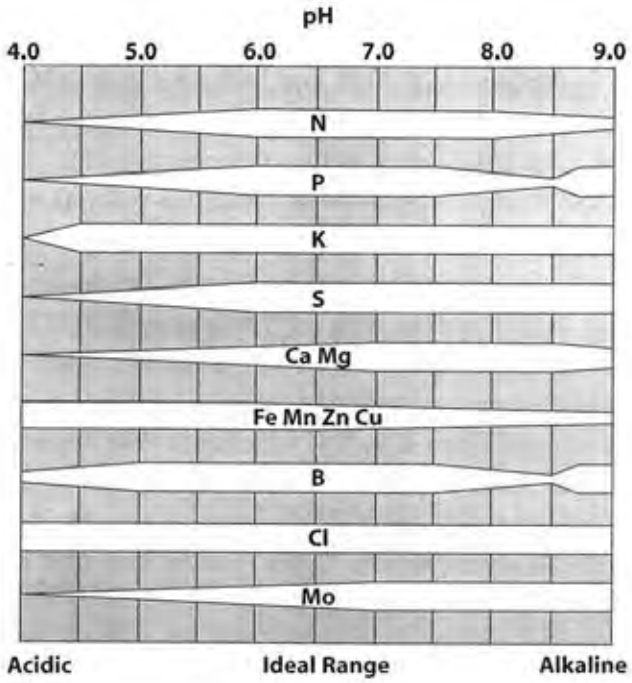


Figure 4. Relative availability of nutrients as affected by soil pH. The bar width for each nutrient indicates its relative availability to plants at a particular pH. The wider the bar, the more available the nutrient.

When pH is too low, applied lime can raise the pH. When pH is too high, applied sulfur can lower the pH. The change will be only temporary, however. Eventually, the soil pH will go back to what it was originally if amendments are not applied regularly. This ability of the soil to chemically revert to the way it was is referred to as buffering capacity. A soil that is high in clay content has a greater buffering capacity and will require a larger quantity of an amendment, such as lime, to change the pH. A sandy soil will require less lime to change the pH.

Soil pH greatly affects the availability of nutrients in the soil for plants to utilize. When pH is too acidic or alkaline then nutrients become unavailable to plants (Figure 4).

Plant Nutrients

ESSENTIAL NUTRIENTS

Plants obtain from the soil 14 of the 17 elements essential to their growth. The other three elements — carbon, hydrogen, and oxygen — come from the water and from the air.

Macronutrients

Large quantities are required. Nitrogen generally is for leaf or vegetative growth, phosphorus is for

root and fruit production, and potassium is for cold hardiness, disease resistance, and general durability.

Primary macronutrients

- Nitrogen (N)
- Phosphorus (P or in fertilizers, designated as phosphate, PO)
- Potassium (K or in fertilizers, designated as potash, K_2O)

Secondary macronutrients

- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

Micronutrients

Small quantities are required. Deficiencies in these nutrients are less common.

- Boron (B)
- Iron (Fe)
- Molybdenum (Mo)
- Chlorine (Cl)
- Copper (Cu)
- Manganese (Mn)
- Zinc (Zn)
- Nickel (Ni)

FUNCTIONS OF MACRONUTRIENTS

Nitrogen (N)

Nitrogen can be taken up by plants as ammonium (NH_4^+) or nitrate (NO_3^-). Nitrogen is essential for the synthesis of proteins. It is essential to chlorophyll, which gives green color to plants; induces rapid vegetative growth; increases yields of leaf, fruit, or seed; improves the quality of leaf crops; increases the protein content of food and feed crops; and feeds soil microorganisms. Nitrogen tends to extend the length of the plant's maturity period, but too much will cause plants to fall over.

Phosphorus (P)

Phosphorus plays an important role in the metabolic processes of the cells such as cell division and expansion, respiration, and photosynthesis. In addition, P is important for early root growth and development. Phosphorus is significant in plant reproductive functions such as reducing the maturity period and stimulating flowering and seed formation. For some species, P improves winter hardiness.

Potassium (K)

Potassium is vital to water relations in the plant. It is responsible for the movement of water in and out of the guard cells that open and close the stomata and the movement of water in and out of the plant leaf. It also serves as a nutrient regulator; increases vigor, strength, and disease resistance; makes stalks and stems stronger; helps early roots form and grow; and improves winter hardiness.

Sulfur (S)

As part of several amino acids, S is essential for protein synthesis. It is also involved in nodule formation and N fixation in legumes.

Calcium (Ca)

Calcium aids in the development of leaves and roots. It is an essential part of the cell wall structure and must be present for the formation of new plant cells.

Magnesium (Mg)

Magnesium is essential for photosynthesis because it is the central atom in the chlorophyll molecule. Magnesium is also involved in phosphate metabolism and plant respiration and serves as an activator for many plant enzymes required in growth processes.

FUNCTIONS OF MICRONUTRIENTS

The content of micronutrients in the soil is variable, as is their availability to plants. Soil pH is a significant factor in micronutrient availability. In very acidic soils, micronutrients can be toxic to plants.

Boron (B)

Boron is probably the most commonly deficient micronutrient. Boron is essential for germination of pollen grains, growth of pollen tubes, and the formation of seeds and cell walls. Boron may also be involved in carbohydrate transport.

Chlorine (Cl)

Chlorine, usually as the chloride ion, is active in the energy reactions of the plant, specifically in the breakdown of water during photosynthesis. Chloride is present in the stomatal guard cells that regulate the loss of water from leaves through transpiration. Chloride has also been linked to increased resistance to fungal diseases in roots.

Copper (Cu)

Copper is necessary for chlorophyll production and may play a part in vitamin A production. Copper is also a component of several plant enzymes.

Iron (Fe)
Iron is a catalyst of chlorophyll formation and acts as a carrier of oxygen. It is also involved in the formation of some respiratory enzymes.

Manganese (Mn)
Manganese is part of the enzyme systems and metabolic reactions of the plant. It is also directly involved in the synthesis of chlorophyll.

Molybdenum (Mo)
Molybdenum is required in the smallest quantity of all the essential nutrients. Plants need it to use N, particularly for N fixation in the root nodules found on legumes.

Nickel (Ni)
Nickel is the most recent nutrient to be added to the essential nutrient family. It is an important component in N metabolism, particularly in the conversion of urea to ammonia.

Zinc (Zn)
Zinc is necessary for the production of chlorophyll and carbohydrates. Zinc is involved in the synthesis of plant growth hormones and in some metabolic reactions.

NOTE: Cobalt (Co) is not considered an essential nutrient, but root-nodule-forming bacteria in legumes need it for fixing N.

GENERAL NUTRIENT DEFICIENCY SYMPTOMS
Nutrient deficiency symptoms are an indication of severe starvation. A nutrient deficiency will limit plant production before deficiency symptoms actually show. Deficiency symptoms are sometimes difficult to distinguish visually and may resemble disease or insect problems.

General nutrient deficiency symptoms are categorized here according to whether or not the nutrient is translocated in the plant. Deficiencies of translocated nutrients exhibit symptoms in the lower or older leaves because the nutrients are mobilized and moved to new, growing parts of the plant.

Translocated Nutrients
Nitrogen. Plants are light green in color; older leaves yellow starting at the leaf tips.

Phosphorus. Plants are small and dark green with purple coloration.

Potassium. Yellow or brown discoloration appears along the outer margins of the older leaves.

Magnesium. Yellow discoloration occurs between the leaf veins. Reddish-purple discoloration extends from the outer edge of the leaf inward.

Nontranslocated Nutrients — Terminal Bud Dies
Calcium. Primary leaf emergence is delayed and terminal buds deteriorate.

Boron. Leaves near the growing point (meristem) are yellow and buds look like white or light brown dead tissue.

Nontranslocated Nutrients — Terminal Bud Remains Alive
Sulfur. The whole leaf turns pale green to yellow starting with the younger leaves.

Zinc. Distinctive yellowing appears between the leaf veins; some plants show a broad band of discoloration on each side of the midrib. The plant is stunted and has short internodes.

Iron. Leaves are pale yellow or white between leaf veins.

Manganese. Leaves are yellowish gray or reddish gray with green veins.

Copper. Young leaves are pale yellow and/or are wilted or withered; seedheads may not form.

Chlorine. Upper leaves wilt then yellow.

Molybdenum. Young leaves wilt and die along the margins; older leaves yellow due to their inhibited ability to utilize N.

Nickel — The Exception
Deficiency symptoms have not been observed in field conditions, only in research settings, but include yellowing of young leaves and the death of meristem tissue.

Mulches
Mulch is any material, organic or inorganic, that is spread upon the surface of the soil to protect it and plant roots from the impact of raindrops, crusting, freezing, and evaporation.

ORGANIC MULCHES
Organic mulches include grass clippings, hay, straw, bark, sawdust, wood shavings, leaves, and

newspapers. You can use almost any plant material for mulching as long as it allows air and water to penetrate to the soil below. Coarse-textured material, such as coarse-textured hay, straw, wood shavings, and chips, are more desirable than fine-textured materials such as leaves, pine needles, and sawdust. When using fine materials, loosen them occasionally to keep them from sealing the soil surface.

INORGANIC MULCHES

Inorganic mulches include plastic films, mat-type weed barriers, aluminum foil, and even old carpet. Although inorganic mulches provide some of the same benefits as organic mulches, they cannot be incorporated into the soil at the end of the growing season and must be removed where you plant annual crops. Perforated plastic film or spun-bound material, such as landscape cloth, allows water and air to easily reach the soil.

SEASONAL MULCHES

A thin layer of mulch will conserve soil moisture and 2 or more inches of mulch will control most weeds. Mulch effectiveness depends upon the material you are using and the weed species to be controlled.

Summer Mulches

Use summer mulches to control weeds, reduce water evaporation from the soil, stabilize water temperature, and reduce fruit rot on bare soil. Incorporate organic summer mulches in the fall to improve soil structure.

Winter Mulches

Use winter mulches to reduce water loss from evergreen plant tissue and to stabilize soil temperatures. Stable soil temperatures will minimize soil heaving caused by alternate freezing and thawing. Winter mulch applied too early in the fall can cause more winter injury than none at all.

PROBLEMS WITH MULCHES

Organic mulches, such as cereal grain straw, can introduce weed seeds. The mulch may attract rodents, insects, and other pests as an overwintering site. Mulching too soon in the spring can prolong cool soil temperatures, which will delay the growth of warm-season crops. Material with a high C:N ratio such as bark, wood shavings, sawdust, or straw may temporarily reduce soil N available to plants unless you incorporate additional N fertilizer into the soil.

Fertilizers

Fertilizer is defined as any substance added to the soil or sprayed on plants as a foliar fertilizer to supply one or more plant nutrients. Every mixed fertilizer or individual material sold has a guaranteed analysis written on the bag. The analysis gives the amounts of available nitrogen (N), available phosphate (P_2O_5), and soluble potash (K_2O), in that order. The three numbers are always percentages by weight. Certain secondary macronutrients and micronutrients may also be included in the analysis.

Many brands and formulas of fertilizer are on the market. Select a brand that supplies N, P_2O_5, and K_2O in approximately the same ratio your soil test indicates. For example, if your test indicates you should use 1 pound of N, 2 pounds of P_2O_5, and 1 pound of K_2O, the ratio indicated is 1-2-1. You could use a 10-20-10, a 5-10-5, a 6-10-4, or an 8-17-7 analysis fertilizer. All of these are in approximate 1-2-1 ratios.

FERTILIZER TERMINOLOGY

- **Mixed fertilizer** — A fertilizer that contains two or more of the macronutrients (N, P, K).
- **Complete fertilizer** — A fertilizer that contains all three macronutrients (N, P, K).
- **Incomplete fertilizer** — A fertilizer that is missing one or more of the major components found in a complete fertilizer.
- **Grade** — The guaranteed minimum analysis in percent of plant nutrients in a fertilizer expressed as total N, available P_2O_5, and soluble K_2O.
- **Chelates** — The word chelate comes from the Greek word for "claw." Chelates are organic substances or chemicals that act like claws and help hold metal ions in solution in an available form so that plants can absorb them. The solubility of metals, particularly Cu, Fe, Mn, and Zn, is greatly increased when they are held by chelating agents.
- **Soil amendment** — A substance added to the soil to change its pH or physical properties. A common example is the use of lime to increase soil pH.

NUTRIENT SOURCES AND FERTILIZER TYPES

Common nutrient sources and contents of fertilizers appear in Table 3.

Table 3. Common sources and nutrient contents of fertilizers.

Nutrient and source	Nutrient content of fertilizer (% by weight)
Nitrogen (N)	
Anhydrous ammonia (gas)	82
Ammonium nitrate	33–34
Ammonium sulfate (24% sulfur)	21
Urea	46
Urea-ammonium nitrate solution (UAN)	28–32
Sulfur-coated urea (slow release)	39
Monoammonium phosphate (MAP)	10–11
Diammonium phosphate (DAP)	18
Potassium nitrate	13
Calcium nitrate	15
Phosphorus (P_2O_5)[1]	
Normal or single superphospate (NSP or SSP)	20
Concentrated (CSP) or triple superphosphate (TSP)	46
Monoammonium phosphate (MAP)	48–55
Diammonium phosphate (DAP)	46
Ammonium polyphosphates (APP)	40–70
Potassium (K_2O)[2]	
Potassium chloride	60–62
Potassium sulfate (SOP)	50
Potassium nitrate	44
Sulfate of potash-magnesia (Sul-Po-Mag or K-Mag)	22
Calcium (Ca)	
Calcitic limestone	32
Dolomitic limestone	22
Gypsum	22
Burned lime	60
Magnesium (Mg)	
Dolomitic limestone	3–12
Magnesium oxide (magnesia)	55–60
Magnesium sulfate	9–20
Potassium-magnesium sulfate	11

Nutrient and source	Nutrient content of fertilizer (% by weight)
Sulfer (S)[3]	
Ammonium sulfate	24
Potassium sulfate	18
Gypsum	12–18
Magnesium sulfate	14
Boron	
Borax	11
Boric acid	17
Chlorine (Cl)	
Potassium chloride	47
Copper (Cu)	
Copper sulfate	22
Copper ammonium phosphate	30
Iron (Fe)	
Iron sulfate	19–23
Iron chelate	5–14
Manganese (Mn)	
Manganese sulfate	26–28
Manganese chelate	12
Molybdenum (Mo)	
Ammonium molybdate	54
Molybdic acid	47
Nickel (Ni)	
NA	
Zinc (Zn)	
Zinc sulfate	23–36
Zinc chelate	9–14

[1] Rock phosphate is the basic material used in all P fertilizer production. Phosphate for use in fertilizers is either acid treated or thermal processed. Acid treatment is the most important and utilizes sulfuric and phosphoric acids.

[2] Elemental K is not found in nature due to its chemical reactivity. Potash (K_2O) is the primary source of potassium for fertilizer use. Potash is found beneath the surface in salt beds or in the brine of salt lakes and seas. Many minerals contain potassium, but the most important are sylvinite (20%–30% K_2O) and langbeinite (23% K_2O).

[3] The primary source of S is soil organic matter.

FERTILIZER APPLICATION AND TIMING

Fertilizer Timing

The timing of fertilizer application depends somewhat on the type of fertilizer and the plant being fertilized. In addition, soil texture determines application frequency and the amounts to apply. For soils with high sand content, the recommended fertilizer application may need to be divided into smaller quantities applied more frequently. The opposite is true for soils with high clay content.

As a general rule, the best time to apply any nutrient is close to the time the plant is growing the most and thus needs the nutrients. This prevents environmental losses and the nutrient's becoming unavailable in the soil before the plants can use it. It is best to apply foliar fertilizers when the weather is cool, but not cold, and when there is adequate soil moisture.

Phosphorus, K, and lime can be applied in the fall or as part of a tillage operation. It is important to apply N early in the spring during the active growth period. If your plants need a lot of N, it is best not to apply it all at once but rather to split the application into smaller amounts at two or three intervals. Some forms of N are very soluble and do not stay in the rooting zone very long. As a general rule, apply no more than 50–75 lb/acre of N in one application. Plants are more likely to utilize N applied in smaller amounts more frequently and our groundwater and streams will be protected from nitrate pollution.

Fertilizer Application

There are several methods for applying fertilizers. The most common is to broadcast granular formulations on the surface or till them into the seedbed. Another method is banding — placing the fertilizer below the surface in a band below or beside a seed at planting time. Some fertilizers can be applied through an irrigation system. Fertilizers can also be applied in liquid or powder form. Micronutrients are usually most effectively applied as foliar sprays.

Salt Accumulation and Soil Leaching

Fertilizer is more likely to burn a plant in hot, dry conditions when the plant is stressed. If there is insufficient moisture after fertilizer application, then the salt concentration can increase, making it even harder for plants to take up water. Adequate water will help prevent high salt accumulations.

Potted plants should be leached every 4–6 months and garden soils at least once a year. Leach the soil by saturating it with water and letting it drain completely. A rule of thumb is to apply water in an amount that is double the volume of the pot. For instance, a 6-inch pot will hold about 10 cups of water, so use 20 cups of water to leach out accumulated salts. Different plants have different levels of tolerance for salt accumulation.

GREEN MANURE AND COVER CROPS

By definition, green manure crops are grown and incorporated into the soil to improve the latter. Cover crops are grown primarily to reduce soil erosion and nutrient leaching.

Usually, green manure crops are annuals and cover crops are perennials, either legumes or grasses. Cover crops can be incorporated into the soil and used as green manure crops.

When managed properly, both green manure and cover crops add N to the soil for use by the crops planted later. They tend to increase the level of soil fertility and soil humus. They improve the soil's physical properties of aggregation, porosity, bulk density, and permeability. Their effects are more pronounced in clay soil than in sandy soil.

Green Manure

The benefit of using green manure crops depends on the soil, climate, and species of plants grown. Environmental conditions that affect microbial growth determine the rate of decay of organic residues. Warm soil, proper aeration, and ample soil moisture increase microbial activity, thereby increasing the rate of decomposition of organic matter. Decomposition releases carbon dioxide and weak acids that help release nutrients. The chemical composition of the plants affects their value as a green manure crop.

Green manure crops have little influence on soil organic matter content if cultivation is continuous. In cooler climates, green manure crops can increase soil organic matter and N. In warmer climates, cultivation speeds up the rate of decomposition so an increase in soil organic matter content is difficult to achieve. Using green manure crops can improve soil structure, which enhances aggregation and increases the space between soil particles.

Any fast-growing annual crop is a good choice for a green manure crop, such as ryegrass, wheat,

barley, vetch, or field peas. A legume is a great choice because of its ability to fix N. Green manure crops should be seeded immediately following the harvest of the main crop and not allowed to go to seed. Incorporate them at least 2 weeks before planting the next crop. As grasses and cereal grains reach maturity they can tie up N, so they should be incorporated into the soil early in the growing season.

Cover Crops

Use cover crops for alleyways in orchards and vineyards to prevent weed growth and in gardens for pathways. Cover crops may require some maintenance such as mowing and fertilization. Cover crops are good for fall gardens in-between the rows and in any other cleared areas.

Cover crops provide organic matter and store nutrients, which helps reduce nutrient losses from the soil profile by leaching of N, K, and other nutrients. Legumes add N to the soil and reduce erosion because they are deep rooted. Leaching is more of a problem on soils with high sand content.

A good ground cover reduces soil erosion by reducing raindrop impact on soil particles. Plant cover increases the water infiltration rate and minimizes water runoff. Leaves and stems "catch" the rain and roots create channels for water movement in the soil.

Negative aspects of cover crops include competing with the main crop for nutrients and moisture and encroaching on the main crop. Cover crops may also provide a safe haven for gophers, mice, insects, and diseases that can attack the main crop.

ORGANIC FERTILIZERS

Research has found no difference in the nutrient contents of organic food and regularly produced food. However, organic foods are less likely to have chemical residues. As far as the plant is concerned, it does not matter if nutrients are supplied by decaying plant material or from commercial fertilizers: N is N is N. Plants are self-contained biochemical factories. All they need are raw materials (nutrients).

Generally, organic fertilizers release nutrients slowly. Organic fertilizers depend on microorganisms to break them down in order to release their nutrients. Therefore, most are effective only when soil moisture and temperature are suitable for microorganisms to be active. Some examples of organic fertilizer sources are listed below:

- **Cottonseed meal** — Approximate analysis: 7-3-2. It can be somewhat acidic so it is often used to fertilize acid-loving plants.
- **Blood meal** — Dried, powdered blood collected from slaughterhouses is a rich source of N and may contribute some trace elements, including iron. Issues associated with animal by-products used in food sources may be a concern.
- **Fish emulsion** — A partially decomposed blend of finely pulverized fish, it is high in N, a source of some trace elements, and has a strong odor.
- **Manure** — Nutrient content is generally low and varies with animal source and feed. Manures are best used as soil conditioners rather than as sources of nutrients. Fresh manure can damage young plant material due to its high mineral salt content if irrigation is not managed properly.
- **Sewage sludge** — A by-product of municipal sewage treatment plants, it generally comes in two forms, activated and composted. Activated sludge has a higher nutrient content (approximately 6-3-0) than composted sludge (approximately 1-2-0). There is some concern that long-term use could lead to the buildup of certain heavy metals. Another concern focuses on its use in a garden around edible plants. The origin of the sludge determines its nutrient and heavy metal contents. A sludge-based nutrient source should be analyzed for heavy metals before use.

Further Reading and Resources

BOOKS

Havlin, J. L., J. D. Beaton, S. L. Tisdale, and W. L. Nelson. 1999. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management*. 6th ed. Englewood Cliffs, NJ: Prentice Hall.

Minnich, J., and M. Hunt. 1979. *Rodale Guide to Composting*. Emmanus, PA: Rodale Press.

Soil Improvement Committee, California Fertilizer Association. 1997. *Western Fertilizer Handbook: Second Horticulture Edition*. Prentice Hall.

BOOKLETS AND PAMPHLETS

BUL 915 *Soil Testing to Guide Fertilizer Management*

CIS 787 *Liming Materials*

CIS 815 *Northern Idaho Fertilizer Guide: Blueberries, Raspberries, and Strawberries*

CIS 853 *North Idaho Fertilizer Guide: Grass Pastures*

CIS 863 *Fertilizer Primer*

CIS 911 *Northern Idaho Fertilizer Guide: Northern Idaho Lawns*

VIDEOS

How Water Moves through Soil. University of Arizona. Available for checkout from the Benewah County Extension Office, St. Maries, ID.

Soil Monolith Collecting and Preserving. 1987. Available from the UI Soil and Land Resources Division, College of Agricultural and Life Sciences, Moscow, ID.

WEBSITES

Idaho State Department of Agriculture. **https://agri.idaho.gov/main/**.

Natural Resources Conservation Service. Published Soil Surveys for Idaho. **https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx**.

Smithsonian Environmental Research Center. "Dig It! The Secrets of Soil." **https://forces.si.edu/soils/**.

University of Idaho. Idaho Master Gardener Program. **https://www.uidaho.edu/extension/master-gardener**.

University of Idaho Pedology Laboratory. **https://www.uidaho.edu/cals/soil-and-water-systems/research/pedology-laboratory**.

INSTRUCTOR RESOURCES

Soil Texture Kits. Nine 2-lb texture samples can be purchased from the UI Soil Evaluation Team, Moscow, ID, (208) 885-7554. ($75.00)

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CHAPTER **SIX**

HORTICULTURAL EQUIPMENT MANAGEMENT

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6 HORTICULTURAL EQUIPMENT MANAGEMENT

Learning Objectives

- Learn about the different types of equipment used in horticulture
- Learn how to select, purchase, and care for equipment
- Learn the basic practices of soil cultivation

Equipment Selection

The type of equipment used to prepare your garden will depend on the size of the garden, as well as your physical ability, time, and budget. Options include a spade or shovel, a power rotary tiller, a small garden tractor, or a full-sized farm tractor.

HAND TOOLS FOR CULTIVATION

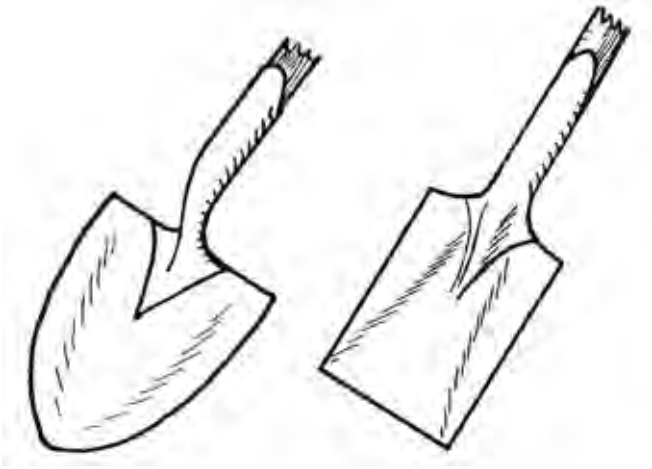
The minimum equipment needed by most gardeners is a shovel or spade, a hoe, a rake, and a trowel. A wide selection of styles is available. The right choice is one of personal preference and price. You can get the best value by knowing each tool's uses and particular qualities.

Shovel

A dish-shaped blade mounted to the handle at an angle and is used for moving soil. A garden shovel with a pointed blade is lighter and smaller than most other shovels and is well suited for use in the garden.

Spade

A flat blade and designed for cutting rather than lifting or moving soil. A spade is an excellent tool for shaping straight-sided trenches and edging beds.



SHOVEL SPADE

NOTE

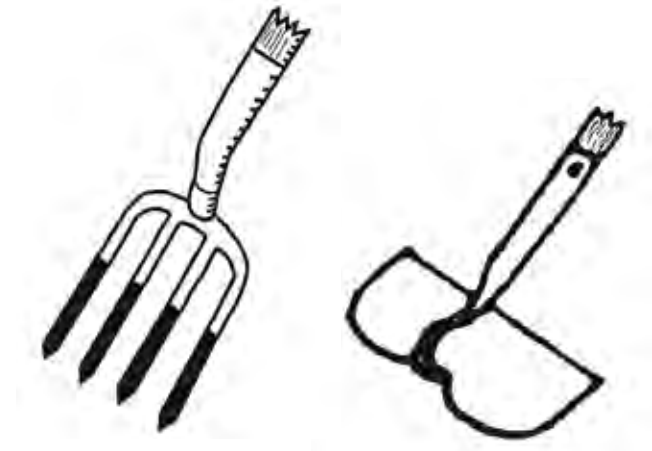
Shovels and spades come with long handles in standard or D-shaped styles. Choice of handle style will depend on personal preference: long handles offer greater leverage and are less tiring to use; short handles are often thicker and stronger. For general-purpose digging, lifting, and moving, a long-handled shovel is ideal.

Spading Fork

Another useful digging tool. It is ideal for breaking and turning heavy soil and for loosening subsoil layers when double digging a bed. Turning coarse compost, spreading mulches, and digging root crops are other jobs suitable for a spading fork.

Hoe

Essential in any garden for preparing the seedbed, removing weeds, and breaking up encrusted soil. Several different hoe styles are available.



SPADING FORK HOE

Pointed Hoe

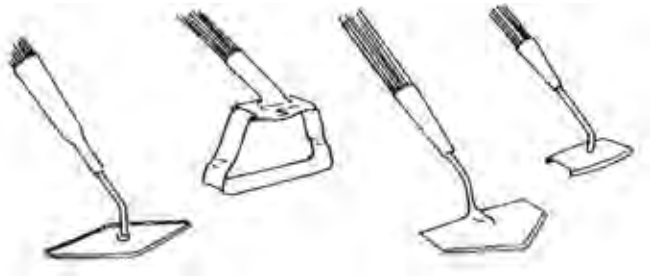
Has a heart-shaped blade and is lightweight and useful for opening seed furrows and cultivating between plants.

Hula

Also known as an action hoe, a hula is very lightweight and maneuverable. You push and pull it just under the soil surface. Because the blade is relatively thin and lacks the clod-breaking capabilities of a heavier hoe, this type of hoe is most easily used where soil is not compacted and where weeds have not gotten started.

Scuffle Hoe

Somewhat more sturdy, this hoe is used with a pushing motion rather than a pushing and pulling motion.



DIFFERENT KINDS OF SCUFFLE HOES

Square-Bladed Hoe

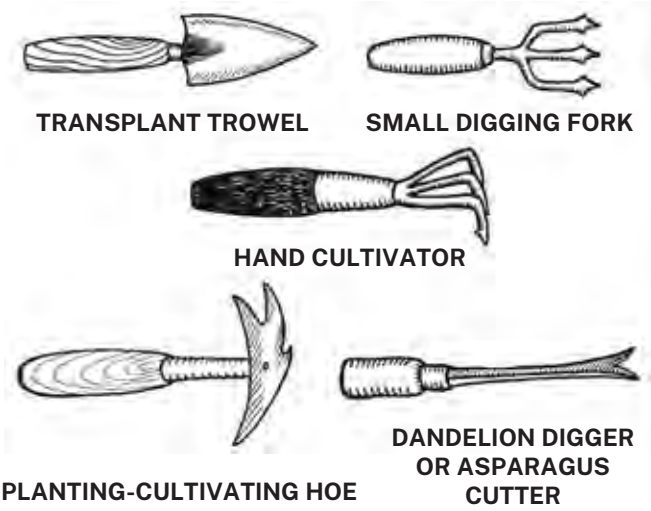
Probably the most commonly used hoe, lends itself well to many garden tasks.

Rake

Useful in clearing the garden of rocks and debris. It is also helpful in spreading mulches and smoothing seedbeds. The right rake depends on your size and strength and the uses you intend. As the number of tines increases, the rake weight also increases. Avoid choosing a rake that is so heavy it will tire you after a short period of use. The length of the rake handle is important too. The tip of the handle should come up to your ear when you stand upright. A handle that is too short will make your work harder, causing excess bending and back strain.

Trowel

Used for many digging jobs that do not require a full-sized tool. Especially in the spring, a trowel is perfect for transplanting seedlings and bulbs or digging shallow-rooted weeds.



TRANSPLANT TROWEL

SMALL DIGGING FORK

HAND CULTIVATOR

PLANTING-CULTIVATING HOE

DANDELION DIGGER OR ASPARAGUS CUTTER

Small Hand Cultivator

Often sold in sets with trowels, it is useful for weeding small areas and between closely spaced plants.

Digger

Also called a weeder, cultivator, or asparagus knife, a digger is a small, useful digging tool. It is indispensable for digging up weeds with long taproots, such as dandelions or Queen Anne's lace; or for prying out Johnson grass rhizomes. It consists of a 10–14-inch long solid metal rod with a two-pronged blade at one end and a handle at the other. This tool is practically indestructible and well worth its price.

Pickax

Used to break up extremely stony or hard-packed soil.

Mattock

Used to break up soil, but is equipped with a cutting blade for removing large roots. A mattock may also be used to chop up debris for composting.

Wheel Cultivator

Has a number of attachments for soil preparation and weed control and may prove to be a good investment for those with larger gardens.

POWER TOOLS FOR CULTIVATION

Rototiller

The power rotary tiller is the tool most commonly purchased by gardeners. Whether you need a rototiller depends on the size of your garden, your capabilities, and the intended uses of the tiller. Tiller selection may be based on the nature of the work to be done, the quality of the machine, ease of repair, and personal preference.

The tiller's engine powers rotating blades or tines, which turn the soil and make it loose, fluffy, and ready for planting. It can also chop plant debris and mix it into the soil. The ability of the tiller to do these jobs effectively is a function of its weight, strength, design, type of tines, and type of soil.

A heavy, powerful tiller is most effective on stony clay soils, while a smaller tiller is more appropriate in a small garden or a garden with light soil. Very lightweight tillers, known as soil blenders, are designed mainly for raised bed gardening; however, they are not widely available and generally must be mail-ordered. A tiller is a major investment.

Look for tiller features such as: heavy cast iron, steel plate, and tubing; heavy bearings; strong welds used during construction; and easily operable controls. Ask to look at the operator's manual and try to determine how simply a tune-up can be performed. You can save yourself a great deal of trouble and money if you can replace plugs and points yourself. Also consider the locations of service centers and parts dealers. Careful attention to your needs, abilities, and price range is important.

Talk to people who have the types of tillers that interest you. If possible, borrow or rent various types of tillers and send for information before buying. If you are considering the purchase of a used rototiller, plan to do so well ahead of time so you will not be rushed into a purchase. If you know little about tillers, have a mechanically minded friend evaluate the models you are considering.

ROTOTILLER

Above all, test each tiller for ease of starting and operation. An engine that smokes or runs roughly may require a lot of work. Tines should operate smoothly and freely. Check the welds in the handles to see that they are strong; rewelding may mean that the handles have broken at some time, a common problem in older tillers. Look at the dipstick if there is one; low oil or very sludgy oil may mean that the tiller has been poorly maintained. The oil and other fluids may also be checked by opening the drain plugs. Look for excessive dirt around the engine or in the air filter. This may also indicate bad maintenance habits.

Rear-Tine Tiller

If gardening is a full-time business or if you have a large garden, it would be wise to purchase a rear-tine tiller. It should be a heavy-duty machine capable of continued operation. The rear-tine tiller is easier to control and is smoother in its cultivating process. It requires less maintenance because it doesn't bounce around; leverage is required for control. New gardeners are sometimes scared away from these tillers because they can run away from them.

Front-Tine Tiller

If gardening is simply a hobby or if your garden is small, a front-tine tiller may be suitable. Front-tine tillers are usually light in weight, but may require considerable strength to guide them through the soil. Operating this type of tiller is comparable to handling a large floor polisher such as those used in schools and hospitals. Leverage is required for control. New gardeners are sometimes afraid that these tillers will run away from them. The front-tine tiller may not make as straight a path as the heavier rear-tine type, but it is much easier to turn. The front-tine tiller is easy to use in small gardens and in corner areas.

Cordless Tools

Most are rechargeable, come with various cultivating attachments, and can make garden chores more pleasurable. Cordless tools are especially useful to those with physical disabilities that limit strength.

Garden Shredder

This tool is helpful for a large garden with a lot of plant wastes. Hand-operated shredders are slow but useful if wastes are in small quantities and are not too coarse. Gasoline shredders are quite expensive and may be disappointing to the gardener who wants to chip branches and other large materials. Shredders are best used for shredding leaves, small branches, and other plant wastes. A chipper, however, will chip large branches and other coarse materials, but the cost ($1,000) is high.

WHEELBARROW OR CART

A wheelbarrow or cart is handy to have in and around the garden area. It should be easy to handle when full. Durable construction is well worth the cost to ensure a long, useful life. Be sure to choose the size appropriate for your physical abilities and garden needs.

A wheelbarrow generally requires more strength and control than do most garden carts, but many of the small carts generally available are made of relatively flimsy metal and, though inexpensive, are not particularly long-lasting or suitable for heavy items such as rocks.

Consider your needs. If you plan to haul only light straw, leaves, or sawdust, then a small cart is suitable. For heavier jobs, a wheelbarrow or cart is needed.

The newer garden-cart models, especially ones with bicycle-type tires, are made of heavy plywood and metal and are well balanced and easy to maneuver.

NOTE

These carts do, however, cost a lot (up to several hundred dollars) and require a large storage space. Only serious gardeners or those with other uses for these carts find them economical. One alternative is to build your own from one of several plans available from gardening magazines or private companies.

WATERING EQUIPMENT

Watering is one job that most gardeners must do at least occasionally. An adequate water supply may make a big difference in garden yields. Purchase of watering equipment depends upon available facilities, water supply, climate, and garden practices. Determine whether cultural practices such as mulching, close plant spacing, shading, or wide-bed planting will meet most of your extra water needs, then purchase watering gadgets accordingly.

Spigot

If there is no outdoor spigot near the garden, the expense of having one installed may be greater than the benefits gained, except in very drought-

prone areas or in the case of a gardener who is fully dependent on the season's produce.

Rain Barrel or Garden Hose with a Fan-Type Sprinkler

This simple watering equipment will suffice where rainfall is adequate, except occasionally in summer.

Water Breaker

Useful for small seedlings.

Drip Irrigation System

In areas where there are extended periods of hot weather without precipitation, the local water supply is likely to be short. Since overhead sprinklers waste water, a drip irrigation system may be in order. Drip irrigation puts water right at the roots and doesn't wet plant leaves, thus helping to prevent disease. Timers are available for automatic-drip watering systems, but this type of system is relatively expensive and may be considered a nuisance by some gardeners because of maintenance and replacement requirements.

The Soaker Hose

Probably the least expensive and easiest water system to use. Its fibrous hose allows water to seep out at a slow rate all along its length. There are also hoses with holes in them that do basically the same thing. A flow regulator usually has to be included with the system so that water can reach the end of the hose, yet not be sprayed out at full force. A special double-wall-type irrigation hose has been developed that helps to maintain an even flow.

Emitter-Type System

Best used for small raised bed or container gardens. With this system, short tubes or emitters come off a main water-supply hose. Emitters put water right at the roots of the desired plants. This is generally the most expensive form of irrigation and the most complex to set up.

SEEDLING AND PLANTING TOOLS

Depending on the size of your garden and your physical abilities, you may want to consider a row seeder.

Seeders

Its wheels make easy work of sowing long rows of corn, beans, or other vegetables. Seeders are available that make a furrow, drop the seeds properly spaced, and close up the furrow. It is not worth the effort to set up a seeder for small areas. A handheld seeder is probably a better choice for this type of work.

Broadcast Seeders

Available for sowing seeds such as rye or wheat for cover crop, but are generally not necessary for the average home gardener because broadcasting is easily done by hand once you learn the proper technique.

Fluid-Sowing Kits

Contain presprouted seeds in a gel that prevents drying. These kits may be purchased, but fluid sowing devices may be made inexpensively.

ENVIRONMENTAL MONITORING EQUIPMENT

Serious gardeners often invest in equipment that allows them to monitor the microclimate around the garden or indoors.

Rain Gauge

An inexpensive device that helps you determine if enough rain has fallen for garden plants.

Maximum-Minimum Thermometer

A costly but often useful device to measure soil temperature and the internal temperature of a compost pile.

Light and Watering Meters

Can be purchased for indoor plant monitoring. Electronic water meters measure the conductivity of soil, but are often greatly influenced by fertilizers and other salt concentrations, resulting in a variable or inaccurate measurement of water availability. Tensiometers work well for measuring water content.

TRELLISES AND CAGES

For vining plants, these save space and keep fruits off the ground, reducing plant damage and minimizing the amount of stooping required for harvest. Look for heavy-duty materials and sturdy designs that will stand up to rain, wind, and drying. Wire should be heavy gauge and wood should be treated with nonphytotoxic (nontoxic to plants) materials or materials nontoxic to humans. Metal parts should be rust-proof or rust-resistant. If you build your own trellises and cages, you may save a considerable amount of money and get better quality.

HARVESTING EQUIPMENT

Varies depending on the size and type of garden, whether food is to be stored, and the way in which it is to be processed.

Baskets

Useful to most gardeners. Baskets may be purchased at garden or farm supply stores or sometimes may be scrounged from local grocery stores or fruit stands. Berry baskets for carrying small fruits, baskets with handles for carrying vegetables, and peck or bushel baskets for storing fruits and vegetables are all useful.

Fruit Pole Pickers

Useful and easy to use for tall fruit trees.

A Sharp Knife

Cutting vegetables off plants is handy and helps prevent plant damage.

Equipment Purchases and Maintenance

EQUIPMENT PURCHASES

When purchasing tools, buy for quality rather than quantity. Your tools will be in frequent use throughout the garden season. Cheap tools tend to break or dull easily and may end up making your job unnecessarily difficult and frustrating. Quality tools will last and tend to increase in value if well kept.

Tools should be lightweight for easy handling, but heavy enough to do the job properly. Metal parts should be of steel, which will stay sharp, will keep their shape, and will outlast softer metals. Consumer magazines and garden publications frequently have articles explaining what to look for in tools and listing alternatives to local hardware stores, which often carry a single line of tools. Several excellent books featuring garden tools have been published and may be available at the library.

EQUIPMENT MAINTENANCE

Keeping a tool clean and sharp will increase its usefulness and lengthen its life. Learn the techniques of sharpening each tool and practice them frequently. Professional gardeners often carry sharpening stones or files and sharpen their tools every hour or so while working.

Clean tools after each use. One effective method is to keep a five-gallon bucket filled with sand and used motor oil in the toolshed. At the end of the gardening day, remove clinging dirt from tools by plunging them into the oily sand several times. This will keep the tools cleaned and oiled and will help prevent rusting.

Perhaps the most important step in tool care is to put tools in their proper place. Tools left in the garden will rust and break and can be a safety hazard. Some gardeners paint handles with a bright color to make their tools easy to spot.

Cultivation Practices

TYPES OF SOIL CULTIVATION

Plowing

It once was assumed that gardens should be turned yearly with a moldboard plow, mostly for weed and pest control. While garden plowing is still a common practice, turning the soil over completely has been found to be detrimental in some cases. It can cause soil compaction, upset balances of microorganisms, and bury layers of coarse organic material below the influence of insects and microbes, which would otherwise cause the materials to decompose.

Chisel Plowing

This is an alternative that does not have a disruptive effect, but its use is limited to sandy or loamy soils. Many gardeners do not have chisel plows. In addition, gardeners in nonrural areas have trouble finding a person who will plow and disk a garden for a reasonable price.

Rototilling

Most home gardens' soil condition is sufficient, as long as plant debris is not excessive. Rotary tilling mixes rather than turns the upper layers of soil. One possible harmful effect of rototilling is the formation of a compaction layer just beyond the reach of the tines. Use of deep-rooted cover crops or double digging can help prevent or alleviate this problem.

Hand Cultivation

Spading the soil deeply until it is loose and drains easily prepares the soil.

CULTIVATION TIME

Fall tillage has several advantages over the traditional spring plowing. It allows earlier spring planting, since the basic soil preparation is already done when spring arrives. Turning under large amounts of organic matter in the fall is likely to

result in better decomposition because autumn temperatures are higher than those in early spring and the process has more time to take place. Insects, disease organisms, and perennial weeds may be reduced by killing or inactivating them through burial or exposure to harsh winter weather. The physical condition of heavy clay soils may be improved by the alternate freezing and thawing, which break up hard clods. Fall tilling alone is not recommended for hillside or steep garden plots since the soil is exposed all winter and is subject to erosion when spring rains come.

If a winter cover crop is grown to improve soil and to prevent erosion, the ground will have to be tilled in the fall to prepare the soil for seed and again in the spring to turn under the green manure. A cover crop decreases erosion of the soil during the winter, adds organic material when it is incorporated in the spring, improves soil tilth and porosity, and adds valuable nutrients.

Spring tillage is better for sandy soils and those receiving shallow tilling. Generally, most gardens must be disked or rotary tilled in the spring to smooth the soil for planting.

CULTIVATION REQUIREMENTS

Work the soil only when the conditions are right. Pick up a handful of soil and squeeze it. If the soil crumbles freely, it should be about right. Take samples at the surface and at a 2–3-inch depth at several locations in the garden plot. If the soil is powdery or in clumps, it may be excessively dry and difficult to work. If soil sticks to a shovel or if the turned surface is shiny and smooth when spaded, it is still too wet. Working soil when it is excessively wet can destroy soil structure, which may take years to rebuild. Plowing with a tractor when soil is wet is especially damaging. It causes the formation of a compaction layer that will inhibit root growth. Soils with adequate humus levels generally make cultivation easier because of their improved structural qualities.

Just before planting, break up large clods of soil and rake the bed level. Small-seeded vegetables germinate best in smooth, fine-surfaced soil. Do not pulverize seedbed soil. This destroys the structure and promotes crusting and erosion problems.

Any addition to the soil that improves its physical or chemical condition is considered a soil amendment. Many types of amendments are available to the home gardener.

Further Reading

UNIVERSITY OF IDAHO EXTENSION

CIS 1054 *Low Input Landscaping*

CIS 1065 *Improving Sprayer Accuracy: Simple Methods for Correct Calibration*

Chapter 6 published 1996.

CHAPTER **SEVEN**

PLANT MANAGEMENT:
CHOOSING, PLANTING, AND MAINTAINING PLANTS

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7 PLANT MANAGEMENT

Learning Objectives

- Learn the basics for choosing, planting, and maintaining plants
- Understand the effect that light, climate, heat stress, and the growing season have on plants
- Learn how to avoid weeds and poisonous plants
- Learn about the different types of plants and how to plant them
- Learn the correct practices for fertilization and irrigation

Introduction

Creating a productive and beautiful garden requires care at several stages. It is important to choose plants that will thrive in your climate, soil, and light conditions. Proper planting procedures are key to ensuring successful plant establishment. From the time of planting through maturity, the plant's water needs must be met through proper irrigation. This chapter discusses each of these topics.

Plant Selection

When choosing a plant, consider both the limitations of the site and the intended purpose of the plant. Maintenance issues and plant-disease problems often result from selecting the wrong plant for a location.

Begin by analyzing the site. A plant needs adequate space both above- and below-ground. Your garden must be in an appropriate climate zone (both for winter hardiness and summer heat) and the soil must have adequate structure, depth, drainage, pH, and fertility. Choosing a plant that has some resistance to diseases or pests prevalent in the area might also be beneficial.

To determine the best location for a plant, read the plant tag or seed packet. You can also research the plant online or in a garden book. These resources are useful for de-

termining the winter hardiness and heat zones, light exposure, and water required by a plant. Choosing a plant whose requirements match your site will help ensure a healthier plant for years to come and will decrease maintenance, chemical, and labor costs.

LIGHT REQUIREMENT

Light requirements differ among plants. Plants described as requiring full sun typically need at least 6–10 hours of direct sun per day. Plants adapted to partial sun/partial shade need 3–4 hours of direct sun. Shade-loving plants do best where they receive less than 2 hours of direct sun in early morning or where sun is filtered through a tree canopy.

Light intensity may vary across your yard. The south and west sides of a house receive more intense light (and are warmer) than the east or north sides. For this reason, the south or west sides are generally good locations for a vegetable garden or pollinator flower garden. The north and east sides of a house offer more shade and moisture for shade-loving plants such as hostas. By locating plants in sites with proper light exposure, you can avoid the frustration of having to replace those that died from too much sun or shade.

CLIMATE

Winter Hardiness

The United States Department of Agriculture's (USDA) plant hardiness zone map will help you determine which perennial plants will winter over in your garden. The USDA zone map was first published in 1960 and was updated in 1990 and 2012. Each zone represents the average lowest winter temperature for an area; it does not reflect record cold temperatures. Average temperatures are based on the lowest minimum temperature recorded each year from 1976 through 2005.

According to the USDA zone map, hardiness zones in Idaho range from zone 3b to zone 7b. On the current map, most Idaho locations are half a zone warmer than in previous versions. A current USDA hardiness zone map for Idaho can be found at **https://pdi.scinet.usda.gov/phzm/vm/IDA300.jpg**.

Hardiness zones are based on temperatures recorded for large areas, but small areas within a zone can vary significantly. These areas are called microclimates. Sun reflected from a wall or fence can increase the minimum winter temperature, while shade from a tree or on the north side of a building can decrease it. Temperatures in a valley generally are lower than those found on the side or top of a hill. Even dark mulch material can moderate soil temperature by 5°F–10°F during spring or fall, when plant roots and crowns are not fully dormant, thus increasing winter hardiness. Other factors that affect a plant's ability to withstand cold are plant health, age of the plant, plant dormancy, snow cover, late winter warming, and moisture levels in the plant (especially evergreens) prior to the onset of winter. For these reasons, the hardiness zone map should be used only as a guide.

Heat Stress

Heat stress is defined as exposure to high temperatures for a long enough period of time to cause irreversible damage to a plant's physiological functions. Heat stress can be caused by high air or soil temperatures. Stress increases rapidly as air temperature rises above 85°F. Plants can be injured directly by heat or indirectly when a high transpiration rate causes a water deficit. Transpiration rate depends on plant size, light intensity, temperature, humidity, and wind speed.

It is best to avoid planting heat-sensitive plants near sidewalks, driveways, or buildings that reflect light and heat. Rock mulches can also increase the soil temperature enough to damage heat-intolerant plants.

The American Horticultural Society (AHS) has created a plant heat zone map based on the number of days with temperatures above 86°F. Some plant labels now include the plant's heat zone tolerance. A current version of the AHS plant heat zone map can be found at **https://solanomg.ucanr.edu/files/245158.pdf**.

Growing Season

Knowing the length of the growing season is important if you want to grow warm-season vegetables or collect seeds from annual plants. The growing season is the period between the last average spring frost date and the first average fall frost date. Because frost dates vary greatly from year to year, the length of the growing season in any given location will vary. In Idaho, the growing season ranges from 60–90 days in the central mountains to 150–60 days in the southern high desert region.

Late spring frosts can damage warm-season vegetables and fruits. Because cold air is heavier

than warm air, it flows downhill to low-lying areas. Thus, a garden positioned at the top of a sloped yard may not experience as much frost damage as one at the bottom of the slope. In densely populated areas, closely spaced houses, solid fences, walls, and thick hedges can prevent free drainage of cool air, thus increasing frost damage.

The growing season can be lengthened by using hot beds, cold frames, frost cloths, high tunnels, and "reflector ovens" (Figure 1). These structures protect crops from cold temperatures and inclement weather. For information on season extension structures, see chapter 24, "Houseplants and Home Greenhouses."

AVOIDING WEEDS AND POISONOUS PLANTS

Avoid purchasing invasive species, noxious weeds, or plants that are poisonous to animals and children. Weeds compete with garden and landscape plants for water, nutrients, and space. Without adequate weed control, a garden can become unproductive and a source of frustration instead of joy. Many weeds were brought to the United States as ornamental plants or were used as inexpensive packing material in shipping containers coming from other countries. Plants that behave well in one region can become noxious weeds in another.

A **noxious weed** is defined by the state of Idaho as any plant having the potential to cause injury to public health, crops, livestock, land, or other property. The spread of noxious weeds and their damage to Idaho's agriculture can be reduced by proper identification and handling of certain plants. Before purchasing mail-order plants, exchanging seeds with friends from other regions, or bringing plant materials home from vacation, check Idaho's noxious weed list. See chapter 14, "Weeds," for more information on weeds and control methods.

Some common ornamental plants, such as myrtle spurge (*Euphorbia myrsinites*), can cause eye and skin irritation, while others can cause illness or death in children or pets. Teach children not to put any plant material in their mouth, unless you have intentionally introduced them to it. Various Extension publications list poisonous garden or landscape plants. The American Society for the Prevention of Cruelty to Animals keeps a database of plants known to be poisonous to cats, dogs, and horses.

Figure 1. Season-extension methods, such as a hoop house, protect crops from cold temperatures.

Site Preparation

Prepare the site for planting by removing rocks, weeds, and other debris. Preparation may include grading, tilling, amending the soil, and installing an irrigation system. Grading the soil allows water to drain away from your home or the crowns of plants. In a steeply sloped area, terracing is an option.

If the soil is compacted, turning the soil with a shovel or rototiller may help loosen the soil and increase aeration for better root growth. Amendments are often added at this time. Choose appropriate amendments, based on a recent soil test, your soil's structure, and plant requirements. Humus (composted organic matter) is a good amendment for most soils, as it increases soil fertility and improves soil structure. For more information, see chapter 5, "Soils and Fertilizers."

With heavy clay soil or a high water table, raised beds, mounds, or berms may be needed to improve drainage. In areas with a high water table, tile drains can also be installed.

Planting

SEEDS

Starting vegetables, herbs, and annual flowers from seed is economical and can be fun and rewarding. For more information, see chapter 20, "Principles of Vegetable Culture" or other University of Idaho publications.

BAREROOT PLANTS

Bareroot plants are dormant herbaceous or woody perennial plants that have been dug and stored without

soil around their roots. The roots are usually wrapped in damp sphagnum moss, sawdust, or paper to keep them moist. Bareroot plants weigh less and are easier to ship than plants with soil. Flower bulbs, flowering ornamentals, strawberries, asparagus, caneberries, grapes, fruit trees, and some shrubs, vines, and shade trees are commonly sold as bareroot plants.

Bareroot plants must be planted as soon as possible, while they are still dormant. For this reason, they are usually sold and planted in early spring or late fall.

If you purchase a mail-ordered bareroot plant, check to make sure the plant is healthy when it arrives. Look for mold or mildew and make sure the roots do not smell rotten. Roots, rhizomes, and bulbs should feel heavy for their size, not lightweight or dried out.

The roots of a bareroot plant must not be allowed to dry out before planting. If you must hold a plant for a day or two, keep the roots shaded and wrapped in plastic, wet paper, or moist sawdust. If you cannot plant for several days, place the plant in a container with potting soil and leave the container in a cool, shaded location. Another technique for holding bareroot material is called heeling in. This procedure consists of digging a trench large enough to accommodate the roots and burying them until you are ready to plant. Keep the roots cool and moist to avoid breaking dormancy.

Before planting, make sure the roots are moist. If you have any doubt, soak the roots overnight. Prune off broken roots.

Dig a hole large enough to accommodate the roots without bending or cutting them. Build a conical-shaped mound of soil in the bottom of the hole and spread the roots over the mound so that they will grow down and outward. Adjust the plant so that the old soil line at the base of the trunk or crown is at ground level or slightly higher. On fruit trees, the graft union should be well aboveground. If a stake is needed for stability, add it now. For information on staking trees, see chapter 18, "Woody Landscape Plants."

In most loamy soils, it is not necessary to amend the backfill. In heavy clay soils, you may want to add some humus to improve aeration and drainage. In very sandy soils, humus can improve the soil's nutrient-and water-holding capacity. Any amendment should not represent more than 25% of the backfill volume, so that the backfill does not vary greatly from the surrounding soil.

Fill the planting hole halfway with backfill, making sure to work it in and around the roots. Water to help remove voids. Let the water soak in and then fill the remainder of the hole with soil. Finish by watering again. Do not keep newly planted bareroot materials too wet after planting, since they are dormant and require little water.

BALLED-AND-BURLAPPED STOCK

Balled-and-burlapped (B&B) plant materials are trees or shrubs dug from the ground with a portion of their root system and soil intact. The root ball is wrapped in burlap and secured with twine. If the plant is held at the nursery for a long time, new roots may grow through the burlap. If the ball is very heavy, a metal basket may be added to protect it from breaking and for easier handling. Plants often sold as B&B stock include needled evergreens, rhododendrons, and azaleas, as well as many deciduous trees and shrubs.

B&B plants can be planted almost anytime the ground can be worked. Because of their limited root system, however, it is best to plant them in the spring or fall when it is cool and moist so they can establish rapidly. If B&B plants are planted in summer, they must be adequately watered to ensure that the roots do not dry out.

Careful handling of the root ball is very important. If it is cracked or broken, the plant most likely will die. Never drop the root ball on the ground. Always support the root ball on the bottom when moving the plant; do not lift only by the trunk, as doing so can stress the root ball and cause it to break from the trunk. Keep the root ball moist, shaded, and covered with soil or sawdust until you are ready to plant.

The size of the root ball determines the size of the planting hole. To prevent settling of the plant, dig the hole no deeper than the depth of the root ball. Make the hole at least two to three times wider than the width of the ball. Slant the sides of the hole outward so that the top is wider than the bottom (Figure 2). This will allow water to enter the hole more easily and will provide space for the delicate roots to grow outward into the backfilled soil.

Place the root ball in the hole and half-fill the hole with soil. Water to settle the soil and remove voids. Next, untie the burlap from the trunk and lay it back on the soil, but do not remove it. Burlap should be removed only if it is *not* jute but rather nylon or some other nondecomposable material. Fill the remainder

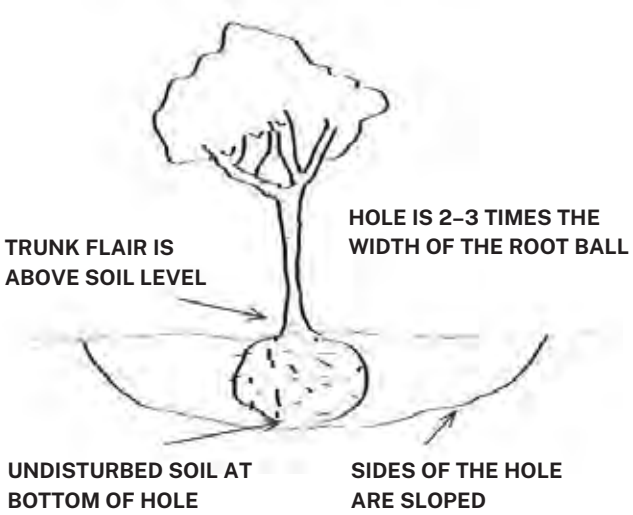

Figure 2. Planting-hole size and configuration for balled-and-burlapped plants.

of the hole with soil and then water again. If the burlap is not untied and buried, it will wick moisture from the root ball. For information on staking trees, see chapter 18, "Woody Landscape Plants."

CONTAINERIZED STOCK

Most plant materials sold at nurseries and garden centers are in containers. Container-grown plants need the same careful planting as other plant materials. Their advantage is that they can be planted anytime the ground is workable.

The planting hole should be as deep as the soil in the pot and two to three times wider than the container. Slant the sides outward. Remove the container, no matter what it is made of. The only exception is a small plant in a thin peat pot with roots growing through the pot. Even with peat pots, however, remove the top half of the pot to prevent wicking of soil moisture and damage or remove the bottom of the pot to allow roots to escape. Thick paper or cardboard pots, sometimes erroneously called "peat" pots, should always be removed.

If roots are circling inside the pot or have taken on the shape of the pot, make four vertical knife cuts, one on each side of the root ball, to a depth of ¼ to ½ inch. Also make an "X" cut across the bottom of the root ball. If the roots are woody, use a hand clipper or sharp spade. New roots will grow from the cut roots.

Once cut, spread the roots slightly without breaking them and place the plant in the hole. Fill the hole with backfill soil as described under "Balled-and-Burlapped Stock."

Fertilizing

Plants need nutrients for proper growth and health. It is important to choose the proper fertilizer and method of application. For more information, see chapter 5, "Soils and Fertilizers" or the chapter that covers the relevant type of plant.

Irrigation

Adequate soil moisture is essential for plant growth and vigor. A healthy plant is 75%–90% water. Plants need water to carry out vital functions such as photosynthesis, structural support, transpiration, and transport of nutrients and sugars. Poor irrigation practices can lead to problems such as iron chlorosis, wilting, leaf scorch, foliar diseases, root rots, and ground or surface water pollution. There is much to lose by not irrigating properly. Landscape plants can be expensive and fully grown shade trees are impossible to replace.

Many gardeners underwater their plants by irrigating frequently for short periods of time. While a lawn can grow well enough with short, frequent irrigations, shrubs and trees do better with long, slow, infrequent irrigations.

Overwatering is as serious as underwatering. Roots require soil oxygen and can be damaged when excess water excludes oxygen from the soil profile. Excess irrigation also encourages root rots and other plant diseases.

Watering a landscape requires balancing the water needs of several types of plants. A typical suburban landscape includes an expansive lawn with a few mature trees. Flower and shrub beds may be located near the home's foundation or scattered around the lawn. There might be a vegetable garden in the backyard and a compacted path through the lawn leading to the back. There likely is a confusing mix of plants with varying drought and heat tolerances, such as pansies planted under junipers. Add a couple of planted containers on the front porch and you have a typical suburban landscape that is challenging to irrigate.

Furthermore, moisture conditions vary throughout a landscape. A planted berm that continually loses water downhill will make the area below it overly wet. Areas shaded by mature trees likely will remain moist, but thickly matted tree roots inhibit grass growth. The north and east sides of a house are shaded and hold water longer than the south and

west sides. Foundation plantings on the south and west sides of a house may need to be drip irrigated, as they will dry out quickly due to heat radiating off the house. Plants near a driveway or sidewalk face the same fate.

FACTORS AFFECTING IRRIGATION

Many variables affect the amount of water available to a plant. Soil type, slope, soil organic matter content, mulch, plant rooting depth, soil compaction, plant competition, evapotranspiration, and sprinkler efficiency all affect the availability of soil water.

Plant Roots

The structure and growth habit of healthy plant roots strongly influence plant size and vigor. Since roots are out of sight, they often are misunderstood and their significance overlooked.

The depth and width of a root system depends on the growth characteristics of the plant, as well as on soil texture and structure. A root extracts most of its moisture from the top half of the root zone. This area is known as the effective root depth (Figure 3). The effective root depth determines the amount of soil water accessible to the plant.

Newly emerged vegetable seedlings tend to have very shallow roots and must be irrigated frequently. Roots of most mature flowering perennials and vegetable plants exceed 24 inches in depth and width. See Table 1 for effective root depths of common vegetables, fruits, and flowering plants.

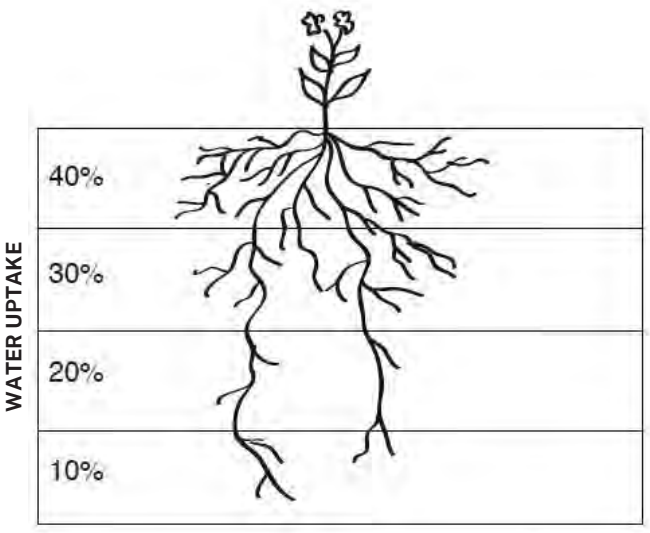

Figure 3. Effective root zone depth. Seventy percent of the moisture is extracted by the roots from the top half of the root zone.

Table 1. Effective root depth in unrestricted soils.

Crop	Effective root depth (inches)
Vegetables	
Asparagus	36
Beets	18
Broccoli	18
Cabbage	18
Carrots	18
Cauliflower	18
Celery	12
Chives	6
Corn (sweet)	24
Cucumbers	18
Eggplant	18
Kale	18
Kohlrabi	18
Lettuce	6
Melons	24
Peas	18
Peppers	18
Potatoes	18
Pumpkins	24
Radish	6
Snap beans	18
Spinach	6
Squash	24
Swiss chard	12
Tomatoes	24
Turnips	18
Fruits	
Cane fruits	24
Grapes	36
Strawberries	6
Flowers	
Annual flowers	6
Bulbs, corms, rhizomes	12
Ground cover plant	6
Perennial flowers	18

On larger plants, it can be difficult to estimate the depth and width of the root system. Roots of deciduous trees growing in favorable conditions can spread two to three times the width of the canopy (branches). The horizontal root spread of evergreen trees is about twice the height of the tree. In both cases, the majority of the roots (the effective root depth) is in the top 2 feet of soil.

The rooting depth of turfgrass depends on the species. Kentucky bluegrass can have a rooting depth of 12 inches, while roots of turf-type tall fescue can be 4–6 feet deep! The effective root depth, where the turf obtains the majority of its water, is in the top half of the rooting zone. See chapter 15, "Turfgrass Establishment and Management," for more information.

In general, most plants need to have the soil thoroughly moistened around their roots with each watering. Allow enough time for the roots to extract most of the available water before irrigating again. See "Irrigation Scheduling" and "Irrigating Sections of the Landscape" for information about determining how often and how much to water.

Evapotranspiration

Water moves to the atmosphere from the soil surface by evaporation and from plants by transpiration through plant stomata. Together, these processes are called evapotranspiration (ET), usually expressed as the depth of water (in inches) used in a specific period of time. Sunlight, temperature, relative humidity, wind, and the moisture level inside the plant affect the ET rate. By providing an estimate of the amount of moisture used by a crop and lost through evaporation, ET rates indicate the amount of water that must be replaced with the next irrigation.

Daily ET values for crops and pastures are available from the AgriMet Weather Station Network, a service of the US Department of the Interior's Bureau of Reclamation. Unfortunately, these values do not accurately represent water use by biologically diverse plantings, such as those found in home landscapes or vegetable gardens. In general, ET rates often reach 0.3 inches or more in Idaho locations with hot summer days, low humidity, and high winds.

To reduce evaporation, water early in the morning if possible. Mulches (any material applied to the soil surface as a protective cover) improve water retention. They also reduce weeds and moderate soil temperatures. Organic mulches such as bark, wood chips, leaves, compost, grass clippings, and newspaper also improve soil structure and add some nutrients.

Inorganic mulches (solid plastic sheeting, woven nylon landscape fabrics, rocks, and gravel) retain moisture and reduce weed growth, but can have detrimental effects on plants. During hot, dry weather, rocks can absorb and reflect heat back to landscape plants and your home, making the area inhospitable for both plants and people. The weight of rocks also compacts the soil. Solid plastics do not allow oxygen or water to freely enter or leave the soil; these materials should be used only temporarily in vegetable gardens and never in a landscape. Both plastic sheeting and woven fabrics must be pinned down and covered with another mulch, such as wood chips, to prevent deterioration by ultraviolet light. Plastics and fabrics can migrate to the surface over time, even when secured with pins and covered with organic mulch, causing a landscape to look unsightly.

Water Infiltration Rate

Infiltration is the movement of water into the soil. The rate of infiltration is measured in inches or centimeters per hour. Clay soils have a slow infiltration rate, while sandy soils have a faster one. For example, a sandy loam soil accepts ½–3 inches of water per hour, while a clay loam soil absorbs less than ½ inch of water per hour. If water is applied faster than the soil can accept it, either through precipitation or irrigation, the excess will pond or run off.

Compacted soils do not allow water to penetrate the soil surface. In a vegetable garden, tillage and organic matter additions will reduce compaction over time, but soils are very slow to change. Even with the addition of 1–2 inches of humus every year, it may be 4–5 years before any difference is noted in soil structure. Designated paths and planting beds will help prevent compaction in vegetable and flower gardens. For landscape beds, a 3–4-inch layer of organic mulch will reduce compaction by cushioning the soil from foot traffic and the pounding of water droplets.

In lawns, water infiltration can be reduced by compaction or a thick thatch layer. The best treatment for soil compaction in lawns is annual core aeration, followed by top-dressing with ¼ inch of humus or good topsoil. Core aeration is usually done in the spring or fall to reduce moisture loss around exposed turf roots.

Thatch is a spongy, brown layer made up primarily of dead grass stems and roots. Thatch production is a normal process for rhizomatous grass species, such as Kentucky bluegrass. To check for thatch, remove a section of turf, leaving the root system attached. The thatch layer is below the green grass blades but above the soil and roots.

A ½-inch-thick thatch layer is beneficial. Thicker thatch can harbor diseases and insects and can interfere with water movement into the soil. Excessive thatch is often caused by overuse of nitrogen fertilizers, which causes grass to grow and die rapidly. Overwatering, poor drainage, and excessive use of fungicides or insecticides can also cause thatch buildup by harming the beneficial soil microbe populations responsible for decomposing thatch. A power rake or dethatcher is used to repair a lawn with an excessively thick thatch layer.

See chapter 15, "Turfgrass Establishment and Management," for information about core aeration and thatch removal.

Permeability

The permeability rate of a soil is the speed at which water moves down through the soil profile. It is measured in inches or centimeters per hour. Soil compaction, plow pans, hardpans, clay layers, caliche layers, rocks, or changes in soil texture can influence permeability. A plow pan is a compacted soil layer created by tillage operations. A hardpan is an impervious layer, typically clay, that impairs drainage or plant growth. Caliche is a layer of lime (calcium carbonate) whose particles have been cemented together over time. A caliche layer can be so tightly cemented that roots and water cannot penetrate it.

Soil Water-Holding Capacity

Soil stores moisture and supplies it to plants between precipitation events and irrigation. Water is held in pore spaces within the soil by capillary action and gravity.

The size and number of pore spaces is directly related to soil texture and organic matter content. A soil made up of large particles, such as sand, has a lower water-holding capacity than a soil composed of tiny particles, such as clay (Figure 4). Regular addition of organic matter helps sandy soils hold water longer. Although clay can hold more water, the water is not necessarily available to plants because it takes more energy for plants to remove water from tiny pores.

See chapter 5, "Soils and Fertilizers," for more information about soil structure.

Soil Texture Interfaces

Soil texture interfaces occur where there is an abrupt change in the soil texture and the size of pore spaces. Water and oxygen can be very slow to cross an interface boundary.

Interfaces can occur naturally or be created by improper plowing, tilling, or planting methods. Amending the backfill during planting can create an interface by introducing a soil that is different from both the soil in the root ball and the native soil. All three soils will have different pore spaces, water-holding capacity, and water permeability.

A severe soil texture interface can inhibit root development and plant growth. Researchers at Washington State University's Research and Experiment Station in Puyallup, Washington, observed that when plants were transplanted into heavy clay soil, using a heavily amended backfill, roots began circling within the hole as though they were in a pot. The surrounding native soil did not have the same oxygen content, nutrient levels, drainage, or water-holding capacity as the amended backfill. For this reason, it is best to avoid amending the backfill when transplanting in most soils. Heavy clay soils or very sandy soils will benefit from some addition of humus, but do not change the backfill by more than 25%.

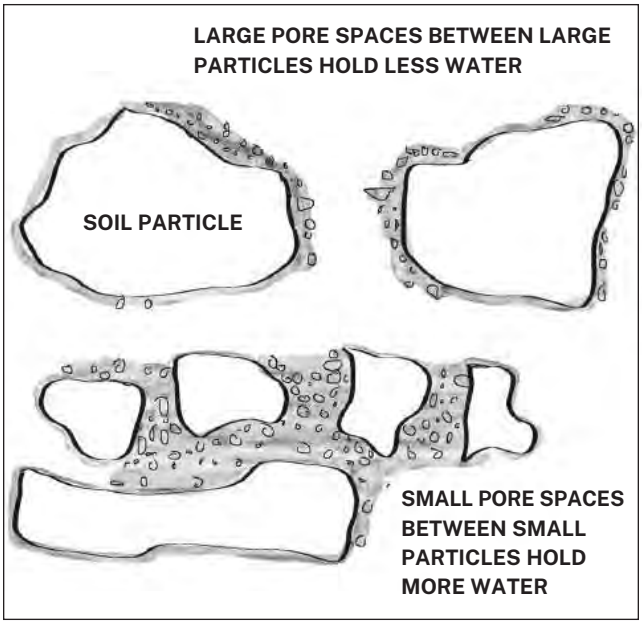

Figure 4. Pore spaces in soil. Soils with lots of large pore spaces, such as sand, hold less water than soils with small pore spaces, such as clay.

Sprinkler Efficiency

Landscapes are typically watered by sprinklers. Sprinkler systems range from hose-end sprinklers to fully automated underground systems. The irrigation principles are the same for all types.

Hose-end sprinklers vary widely in application rate and spray pattern. Some apply more water near the sprinkler and less near the edge of the spray pattern. To ensure uniform coverage, overlap the spray patterns when moving a hose-end sprinkler. The middle of the new spray pattern should be on the outside edge of the previous spray pattern (Figure 5). Oscillating fan-type sprinklers give more uniform coverage.

With underground sprinkler systems, the landscape is typically divided into zones. Sprinkler heads are arranged so that one sprinkler sprays all the way to the next, a configuration known as head-to-head coverage. Often, one area is included in two or more zones, especially near the middle of the lawn.

Regardless of the type of sprinkler system, check application rates and uniformity. On a windless day, place several straight-sided containers, such as soup or tuna cans, at regular intervals throughout the lawn. Run the irrigation system normally, noting how long it runs. Measure the depth of water in each container to see how much water is applied during that period of time. Compare containers to see if a similar amount of water is applied to each area.

Figure 5. Sprinkler overlap to provide head-to-head coverage.

IRRIGATION SCHEDULING

Irrigation scheduling involves planning when and how much to water. The goal is to maintain healthy plants without wasting water. Effective irrigation scheduling is possible only with regular monitoring of soil water availability and ET. It is easy to think you are watering plants, but in reality you are making a water deposit into the soil.

When to Water

Soil texture is an important factor in determining how frequently you should water. Although sandy soils allow quick, deep penetration of water, they tend to dry out more rapidly than clay soils and need more frequent irrigation. Heavy clay soils are more difficult to wet, but dry out much more slowly than sandy soils, requiring less frequent irrigation. Take the time to learn how long it takes for your soil to dry.

You can estimate soil moisture by feel and appearance. Obtain a soil sample to a depth of at least 1 foot using a probe, auger, or shovel. Squeeze the sample firmly in your hand to form a ball. Soil that needs to be watered will be dry and soil aggregates will separate easily. There will be no water staining on your fingers. In a clay soil, clods will be hard to crumble with applied pressure. Notice how the moisture at the surface compares to the moisture deeper in the soil profile. If the top is very moist but the soil is dry at 1-foot deep, increase the length of irrigations to allow moisture to travel down through the profile.

Resistance to the probe or shovel can be useful in gauging soil moisture content. If the probe enters the soil easily but stops abruptly after several inches, even with all of your weight on the handle, you may have reached dry soil or an impervious layer. Keep in mind, however, that compacted clay soil can be very difficult to probe even when moist, while a sandy soil can be easily probed even when dry.

Rocks or gravel will also stop the probe, but they are easily identified by a metallic sound when hit.

Soil moisture meters, available at nurseries and garden centers, are another method of checking soil moisture levels. These inexpensive meters are often inaccurate, however. If soil fertility is high, meters tend to overestimate soil moisture. If fertility is low, they underestimate moisture. You will need to learn how to interpret meter readings for your soil by trial and error.

Often, close observation of plants can help with irrigation scheduling. The level of drying a plant will tolerate depends on species and plant size. See “Irrigating Sections of the Landscape” for information relevant to specific plant types.

How Much to Water

Always water long enough to fill the entire root zone. In a typical garden or landscape, you must learn how

long it takes to adequately moisten the root zones of various plants.

Because newly emerged vegetable seedlings have shallow roots, moistening just the top few inches of soil is often recommended. However, for a large shade tree with a root system the width of the yard or beyond, it can take hours to adequately water the entire root zone in clay soil. If the infiltration rate is low, some of this water is likely to run off rather than soaking into the soil. For this reason, some gardeners with clay soil "cycle water." This technique involves watering several times in one day, allowing the soil to soak in the water in-between irrigations.

The easiest way to determine how long to water is to wait 12 hours after an irrigation and use a shovel or soil probe to dig or probe to a depth of 10–12 inches. Take a small handful of soil from the bottom of the hole or soil core and squeeze it. It should form a weak ball and feel slightly damp, like a wrung-out sponge. If the soil feels drier, water longer. If water drains freely from the soil when squeezed, reduce the length of irrigations. Check the soil moisture at this depth once a month in several areas of your yard.

IRRIGATING SECTIONS OF THE LANDSCAPE

Lawns

Water lawns deeply but infrequently. Deep watering improves soil aeration, reduces water loss to evaporation, reduces weed populations, and produces a healthy lawn. Water long enough to wet the soil to a depth of approximately 1 foot. Often, irrigating once or twice a week in summer is sufficient, as long as the proper depth is reached.

The frequency of irrigation will change based on the weather, while the amount applied should remain fairly constant. It always takes the same amount of water to fill a 1-foot depth, but the length of time it takes the lawn to use this water depends on the weather. Irrigate less frequently in the spring and fall than in the summer.

It is best to *not* wait for your lawn to show symptoms of drought stress before irrigating. Stress symptoms are a sign that you've stretched the irrigation interval too long. If the grass does not spring back when walked on or it takes on a bluish-gray cast, it is past time to irrigate and you should water immediately. If healthy turf dries up and turns tan, it may indicate that cool-season grasses have gone dormant. If not left too long, the grass will green up again when it receives adequate moisture.

For more information, see chapter 15, "Turfgrass Establishment and Management."

Trees and Shrubs

Whenever possible, avoid overhead watering of woody trees and shrubs. Frequent wetting of leaves provides an environment in which foliar diseases can thrive and increases water loss to evaporation.

The water requirements of trees and shrubs change as they grow and mature. Even a tree or shrub that is described as "drought tolerant" or "low water use" needs to be watered regularly until it is well established.

Mature trees and shrubs need to have water available from their trunks out to and beyond their drip line (the end of the branch tips; see Figure 6). Root systems can easily extend beyond the drip line, so watering right next to the trunk does very little, especially for large trees.

If a tree or shrub is surrounded by lawn, the lawn's sprinkler system will supply some water. However, trees and shrubs need deeper, less frequent irrigation than lawns; otherwise, the roots will grow close to the surface and be subject to drought stress. Thus, occasional deep irrigation with a garden hose or soaker hose may be necessary. Water deeply every 1 or 2 weeks in summer. Soak the ground in several areas around and beyond the drip line. If using a garden hose, use a low flow rate and let the water soak in.

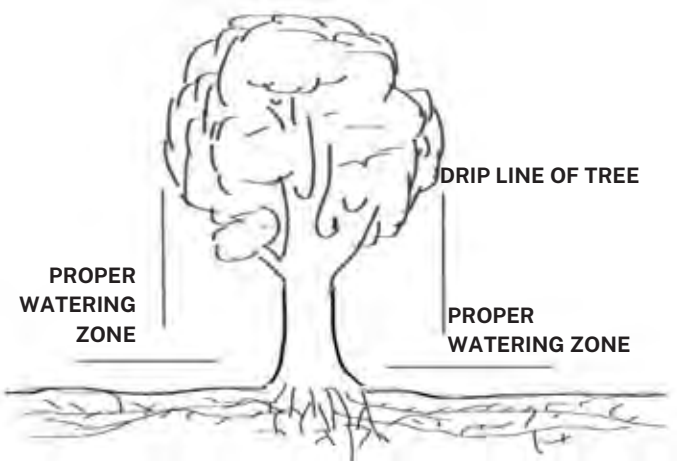

Figure 6. Proper watering area for a mature tree. The root systems of trees extend beyond their crowns.

If the tree or shrub does not receive water from lawn irrigation, water with a garden hose or drip-irrigation system. If using drip irrigation, place emitters around the drip line of the plant, not near the trunk. For more information, see chapter 18, "Woody Landscape Plants."

Flowers and Vegetables

In general, most flowers, small fruits, and vegetables require adequately moist soil all season long to produce their best. All of these plants differ in their water requirements, making irrigation a challenge. With inadequate water, lettuce and cucumbers can become bitter and some flowers (such as peonies) may not bloom. However, tomatoes and irises may do fine with less frequent watering.

Gardens can be watered by gravity (flood), sprinkler, or drip irrigation. Gravity irrigation is not the most efficient method, but it fits well with a traditional vegetable garden consisting of long rows. Sprinkler irrigation is more efficient, but may increase the risk of foliar diseases. Sprinklers can be difficult to use with tall flowers or crops and with trellised plants. Drip irrigation is well suited to flower beds and vegetable gardens, because it applies water efficiently and keeps the leaves dry. Many types of drip tubing and emitters are available.

When using flood irrigation, make sure the water reaches the end of the row in a third of the time it takes to do a full irrigation (for example, within 10 minutes for a 30-minute irrigation). This ensures that the plants at the ends of the rows will receive enough water to reach into the lower depths of their root zones.

See chapter 20, "Principles of Vegetable Culture," chapter 23, "Small Fruits," and chapter 19, "Herbaceous Ornamentals" to learn more.

Containers

Plants in containers need more water than plants in the ground. Most potting soils dry rapidly. Also, the root zone in a container is limited and roots are not well insulated from high temperatures. Outdoor container plants may need to be watered several times a day during warm, sunny periods. Check the soil moisture by probing the top inch of soil with your finger. If the soil is dry, it's time to water.

A drip-irrigation system on a timer is a very effective way to keep containers adequately watered. However, containerized plants can be watered with a garden hose or watering can if watering is consistent throughout the summer.

Always irrigate several times or until water runs through the drainage holes in the bottom of the container. (Planting containers must have drainage holes for proper watering.) Don't be fooled, however, by a dry root ball that allows water to run around the edges of the pot and out the bottom without moistening the root ball.

Very dry root balls and soils with high peat content are especially difficult to rehydrate once they become dry. You may have to set the bottom of the container in a basin of water to remoisten the root ball or peat moss. Rehydration may take an hour or more, but do not leave a container sitting in water for more than 12 hours, as doing so may cause root damage due to lack of oxygen.

A good test to see whether the soil has taken up adequate moisture is to lift or tip the container. A well-watered container is much heavier than a dry one.

A pot that is too small for its plant will fill with roots, leaving little room for potting soil or water and causing the plant to dry out quickly. Transplant root-bound plants into larger containers.

Unglazed clay pots are porous and need to be watered more often than glazed or plastic pots. However, plastic pots offer poor root insulation. Adding a layer of thin Styrofoam sheeting on the inside of a pot prior to filling it with soil will improve insulation.

Further Reading and Resources

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CHAPTER **EIGHT**

BACKYARD COMPOSTING

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8 BACKYARD COMPOSTING

Learning Objectives

- Understand what defines composting
- Understand the benefits of compost
- Understand what materials can and cannot be composted
- Understand what organisms play a role in the compost process
- Understand how to make and maintain a simple compost pile
- Understand various other methods for creating compost
- Understand how to troubleshoot if a problem arises
- Understand how to judge when compost is finished
- Understand how to use compost in a garden or landscape

Introduction

Composting is an easy and sustainable method of reducing, reusing, and recycling organic debris from landscapes, gardens and kitchens. It is a way of mimicking what happens continually in nature — the breaking down of organic matter and the recycling of nutrients by microorganisms in the environment. Composting is simply the controlled biological decomposition of organic matter on a smaller scale. Gardeners know that growing robust plants starts with healthy soil. Adding finished compost as an amendment to almost any soil over time improves its characteristics such as structure, workability, and moisture- and nutrient-holding capacity.

MASTER GARDENER TIP

While decomposition occurs on a regular basis in nature, human intervention through composting can speed up the process of plant decay.

The Composting Process

The quality of compost and speed of production depends on several factors that can be manipulated by the gardener. Composting is an aerobic (oxygen-requiring) process. Beneficial microorganisms (microbes) and other larger organisms called macroorganisms are responsible for breaking down (decomposing) organic materials. These decomposers need oxygen and water to live. As they work breaking down organic matter, they generate heat and release water and carbon dioxide (Figure 1).

MASTER GARDENER TIP

Avoid adding weed seeds, diseased plants, or pesticide-treated plants to a compost pile.

WHAT MATERIALS ARE USED IN COMPOSTING

Almost all natural organic materials decompose, but not everything belongs in a backyard compost pile. Generally, compost is made up of garden vegetation, landscape trimmings, food scraps (vegetable or fruit), and livestock manure, but materials like newspaper and wood chips can also be used (Table 1). New items can be added to an existing compost pile as they become available or stockpiled until enough material is gathered to finally construct a compost pile.

Refrain from adding fatty or oily foods, since they can generate odors and attract animals such as rats, racoons, dogs, and skunks. Cat and dog feces should not be added to a compost pile because it may contain pathogens harmful to humans.

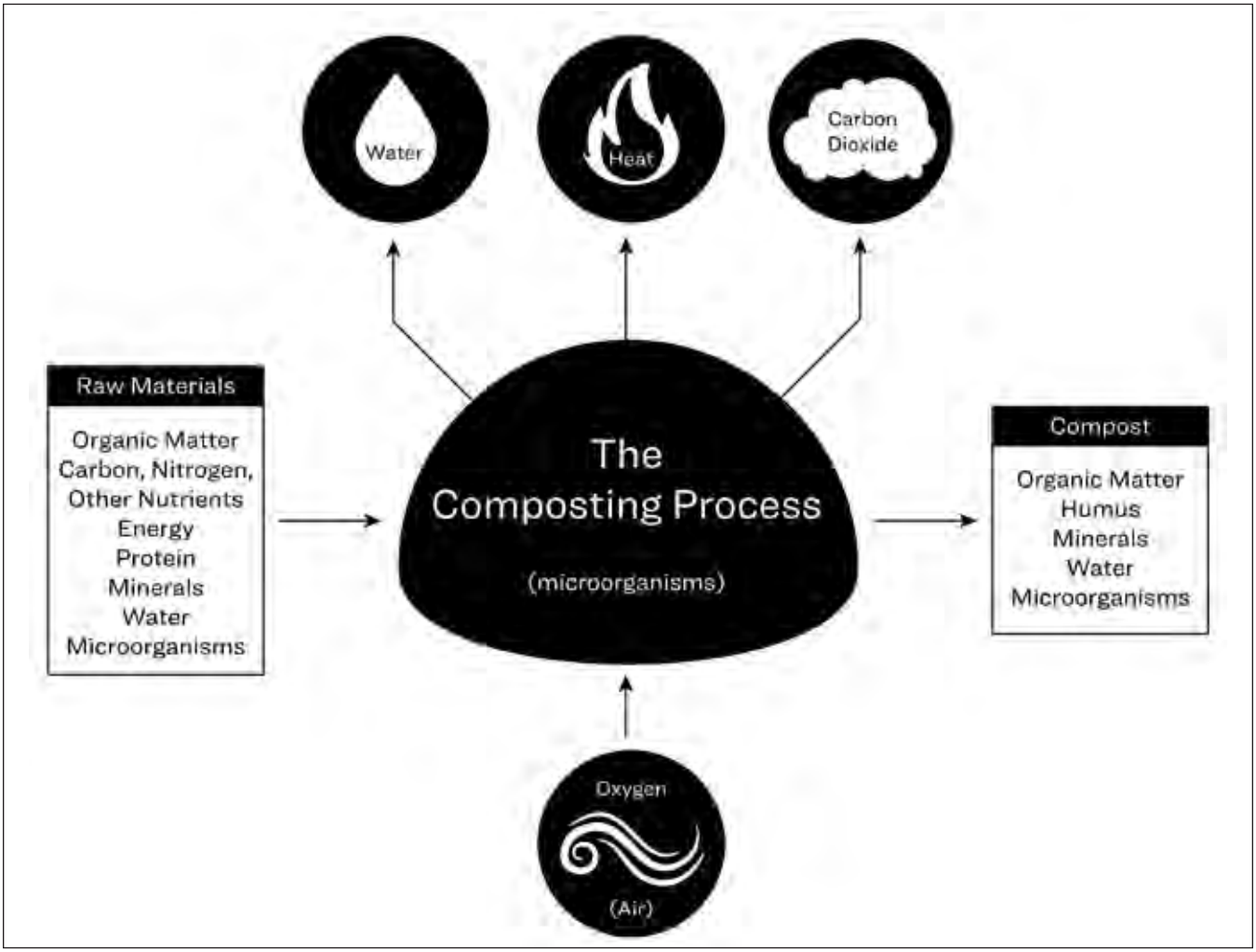

Figure 1. The composting process.

Table 1. Materials that should and should not be composted. Adapted from Dickson et al. 1991.

YES	NO
Aquatic plants	**OILY FOODS** (attract pests)
Bread	Butter
Branches — chipped	Bones
Brush — chipped	Cheese
Coffee grounds	Fish scraps
Corncobs	Lard
Cut flowers	Mayonnaise
Eggshells	Meat and poultry
Evergreen needles	Peanut butter
Fruit	Salad dressing
Fruit peels and rinds	Sour cream
Garden trimmings	Vegetable oil
Grass clippings	
Leaves	**POSSIBLE SOURCES OF DISEASE AND WEEDS**
Manure — cattle, horse, rabbit	Cat manure
Paper	Dog manure
Sawdust	Diseased plants
Straw	Plants with rhizomatous stems
Sod	
Tea leaves and bags	Weeds that have gone to seed
Vegetables	
Vegetable trimmings and tops	**POSSIBLE SOURCES OF TOXINS**
Weeds without seeds	
Wood ash	Cedar chips, bark, branches
Wood chips	Grass treated with persistent herbicides
Wool waste	

Avoid diseased plants, weeds with seeds or rhizomes, and plants recently treated with pesticides. Another group of materials to be cautious about are those containing natural compounds that would be toxic to the microbes in the compost pile or the plants where the compost is later applied. Cedar and black walnut wood are two of these. Cedar deters fungi growth and insects, which are needed in the composting process. All parts of a walnut tree contain an allelopathic substance (juglone) that can inhibit the growth of other plants if juglone accumulates to phytotoxic levels. Although the quantity required to be harmful to your compost pile is not well defined, current studies indicate that composting walnut tree leaves should be fine for compost piles because the composting process breaks down the allelopathic substance juglone.

Some gardeners add lime or wood ash to compost piles, but neither are necessary in the composting process. Lime is added with the intention of neutralizing acidic materials like pine needles or organic acids formed during composting, but the effect of these acids is seldom damaging. In addition, microbes can work at a relatively low pH. The pH of most compost once finished tends to be close to neutral. Lime also encourages ammonia loss, especially when the carbon to nitrogen ratio is too low. Wood ash encourages ammonia loss as well, although it does add some mineral nutrients to compost. Unfortunately, wood ash is highly alkaline, something that might improve low pH soils, but is not needed where soil pH is already high.

HOW MUCH ORGANIC MATTER DO I USE?

Estimating a carbon to nitrogen (C:N) ratio can be simplified by categorizing carbon sources as “browns” and nitrogen sources as “greens.” These categories don’t necessarily represent the color of the materials. For example, livestock manure is considered one of the greens (N), while yellow straw is one of the browns (C). Different materials have different levels of C or N in them and gardeners who are building compost piles need to be aware of these ratios to maximize their composting efforts.

The microorganisms in a compost pile primarily use carbon compounds as an energy source while ingesting N for protein. Because microbes require a nutritional balance of both, the proportion of C to N is important when combining compostable materials. The most ideal mix of C to N is approximately 30:1, but piles slightly outside this range also compost satisfactorily. Sawdust has a high C:N ratio (Table 2), while cattle manure has a low C:N ratio. Because most compostable materials by themselves do not contain C and N in the perfect ratio, mixing materials is necessary to achieve a desired C:N ratio. The materials and proportions used to achieve the best ratio is referred to as a compost “recipe.”

Table 2. Typical C:N ratios of selected home composting materials.*

	Material	C:N ratio
Browns	Dry leaves	60:1
	Cornstalks	60:1
	Straw	80:1
	Shrub trimmings	50:1
	Wastepaper	400:1
	Wood (sawdust, shavings, etc.)	500:1
Greens	Grass clippings	17:1
	Kitchen scraps	15:1
	Vegetable culls	12:1
	Cattle manure	18:1

* These values are only approximations. The C:N ratio of any of these materials varies considerably from one source to the next and as the materials age.

For example, three volumes of browns (dry leaves) to one volume of greens (fresh grass clippings) produces a C:N ratio in a 30:1 to 50:1 range.

Composting is a flexible practice. All organic matter breaks down eventually, but if time is of the essence for a quickly finished product, consider the C:N ratio. When C is too high in a compost pile, the shortage of N will slow decomposition. When the N is in excess, it can be lost to the atmosphere in the form of ammonia gas. Some compost manuals simply say use about three times as much brown materials as green materials. However, for those who prefer accuracy, C:N ratio calculators are available online.

Creating a Simple Compost Pile

When developing a compost pile, some gardeners add organic materials without mixing them, relying on subsequent turnings to blend ingredients, while others combine their ingredients first in a wheelbarrow and then create the pile. Either way is fine. The most important task in constructing a pile is the appropriate C:N balance.

Building a compost pile (sometimes called a "heap") is the simplest form of composting. The pile needs to be large enough to generate and hold heat, yet small enough to allow air to reach the pile's center. To generate enough heat to raise a pile's temperature, the pile should be 3–5 feet wide and at least 3 feet high. A larger pile retains heat better, but as a pile grows in height and width, it can become more difficult to turn. To improve aeration, build the pile on top of pallets, aeration mats, or branches. Another way to ensure better aeration is to insert perforated PVC pipes, bundled cornstalks, or wire mesh tubes vertically into the pile. Pile volume is most important during winter. As cold weather approaches, gradually enlarging the pile helps to maintain an active compost pile.

As you build the pile, add browns and greens in successive layers that are 4–6 inches thick (Figure 2). The first and last layers in the pile should consist of coarse browns like dry cornstalks, straw, or wood chips. The coarse bottom layer improves aeration and insulates the pile from the cold ground. It also absorbs liquids that may leak from above. The coarse top layer prevents materials from blowing out and protects the pile from excessive heat and moisture loss, as well as contains odors. Water is applied as the pile is built by spraying or watering each layer. When the compost has an optimum moisture content, it will feel like a wrung-out sponge — just slightly damp (see Maintaining the Compost Pile: Moisture).

The surrounding outdoor environment contains plenty of microbes to start the composting process, but a pile can easily be inoculated further during construction by sprinkling a shovelful of good garden soil or finished compost (from another pile) between each 4–6-inch layer. This inoculation speeds up the growth of beneficial bacterial populations in the pile.

Although the pile starts in layers, later turnings mix the ingredients throughout the pile. When adding kitchen scraps later to a pile, bury them 12–15 inches beneath the surface to avoid attracting flies or pests. If the pile is not dry or frozen, the scraps will partially decompose within a week or two. The pile can then be turned regularly again. If using an enclosed bin or barrel, there is no need to bury kitchen scraps.

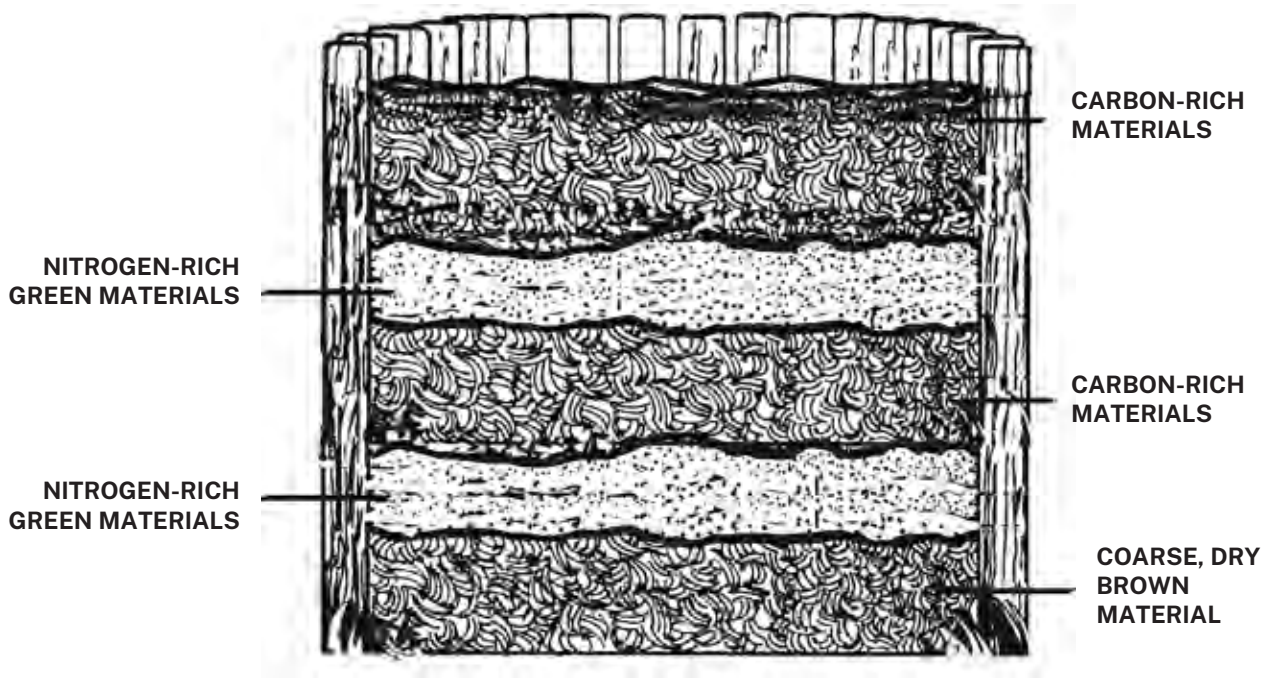

Figure 2. Simple layered compost pile.

MEET THE DECOMPOSERS

The decomposers doing the work in a compost pile make up a diverse and complex system of tiny organisms and animals, both predators and prey. While beneficial microorganisms such as bacteria, fungi, and actinomycetes (a branching type of bacteria) account for much of the decomposition, larger organisms like protozoa and invertebrates (animals lacking a backbone) also play a significant role. In a compost pile you might find nematodes, mites, springtails, flatworms, centipedes, beetles, millipedes, sow bugs, earthworms, snails, slugs, ants, fly larvae, grubs, and other tiny animals and insects.

While many organisms in a compost pile are there just to eat organic matter, others prey on smaller organisms. All the tiny animals and insects found in a compost pile are constantly mixing its materials and transporting nutrients around the compost pile by means of feeding, tunneling, excreting, and dying. The occupants in a compost pile form a complex ecosystem.

Bacteria, considered the workhorses of a compost pile, are the most numerous and active of the resident decomposers. They thrive in moist conditions and attack easily decomposed materials such as green vegetation. Actinomycetes and fungi (mostly yeasts and molds) attack the tougher, more resistant materials like plant stems and wood. They tolerate slightly dryer conditions and become especially important near the end of the composting process when resistant organic compounds, like cellulose and lignin, remain. The hyphae filaments, molds, and spores formed by fungi and actinomycetes are often visible to the naked eye in the later stages of composting.

MASTER GARDENER TIP

Having a watering can or other water source nearby and a 20-inch spike thermometer makes managing a compost pile easier.

MICROBES AND TEMPERATURE

The heat generated in a compost pile arises from the activity of organisms in the pile of decomposing organic matter. Depending on a pile's size, moisture content, and the material being composted, pile temperature can rise temporarily from 100°F to 120°F and may eventually go up to 150°F or higher. However, temperatures between 90°F and 140°F promote the most rapid composting.

Once a new compost pile is constructed, the initial temperature of the pile is usually near ambient air temperature. Psychrophilic bacteria begin the decomposition process. Their activity generates a small amount of heat that increases the pile's temperature. Psychrophilic organisms populate the pile when the temperature range is low with an optimum temperature around 55°F. The temperature change they cause allows another group, the mesophilic organisms, to then populate the pile and dominate. Mesophilic organisms thrive when the temperature is between 70°F and 100°F. Mesophilic bacteria further increase the pile's temperature range and create a perfect environment for heat-loving thermophiles to thrive. Thermophilic organisms live within a temperature range between 115°F and 155°F. Most organisms in the pile die if the temperature exceeds 160°F. If the pile temperature stays high for too long, even thermophilic microorganisms won't be able to work effectively and decomposition slows down.

As compost matures, its temperature decreases naturally, allowing mesophilic bacteria to repopulate and dominate again. With continued cooling of the pile, psychrophiles and invertebrates return. Invertebrates cannot tolerate temperatures that rise above 90°F — they die, go dormant, or escape to cooler sections of the pile. They return when the temperature drops to a more tolerable level.

Because microbial activity generates the heat in a compost pile, temperature is a useful guide to understand how well the compost is progressing. Rising temperatures reflect increased microbial activity. Warm, steady temperatures indicate steady activity. Falling temperatures suggest the microbial activity is decreasing, either because the compost is nearing maturity or because of a problem, such as a lack of oxygen, moisture, or N (See "Troubleshooting" subsection in Maintaining the Compost Pile). Pile temperature can easily be measured with a dial thermometer attached to a 20-inch stem or spike. Such gauges are found online and in nurseries or garden catalogs. Table 3 indicates some simple ways to judge a compost pile's temperature level.

HOT COMPOSTING

Home compost piles tend to be small and frequently lack N. A pile may heat up quickly after adding a large load of greens, such as grass clippings, and then gradually cool down again as the N source is utilized. To keep a pile working at a high temperature like 120°F (sometimes called "hot composting"), add N periodically in the form of greens or N fertilizers (organic or nonorganic). If more raw greens are not readily available, use commercial fertilizers to raise the N level in a compost pile. An organic N fertilizer source might be blood meal, alfalfa pellets, or livestock manure. A nonorganic N fertilizer source might be ammonium sulfate (21-0-0) or another high-N type. When employing a soluble granular fertilizer, first dissolve it in water for more uniform distribution in the pile. Approximating the amount of fertilizer to use takes practice and often the heat reaction in a pile becomes a guide. For example, a bushel (about 4 cubic feet) of dry leaves requires roughly 2.4 ounces of N fertilizer. Table 4 lists a few types of fertilizer and amounts used in composting. If adding more fresh greens to the pile, use less commercial fertilizer.

Table 3. Determining approximate compost pile temperature levels. This is a rough guideline; conditions depend on several factors such as pile size, materials used, and composting stage.

Clue	Temperature Level
Material is frozen beneath the surface	Frozen — little activity
Pile feels cold, colder than the surrounding air	Low — slow rate of composting
Pile feels warm, not hot	Moderate — rapid composting
Pile is steaming and hot to the touch	High — rapid composting
Pile is hot to the touch and the material inside the pile looks or smells charred	Too high — undesirable

Table 4. Amount of various N sources needed to supply 2.4 ounces of N. Adapted from Dickson et al. 1991.

Nitrogen Source	Percent Nitrogen	Ounces of Fertilizer
Ammonium nitrate	33	7.0
Calcium nitrate	15	16.0
Urea	46	5.2
Dried blood	12	20.0
Fish meal	10	24.0

Keeping a compost pile in the range of 130°F–135°F for three consecutive days is said to destroy weed seeds and plant pathogens. In a home compost pile, it is often difficult to sustain even a temperature of 120°F, let alone a higher one. Even if a pile's core reaches 130°F, its edges will not reach the same temperature. This is one reason why turning the pile is important — the outside edges eventually need to make it into the center for the heat treatment. Adding a source of N raises the pile temperature quickly, but it also requires more turning afterwards to regulate the pile's temperature to avoid overly high temperatures.

ACTIVATORS

Any substance that speeds up biological decomposition in a compost pile is considered a compost activator. Commercial activators are available that supply N or microorganisms or both together. Sometimes called "compost starters," these activators influence the compost pile by 1) introducing strains of microorganisms that are effective in breaking down organic matter, and 2) increasing the N and micronutrient content of the pile.

The cultures of compost bacteria sold commercially (called inoculants) are reported to improve the action of a compost pile. Some people claim they see faster composting using commercial inoculants. Researchers at Virginia Polytechnic Institute and Virginia State University, however, found no difference whether or not commercial inoculants were used. Following the instructions found in this chapter for creating and maintaining a compost pile is really all a gardener needs to have composting success.

MASTER GARDENER TIP

Leave a large enough area around your compost pile to provide good air circulation and workspace.

PLACING A COMPOST PILE

Where you put a compost pile is important for several reasons. A location that provides enough space to turn a pile and stockpile raw materials for later use is ideal. Additionally, easy access to water is helpful since the pile may need to be watered frequently, especially when adding new materials and during the summer. Avoid poorly drained sites if you live in an area with frequent rain. A sheltered location for the pile in windy areas is important since wind both cools and dries a pile. Having direct sunlight on a pile is desirable because it provides warmth in winter, but sunlight can also dry it in areas with hot summer temperatures. Using trees for shade is a benefit for the gardener and pile in areas with extreme summer heat, but make sure a pile is not right next to the trunk. Roots can grow into a compost pile that is not moved or turned (passive pile). Avoid placing a pile close to a house, fence, or other wooden structures since the pile could possibly accelerate wood decay, metal corrosion, or staining of siding. Although spontaneous combustion (self-ignited fire) within a backyard compost pile is rare, it should still be considered a remote danger.

MASTER GARDENER TIP

Use the squeeze test to check the moisture level in the compost pile.

Maintaining a Compost Pile

MOISTURE

Several factors affect the composting process, but moisture and oxygen levels are two very important ones. Water serves as a medium for chemical reactions and the movement of nutrients and microorganisms within a compost pile. Water is also essential for efficient microbial action and uniform heating of the compost. Water is periodically needed if little to no rainfall has occurred or the climate has been hot or windy. The compost "squeeze test" is a simple way to gauge the moisture level of composting materials; if you squeeze tightly, you should be able to wring out a drop or two of moisture.

Although the surface of a pile may appear dry, materials a few inches below should look and feel damp. If the pile needs water, add it with a trickling hose or sprinkler. Since water moves slowly through the mass of composting materials, turning compost while adding water often helps distribute moisture. To conserve fresh water, "used" water from certain gardening (pot rinsing) or household activities (washing or cooking vegetables) could be employed. If house water is softened, limit the amount used in composting because composting concentrates the salt levels in the compost.

A moisture content of 40%–60% is adequate without limiting pile aeration. In practice, an acceptable level of moisture depends on the materials being composted. Coarse or fluffy materials such as plant stems or straw can have a higher moisture content than 60% yet still be well aerated. Absorbent materials, however, may need less than a 40% moisture content to avoid compaction or slowing of the composting process.

OXYGEN

Rapid aerobic decomposition only occurs in the presence of oxygen. The oxygen consumed by microbes during the composting process must continually be replaced by air movement through a pile. Aeration of a pile occurs naturally by diffusion and wind and when warm air (heated by the composting process) rises through the pile and draws in cool, fresh air from outdoor surroundings. Microorganisms in a compost pile thrive at oxygen levels greater than 5% (fresh air is approximately 21% oxygen). To maintain adequate oxygen levels, periodic turning of the pile is important. Turning aerates the pile, helps remove heat, and removes excess water vapor, carbon dioxide, and other gaseous products of the composting process. Inadequate oxygen levels in the pile can lead to anaerobic conditions. This type of composting is slow, produces little heat, and creates odorous by-products.

MASTER GARDENER TIP

Improve organic matter degradability by chopping or shredding to reduce the particle size of materials.

DEGRADABILITY, PARTICLE SIZE, AND POROSITY

The nature of the materials added to a compost pile determines the speed at which decomposition occurs. Degradability and particle size are linked. Grass clippings, manure, and food scraps are highly degradable items. If they make up more than one-quarter of a pile's volume, the pile will need to be turned regularly to prevent compaction. Tough materials that contain large amounts of cellulose and lignin, like plant stems, straw, wood, and pine needles, require chopping or shredding to reduce particle size and to help accelerate decomposition. Wood often passes through the composting process with little change. However, paper, a wood derivative, decomposes quickly due to the processing it undergoes during the papermaking operation.

Most microbial activity occurs along particle surfaces, where oxygen is readily available. Because surface area increases as particle size decreases, chopping or shredding materials speeds up decomposition. Cutting up whole pieces of fruit or vegetables destroys the protective barrier of the skin or peel. Maintaining the particle size between ⅛ inch to 2 inches is key to ensuring materials are composted. Pieces that are smaller than ⅛ inch decrease pore size and pile structure, which can restrict aeration.

The compost pile's porosity affects oxygen as well as moisture content. Porosity is a measure of the spaces between particles within the pile. These spaces provide a path for air circulation. Porosity suffers when the material in the pile becomes overly wet and heavy or compacted. Adding coarse items such as straw or chopped-up cornstalks helps increase porosity in a compacted pile.

MASTER GARDENER TIP

Investing in a four-tined potato fork makes turning a compost pile easier than using a shovel.

TURNING THE PILE

Several common farm tools are used to turn a compost pile, like a pitchfork, a shovel, or a flat four-tined potato fork (sometimes called a garden fork). The last is easy to work with because of its shorter handle and handgrip. It is more maneuverable in tight spaces than any long-handled tool.

Turning a compost pile performs several beneficial functions. As the pile shrinks in size and begins to settle, turning fluffs it up, increases porosity, and allows oxygen back in. It can also break up clumps and blend materials. Turning the outer edges of the pile into the center is especially important to ensure that all parts of the pile have a chance to undergo the heat necessary to kill weed seeds and pathogens.

How frequently a pile is turned is up to the gardener. A pile can be turned every time fresh materials are added or in response to a pile's condition, such as a lack of moisture or odors developing. Turning gives

the gardener a chance to add moisture when needed or to add browns when a pile becomes too wet. If the pile's temperature has risen too high (above 140°F), turning cools it. If the temperature continues to climb too high even after turning, **do not** add water since this can exacerbate the problem. Instead, flatten or scatter the pile to cool it, then rebuild it into two smaller piles, using more browns to offset the overabundance of greens or N that was added. Frequent turning is of little benefit with slow decomposing materials like wood or when the C:N ratio is high due to too many browns. These materials just need more time to decompose.

With highly degradable and shredded materials that have adequate moisture and oxygen levels, and a proper C:N ratio, daily turnings may finish up a pile within a few weeks. Weekly or monthly turnings are more realistic and can yield finished compost in about 2–4 months. Without any turnings, a passive pile on the ground may take as much as 1–2 years to decompose. To speed up a pile that is not turned frequently, add aeration by raising the pile off the ground. Construct the pile on top of a raised wooden platform or on a pile of branches. Adding a bundle of dried cornstalks or perforated 4-inch plastic PVC pipe vertically into the center of the pile also helps aerate it.

MASTER GARDENER TIP

Generally, smells in a compost pile are caused by too much moisture or too much N or greens.

ODORS

Most backyard composting presents little risk of odor development. Still, it can occur because of the wrong combination of materials used in a pile or poor pile conditions (too wet or compacted). The best way to manage odors is to correct whatever is causing them right away. Turn the pile at the first hint of an objectionable odor. An ammonia-like smell tells you the compost is immature and has too many greens; add some browns and continue the composting process. If the pile has become soggy, add some coarse carboniferous materials. In an area where it rains frequently, a plastic tarp might be needed to cover the pile.

Anaerobic bacteria are responsible for unpleasant smells, but they cannot live in an oxygenated environment. That is why turning the pile regularly is important. One gaseous product that is produced under anaerobic conditions is hydrogen sulfide, which smells like rotten eggs. Other odorous products that may form in the pile have aptly descriptive names like putrescine or cadaverine. If a pile has turned anaerobic **do not** add water or greens. Disturbing the pile releases a strong burst of odors, while leaving it undisturbed results in fewer odors released gradually over time. Instead, cover the pile's surface with an insulating, odor-absorbing layer of coarse dry materials. The smells should gradually dissipate as the pile decomposes. When the pile becomes more tolerable to work, make a new pile.

MASTER GARDENER TIP

Position your back to the wind when turning a compost pile and wear a mask if you have respiratory concerns.

SAFETY HAZARDS

All outdoor activities and sports have built-in safety issues and composting is no different. Potential of fire (see Placing a Compost Pile) and odors have already been discussed. Because of the many dry materials used or stored near composting sites, avoid smoking in composting areas. Since composting deals with fungi (yeast and molds), various microorganisms, and plenty of dust and airborne particles, wear a mask and keep your back to the wind when building, turning, or harvesting the pile. Aspergillosis is a fungal infection or allergic response that some people have after contacting the *Aspergillus* genus of fungi. It most often occurs in those with suppressed immune systems. Wearing a mask and rubber gloves and washing your hands after handling compost are simple sensible precautions. Repetitive lifting of a heavy-loaded fork or shovel can cause muscle aches or injuries if a gardener does not have adequate strength or uses improper body alignment. Lift only amounts that you feel comfortable with and, if necessary, turn a pile less frequently if muscle strain develops.

TROUBLESHOOTING

The most prevalent problem associated with backyard composting is slow decomposition. The first suspected cause is excessive drying of the pile, followed closely by a lack of N or greens. Poor aeration from overly wet or compacted materials also hinders the rate of composting or allows odors to develop. Other occasional difficulties include visiting pests or too high a temperature from an overabundance of greens. Table 5 lists various ways to identify and remedy composting problems.

MASTER GARDENER TIP

To have a quality compost product, start with an adequate ratio and volume in the pile, consistent moisture, and good air circulation.

Table 5. Troubleshooting guidelines for a compost pile. N, nitrogen; C, carbon.

Problem	Possible Causes	Clues	Remedy
Rotten odor	Anaerobic conditions because of excess moisture	Pile feels and looks soggy	Turn pile and/or mix in dry materials
	Anaerobic conditions because of poor porosity and compaction	Pile looks dense, matted, or slimy with few or no large particles	Turn pile and/or mix in coarse brown materials — straw, chipped wood, etc.
Ammonia odor	Too much N; not enough C	Pile includes a lot of grass, food scraps, or manure	Mix in browns — C-rich materials.
Slow decomposition	Not enough moisture	Pile is barely damp to dry inside	Add water and/or wet materials and turn pile
	Not enough N or slowly degradable materials	There is an abundance of brown materials in the pile — wood, straw, etc., pile is not dry	Add greens or N fertilizer, shred materials more, be patient, wood takes longer
	Not enough oxygen — anaerobic conditions	Pile is dense and looks matted or slimy, with hint of rotten odor	Turn pile and add coarse or dry material as needed
	Pile is cold — small volume	Pile is less than 3 feet high, weather is near freezing	Add fresh material, turn pile, increase pile size
	Pile is totally frozen	Frozen clumps within the pile	Wait for spring, then turn pile
	Compost is mature	Pile conditions are good	None needed
Not reaching high temperatures (over 120°F)	Small volume	Pile is less than 3 feet high	Increase pile size
	Not enough N	Pile is more than 3 feet high, weather is above freezing	Add green material or N fertilizer
	Cold weather	Pile is more than 3 feet high, weather is below freezing	Insulate top of pile with compost, straw, leaves, etc.
Pile is too hot (over 140°F)	Pile is too large	Pile is more than 5 feet high	Divide into smaller piles
	Not enough airflow — poor ventilation	Pile is less than 5 feet high, but dense and moist	Turn pile and decrease pile size
	Pile is becoming too dry. Not enough evaporative cooling.	Pile is less than 5 feet high and only slightly damp	Add water and turn pile
Pests attracted to compost pile (flies, bees, dogs, cats, rodents, skunks, etc.)	Exposed food scraps	Food scraps at or near surface of pile	Bury food 8 inches beneath the pile surface
	Meat, fish, or oily foods in pile	Evidence of digging in pile	Remove food from pile or move it into center of pile center. Use a pest-proof composting bin.

Containing the Compost

STATIONARY AND MOVABLE BINS

Bins are managed the same as a freestanding pile, but they neatly hold the compostables and may allow a gardener to stack materials higher because their design is more self-supporting. Inexpensive compost bins can be made from readily available materials and, depending on their design, they can be built tightly enough to discourage animal pests or to incorporate a roof or lid that seals out the rain.

A wide variety of bin designs are available. They differ in cost, construction materials, method of ventilation, and ease of turning. Some require an effort to build while others need little assembly. Composting bins are divided into **stationary holding units** that allow materials to compost in place and **temporary holding units** that are made light enough to disassemble and move, which facilitates compost turning. Once a bin is taken apart, moved and reassembled, compost can be turned back into it or harvested if finished. Some gardeners use temporary turning units as stationary holding units.

Temporary holding units are generally made of light construction materials. Some common building materials for these types of bins include woven-wire fencing, wood-slat fencing (snow-fence), wooden pallets, or even scrap lumber. A bin made from snow fence materials is simple to make and works more effectively with support posts at each corner (Figure 3).

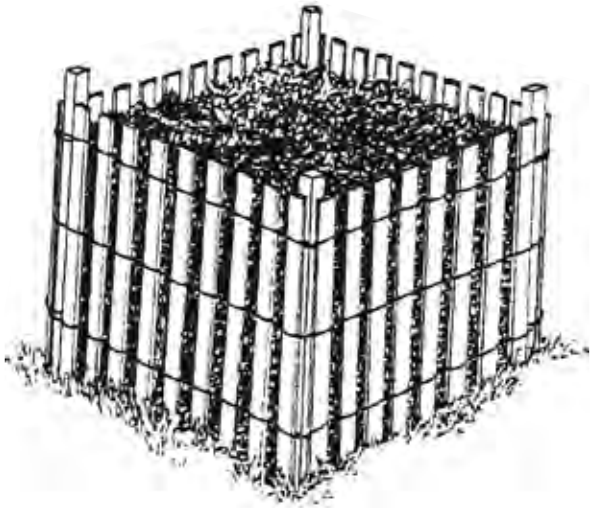

Figure 3. Snow fence–holding unit.

To construct an inexpensive wire mesh bin, use galvanized chicken wire, pig wire, or hardware cloth (sometimes called welded wire mesh). The openings in hardware cloth are smaller than chicken or pig wire, typically between 0.25 and 0.5 inch. Nongalvanized wire can be used, but it will not last as long. Attach the circle of wire to a wooden slat or t-post to provide more stability (Figure 4).

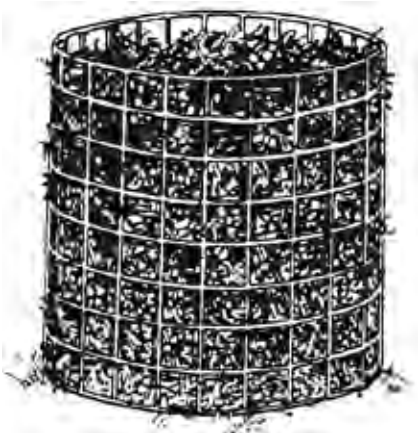

Figure 4. Wire mesh–holding unit.

Stationary holding units are usually more substantially constructed with thicker boards (Figure 5), stacked landscape timbers, bricks, or concrete cinder blocks. They are not intended to be moved. Stationary bins incorporate some access for turning and removal of compost such as one open side or removable boards on one wall. Whichever design is chosen, the bin should allow airflow through all sides.

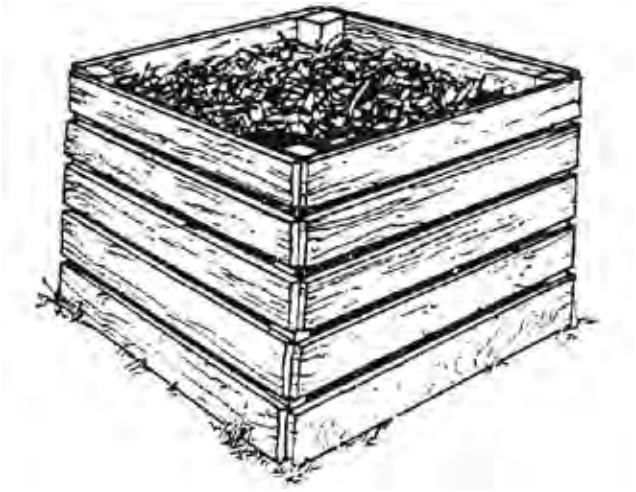

Figure 5. Wooden-pallet holding unit.

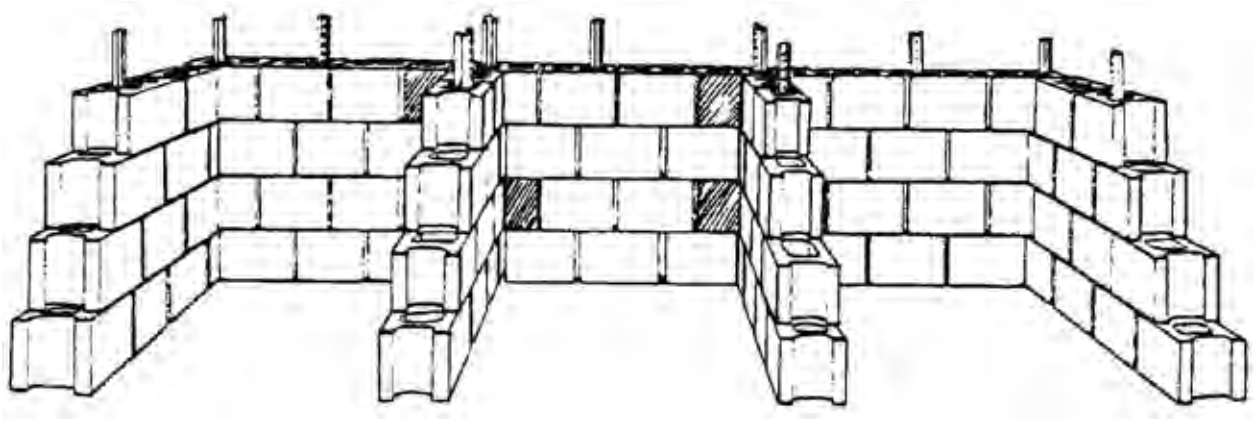

Figure 6. Concrete-block three-bin turning unit.

A bin made of concrete blocks with an open front is sturdy, durable, and easily accessible. Leave at least ½ inch between each block for air movement and stagger the joints. Driving metal rebar or t-posts through the upturned holes in the blocks stabilizes the bin (Figure 6).

A series of three connected bins is a popular design. One bin could hold fresh materials ready for use, a second might hold actively composting material, and a third could store finished compost. Another idea is to alternate turnings between two of the units, leaving one open to receive compost, and reverse the order next time.

MASTER GARDENER TIP

A purchased tumbler unit is an attractive way to compost in a small area, especially for those living in subdivisions that may have open compost pile restrictions.

ROTATING BARRELS AND DRUMS

Rotating barrels (sometimes called tumblers) eases the burden of turning a compost pile because a user spins the compost via a hand crank, tumbling the collection end-over-end. The idea is that because barrels make turning more effortless, users will do it more frequently, thus speeding up the decomposition process. Achieving finished compost quickly is determined by more factors than just frequent turning, however, including size of the materials, their degradability, proper moisture and oxygen levels, and a proper C:N ratio. Because there is no contact with the ground in a barrel, adding a shovelful of soil to the compostables helps increase the diversity of microbial life in the compost. All rotating compost units include some form of aeration holes built into the unit, interior baffles to move the materials, and loading/unloading doors.

Rotating units are handy and compact, but they are not reliable for hot composting due to the difficulty of reaching and maintaining high temperatures within the barrel's limited volume. Materials break down, just more slowly. Some commercial manufacturers claim their rotating compost units can produce finished compost in two weeks, but four weeks is more realistic. Since barrels and drums are closed containers, they keep compostables out of sight, which is a plus for urban areas or subdivisions with restrictions to open compost piles.

Many commercially manufactured rotating compost bin models are available. Most attach to a metal support structure that raises the barrel aboveground so it can be turned (Figure 7). One type rests on a very low platform only inches aboveground.

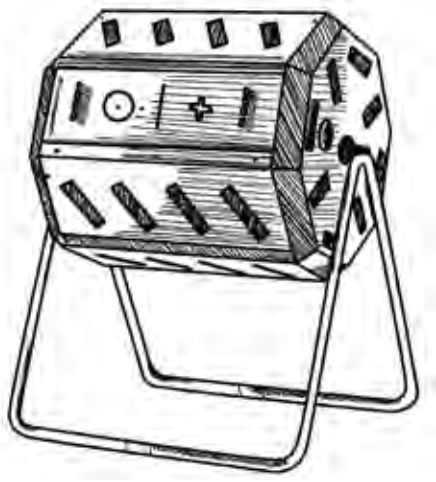

Figure 7. Rotating compost bin.

Its platform has built-in wheels that help rotate the barrel right onto the platform. Another model uses a solar-powered electric motor to rotate its drum. A few other types sit directly on the ground, rolled or pushed end over end to turn the compost.

WHEN IS COMPOST FINISHED?

Judging when a pile reaches the finished point is part of the art of composting. Composting does not really stop at a particular point. The biological decomposition of raw materials continues almost indefinitely until it becomes stable humus in soil. Compost becomes usable and considered finished or mature when the decomposition rate slows so much that the product no longer feels warm, does not create odors, nor adversely affect plants it is used around. To be safe, allow the finished compost to cure in small piles about 3 feet high for a month or two after you judge the process to be complete. Signs of a mature or finished compost include the following:

1. The compost is consistent and has a dark brown color, crumbly texture, and earthy odor.
2. Except for pieces of wood, the compost shows little evidence of the original materials added to the pile.
3. The moist pile remains cool and does not become warmer after turning.
4. Earthworms and other invertebrates have inhabited the compost pile.
5. The moist compost does not develop offensive or stale odors when stored in a closed plastic bag at room temperature for two weeks.

Benefits of Compost

The addition of compost improves soil structure, giving soil a crumbly look and feel. It also increases its porosity and organic matter content. When mixed with sandy soil, compost improves the moisture and nutrient-holding capacities. In heavy clay soil, compost particles bind with clay particles to form loose aggregates of soil that drain better and resist surface crusting and erosion. Most finished compost will have a near-neutral pH and the ability to buffer pH changes in a soil.

Although compost is not considered a fertilizer, it contains trace minerals and small quantities of major plant nutrients like phosphorus and potassium. The amount of nutrients in the compost depends on the materials composted. Nitrogen concentrations can be in the range of 0.5%–1% with phosphorus and potassium ranging from 0.2% to 0.5%. Most of the N and phosphorus are released slowly, over a period of several years, and in a pattern that tends to follow the growth patterns of plants.

Compost contains a large and diverse population of biological organisms plus organic matter that attracts earthworms and other beneficial soil organisms. This trait contributes to a compost's ability to help suppress certain soilborne plant diseases. In general, the addition of compost to most soil types improves soil health.

MASTER GARDENER TIP

Finished or mature compost is often called *humus* by gardeners, although it differs greatly. According to soil scientists, humus is a complex stable component found in native soils.

How to Use Compost

Finished compost can be used in many ways: as a mulch around trees and shrubs, as a soil amendment for gardens and landscapes, as top-dressing after core aerating a lawn, and as a component of potting soil (Table 6). Added to soil, compost benefits plants and soil structure, but using unfinished compost or compost stored under anaerobic conditions can harm seedlings and sensitive plants.

MULCH

Compost applied as mulch is placed on the top of the soil. Mulching helps reduce moisture loss, soil temperature, and suppresses weeds, while also providing supplemental organic matter and nutrients. Microorganisms in the soil slowly integrate and decompose the mulch into the soil. Compost is a good choice for use around trees and shrubs due to its soil-enhancing qualities. Apply woody composts to a layer of 2–4 inches. If the compost is finely textured, use only ½–2-inch-thick layer to provide oxygen flow to the root zone. Keep the mulch several inches away from the tree or shrub trunk to reduce the risk of decay or smothered roots.

Table 6. Amounts of compost to use. Helpful numbers: A 1-inch-deep layer covering 1,000 square feet requires about 3 cubic yards of compost. Compost weighs about 30–40 pounds per cubic foot (about 800–1,000 pounds per cubic yard).

Landscape Use	Approximate Application Rate (lb/1,000 sq ft)	Equivalent Thickness of Compost	Comments
Soil amendment for gardens and lawn establishment	3,000–9,000	1–3 inches	Mix with soil to a depth of about 4–9 inches. Use more compost for poor soils.
Soil amendment for planting trees and shrubs	3,000–9,000	1–3 inches	Mix with soil over an area of 2–5 times the root-ball width and to a depth of 6–10 inches. Use more for poor soils.
Top-dressing for lawns	400–800	⅛–¼ inch	Broadcast evenly over lawn surface. Best applied after thatching or core aerifying.
Top-dressing for gardens and shrubs	400–1,500	⅛–½ inch	Spread evenly then lightly work into the soil.
Landscape or garden mulch	1,500–6,000	½–2 inches	Spread evenly over surface. Use the higher rate with coarse woody composts.
Potting mix	Not more than one-third by volume		Blend with peat moss, sand, perlite, vermiculite, or bark.

SOIL AMENDMENT

Compost applied as a soil amendment can be used at any time of the year. In spring it add it as a soil amendment when preparing a garden bed or lawn area before planting. Mix compost into the soil to a depth at least three times the depth of the compost layer (for example, mix a 1-inch-thick layer of compost into the top 3–4 inches of soil). If only a small amount of compost is available, incorporate it into seed furrows or mix with the backfill soil for each transplant following the 1:3 compost-to-soil ratio.

TOP-DRESSING

Screen top-dressing compost to ¼ inch or smaller. Compost can easily be made uniform in size by sifting it through a welded wire-mesh screen with ¼-inch openings. Although compost with larger particle sizes is acceptable to use in a garden area as a soil amendment, avoid compost with a high percentage of wood since soil microbes will compete with garden plants for N to break down the wood. Gardens amended with woody compost require extra applications of N fertilizer to offset the N deficiency that the plants will show. This deficiency problem is usually evident in raised beds and gardens where an excessive amount of woody compost or raw plant materials are used to create the soil. In an undisturbed compost pile, small particles often tend to settle to the bottom, leaving wood pieces on the surface of the pile. Collect the woody compost to use as another source of mulch around trees and shrubs in the landscape.

Other Methods of Composting

SHEET, PIT, AND TRENCH COMPOSTING

Composting directly on or in soil works well for those who have small amounts of organic materials to recycle. Soil is rich in microbes, so decomposition should not take too long. Sheet composting is the process of spreading shredded organic materials on the soil surface in fall, as though it were a mulch, and allowing them to break down through the fall and winter into spring. These materials can be tilled into the soil although it may not be necessary. If it is objectionable for you or your neighbor to view these raw materials, cover them with a light layer of straw.

Pit composting is a way to dispose of small amounts of kitchen or yard scraps. It can be done any time the ground is not frozen. Simply dig a 12-inch hole (or deeper), add the items, cover them with at least 8 inches of soil, and let the soil microbes work on them. Choose different locations in your garden for the pits.

Trench composting is especially easy if a garden is planted in rows. Bury organic materials in narrow trenches next to planting rows (Figure 8). Rotate the trenches so that last year's planting rows become this year's trenches. In time, the entire garden may eventually be amended with "in-ground" compost.

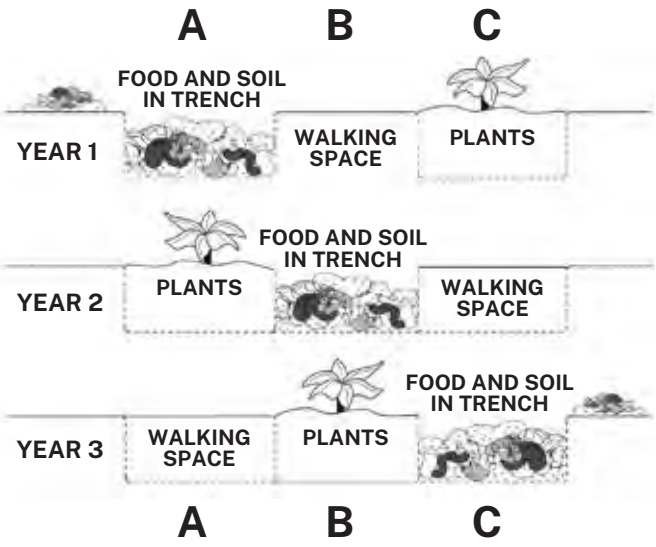

Figure 8. Soil incorporation of food scraps—rotating-trench method among food trenches, rows of crops, and walkways.

HÜGELKULTUR

Hügelkultur (pronounced hoo-gul-culture) means "hill culture" or "hill mound." This type of composting involves building up a raised bed or mound of organic materials. Start by digging a 1-foot-deep trench, fill it with logs and branches, and next add greens and browns like green and dried leaves, straw, grass clippings, cardboard, newspaper, wood chips, and aged manure. Once the mound is built to the desired height, cover it with six inches of soil, planted and mulched like a regular raised garden bed.

The gradual decay of the wood is said to be a long-term source of nutrients and as it composts, it generates heat to extend the growing season for the plants growing above it. Also, the logs and branches act like a sponge, storing rainwater during drier times. Hardwoods break down slowly and last longer while softwoods disintegrate more quickly. Woods that should not be used in the bed are walnut (juglone toxin), black locust (will not decompose), and redwood (heartwood will not decompose). The disadvantage to Hügelkultur is that the breakdown of wood uses much of the N from the pile so it will need to be added back in.

BOKASHI

Bokashi is an anaerobic option that breaks down kitchen waste by fermentation. The Bokashi mix is made with wheat bran, molasses, water, and a type of microbe called "elective microorganism" and applied to the waste in a sealed airtight container. Once the material completely ferments, the leftover solids are buried outdoors, where soil microbes finish decomposing them. The kitchen waste can include meat, bones, fats, and dairy products.

The equipment required is two straight-sided buckets, a tight-fitting lid and the bokashi culture to start the decomposition process. Drill holes in the bottom of one of the buckets to allow the liquid created to drain into the lower bucket and place it on top of a brick or other block that is inside the bucket without the holes. This allows the collected liquids to be used outdoors to amend the soil. The collected liquid has a high acidity level and is carefully diluted at a ratio of 1 part collected liquid to 100 parts fresh water. The remaining solids are pit composted.

The benefit of using this fermentation process is that meat, fat, and bones can be decomposed. The Bokashi composting fermentation process is completed in a couple of weeks; however, the entire composting of the leftover items in the soil takes several months and you cannot plant near where the fermented material is buried.

VERMICULTURE (WORM COMPOSTING)

Worm composting (vermiculture) relies on worms to digest paper, manure, and vegetation (mostly vegetable and fruit leftovers). During the breakdown process the worms leave behind their manure (castings) that are a high-quality soil amendment called **vermicompost**. Worm composting is a suitable option for apartment buildings or homes without yard space. The worms live in an enclosed bin that gives off very little odor (Figures 9–11). The type of worms used for vermicomposting are red worms (*Eisenia fetida*), not the common soil-dwelling earthworms that most people are familiar with. Red worms need a dark, cool, moist, and aerobic environment. Mix their food and bedding in shallow layers in a closed box or bin. The bedding provides a light, airy habitat for the worms to move around in and they eat the food provided. Putting bedding material on top of their food helps reduce fruit fly populations from entering the food. Typical bedding materials include shredded paper, straw, peat moss, and sawdust. Do not use paper that has a sheen or plastic coating.

Keep the bin in a cool place. Many keep it under the sink in the kitchen for convenience, but a basement is a good location as well. Worms live and work effectively at temperatures between 50°F and 70°F (10°C–20°C). If the bin freezes or gets too hot, the worms die. Knowing when to harvest the bin contents is often done by sight. When the material in the bin becomes uniform, dark, and soil-like in texture, harvest it and use the compost. This usually takes 3–6 months. To learn how to properly remove the worms from their rich vermicompost, check the references at the end of this chapter or those in online sites.

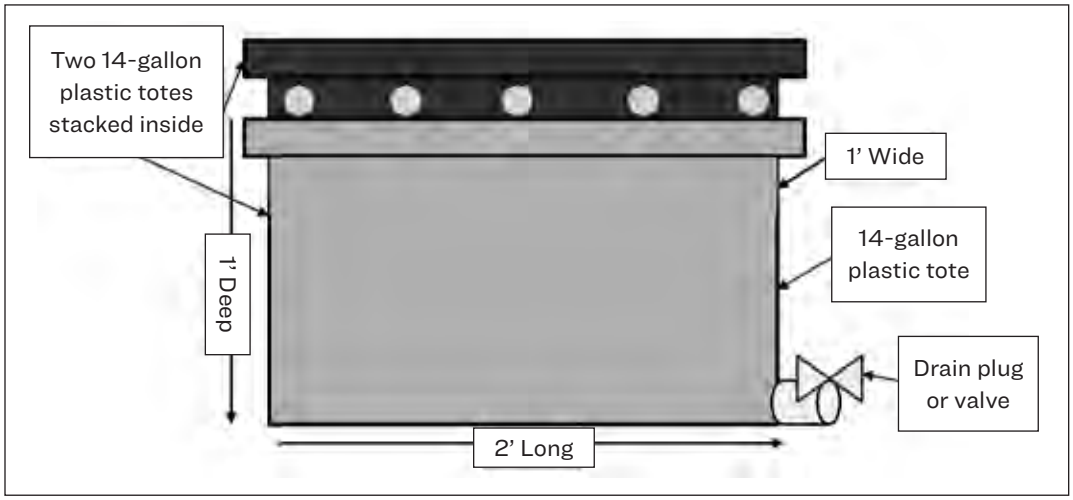

Figure 9. Side view of fourteen-gallon double-stacked plastic tote diagram. Adapted from Angima et al. 2011.

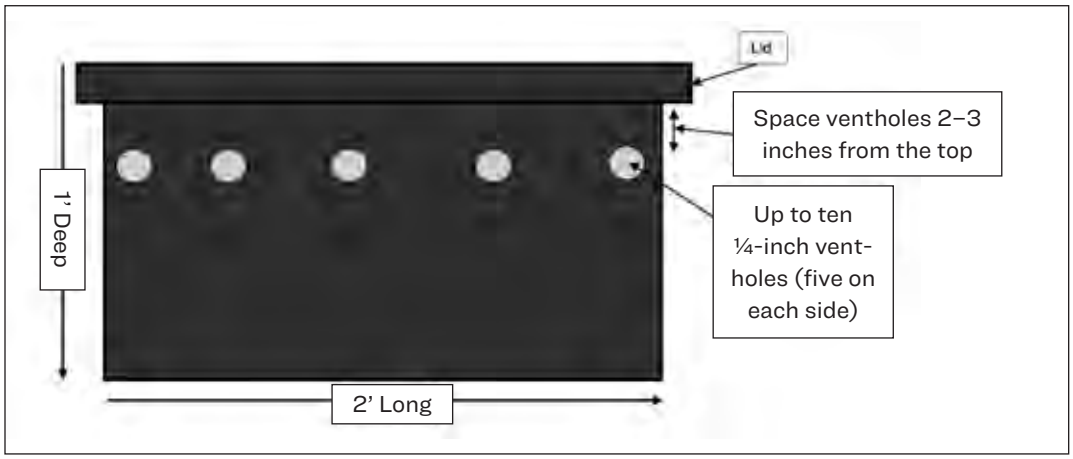

Figure 10. Side view of inner fourteen-gallon tote. Adapted from Angima et al. 2011.

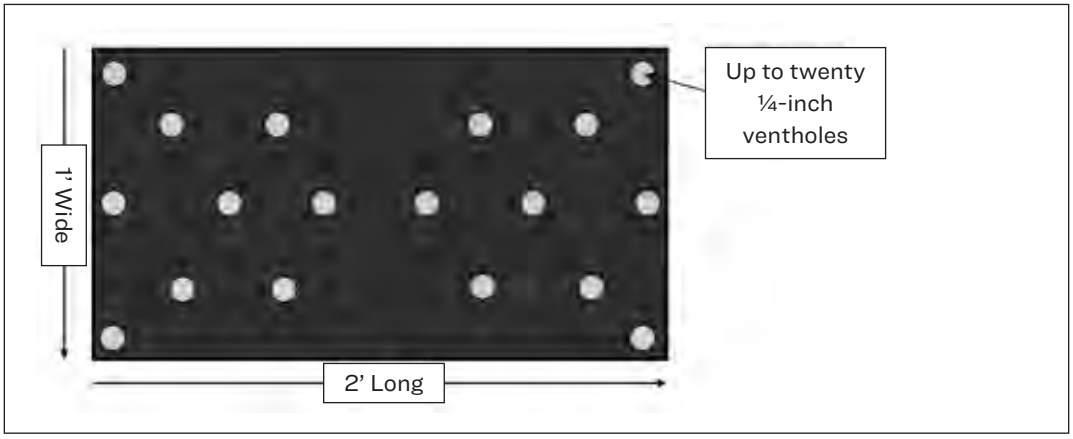

Figure 11. Bottom view of inner fourteen-gallon tote. Adapted from Angima et al. 2011.

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BOOKLETS AND PAMPHLETS

University of Idaho Extension

BUL 982 *Vermicomposting at Home*

CIS 1016 *Don't Bag It! Recycle Your Grass Clippings*

CIS 1066 *Composting at Home*

CIS 1194 *Composting and Using Backyard Poultry Waste in the Home Garden*

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CHAPTER **NINE**

USING PESTICIDES SAFELY

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9 USING PESTICIDES SAFELY

Learning Objectives

- Define the term *pesticide*.
- Summarize how to prevent pesticide resistance.
- List where to find personal protective equipment (PPE) on a label.
- Calculate the total amount of a pesticide mixture.
- Restate pesticide properties and movement.
- Explain how to hire a professional applicator.
- Record important numbers and information.
- Complete the reading of the pesticide label activity.

Introduction

Pesticides are used to destroy, repel, suppress, mitigate, or otherwise control an unwanted organism in our environment, one that is in the wrong place at the wrong time. To some gardeners, this may include powdery mildew in an orchard, a dandelion in a lawn, or an aphid colony eating through a kale patch. This chapter by no means enables you to be a pesticide specialist, but it will help you to understand the best practices for pesticide use, safety, and stewardship.

Pesticide Use

LAW AND REGULATION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) establishes federal regulatory authority for the use, sale, and distribution of pesticides. In 1970 the United States Environmental Protection Agency (US EPA) was created to protect and treat air, water, and land as an interrelated system. That same year, the US EPA was charged with the enforcement of FIFRA. Under the authority of the US EPA,

the Idaho State Department of Agriculture (ISDA) oversees the enforcement of pesticide use and regulations within the state of Idaho.

As consumers purchasing a pesticide product, we enter a legal binding contract with a pesticide company to follow the product's labeled instructions. The label is the law. Master Gardeners (MGs) should be able to understand the elements of a pesticide label and explain them to a homeowner. If MGs make pesticide recommendations to the public, they need to follow all the labeling directions and requirements.

MASTER GARDENER TIP

You may need to invest in a small magnifier because pesticide labels are printed in very small fonts.

Researchers conduct extensive studies that often cost millions of dollars to ensure the efficacy and safety of each pesticide product. Every product that is registered as a pesticide with the US EPA must comply with FIFRA regulations and Idaho's pesticide law, regardless of whether it is an **organic** or a conventional pesticide. Pesticides are registered as one of two types: those for general use and those for restricted use.

Anyone can purchase and apply general-use pesticides. To purchase and apply restricted-use pesticides, however, an individual must possess a pesticide license and be eighteen years of age. This requires passing a state-regulated exam and undergoing a certification process conducted by the ISDA. MGs, who help communities and homeowners to recognize pest damage and identify pests and the stages of a pest's life cycle (and the best pest control method to choose), can only recommend general-use pesticides for use by homeowners. They must be University of Idaho MG–certified, meaning they have successfully completed MG pesticide policy training and follow their county's procedures.

MASTER GARDENER TIP

Pesticides are tools that help gardeners to manage pests that have become a problem. If you are using the wrong tool (or wrong pesticide), your efforts will prove ineffective.

PEST MANAGEMENT

Bactericides kill bacteria, fungicides kill or prevent fungus and mildews, herbicides control weeds and other plant materials, insecticides kill insects, and so forth. Choosing and using the best one as part of an Integrated Pest Management program gets you one step closer to gaining the upper hand on any pest. Refer to Table 1 for the appropriate pesticide to use to improve the health of your garden and landscape setting.

Table 1. Types of pesticides and the pest they control.

Pesticide	Targeted Pest
bactericide	bacteria
fungicide	mildew and other fungi
herbicide	weeds
insecticide	insects
miticide	mites
molluscicide	slugs and snails
nematicide	nematodes
piscicide	fish
rodenticide	rodents (mice, rats, voles, gophers, etc.)

Other good reference sources for pest management methods to add to your library are the Pacific Northwest (PNW) Pest Management Handbooks published by University of Idaho, Oregon State University, and Washington State University. This is a collaborative resource for pest management information. These handbooks provide useful information about both horticultural and agricultural pest management practices.

PESTICIDE PRODUCT TYPES

Pesticides are either selective in targeting a specific pest or nonselective (sometimes called broad spectrum). Broad spectrum insecticides can eliminate all insects, including beneficial ones, so apply them carefully to prevent further insect pest outbreaks. You do not want to inherit the work of beneficial insects! The most common pesticide products homeowners apply include the following:

Bactericides

In addition to bactericides for plant protection, bactericides are commonly found in household products such as disinfectants. These products are labeled as pesticide and are registered through the US EPA.

MASTER GARDENER TIP

Use these products to keep your garden tools clean and sanitized (follow the label's instructions and wear the required protective equipment). Routine sanitation practices reduce the chance that plant diseases will spread in your garden or landscape.

Fungicides

Fungicides are used to prevent and control fungal infestations. Some fungicides are systemic, working from the inside of the plant to control an infection that has already occurred. This prevents further spread of the disease. Other common fungicides are protectants that prevent the infection and establishment of a possible fungal disease. Protectant fungicide must be reapplied on new plant growth or after rainfall and overhead irrigation. Many fungicide products are available as premixes that contain both a systemic and a protectant. These products protect the plant with the two types of fungicides and help to prevent fungicide resistance.

MASTER GARDENER TIP

If a gardener has a problem with fungus in their landscape, investigate their watering and planting practices. They may be creating their fungal problem.

Herbicides

Herbicides affect plants differently, depending on the chemical properties and how the herbicide attacks the weed, qualities collectively called the mode of action (MoA) of a herbicide. Herbicides generally control weeds as a preemergent, attacking underground weed growth when germination occurs, or as a postemergent, after the weed has begun growing. Preemergent herbicides are applied to the soil before weeds emerge. Postemergent herbicides are applied directly to the weeds after they have emerged. Proper spray coverage is important for good weed control. Some herbicides may be persistent in the soil and will not break down quickly. They can remain active in the soil for several weeks. Check the herbicide label to determine what plants can be sown into the treated area. Otherwise, plant/crop damage can occur.

MASTER GARDENER TIP

When a homeowner client wants to control a weed, identify the weed species accurately and understand its life stage. Consult the PNW Weed Management Handbook for a list of management options and herbicides recommended for the weed species and life stage.

Insecticides

Insecticides attack insects in several ways. Stomach-poison insecticides must be ingested as an insect feed. These products are used to eliminate insects with chewing mouthparts.

Other insecticides, classified as contact poisons, penetrate an insect's outer membrane or enter through its respiratory tubes or spiracles. These products must be sprayed directly on an insect.

When insecticides are absorbed and translocated throughout a plant you are protecting, they are called systemic insecticides. They are especially effective against insects with piercing-sucking mouthparts.

Broad-spectrum insecticides kill many insects or other arthropods; however, they also destroy predator insects. The smart gardener retains these predators by using selective insecticides that control the insect pest. These products control fewer but more biologically similar insects. Other selective insecticides are repellent products that discourage insects from eating plant materials and pheromone products whose chemical makeup confuses insects from mating properly.

Because there are many types of insecticides on the market, we recommend you seek advice from a county educator or consult the PNW Insect Management Handbook. Insecticides are crucial to pest management because insects can take down any untreated single plant or tree.

MASTER GARDENER TIP

When a homeowner wants to control any insect, identify the insect species and understand the life stage of the insect. Consult the PNW Insect Management Handbook for a list of management options and insecticides recommended for the insect species and for information on proper insecticide timing and coverage.

ACTIVE INGREDIENTS

Pesticide concentrates are formulated products that contain different combinations of ingredients. The **active ingredient** is the working portion of the product that controls the pest problem. Other ingredients, called inert ingredients, are added to the active ingredient to enhance its performance. For instance, surfactants help pesticides to adhere to plant surfaces. For science-based pesticide information, contact the National Pesticide Information Center (NPIC).

Because homemade remedies and concoctions are not labeled for pesticide use, Idaho MGs cannot recommend these products. Be sure to complete the Idaho MG Pesticide Policy module and sign the MG Pest Management Agreement prior to making any pesticide recommendation.

MASTER GARDENER TIP

All recommendations must follow the pesticide label to ensure that the host plant or application site and the pest is listed on the manufacturer's label.

RESISTANCE

Most pests can rapidly reproduce in favorable environmental conditions. Pests that produce multiple generations in a season have a better chance of developing **pesticide resistance** if repeatedly exposed to the same group of pesticides. Some individual pests have the natural ability to survive a pesticide application. Those that do may produce offspring or seeds with the same genetic traits, thus hastening the development of a pesticide-resistant population. Rotating pesticide products with a different MoA will play a role in thwarting resistance. In agricultural settings, it's a particularly vital strategy, so rotate the pesticides every two years to keep exposure to the same MoA at a reasonable minimum. When you notice poor results from a pesticide application, pesticide resistance may occur or it may be an application problem. Investigate it to rule out one or the other. It is very important to identify potential pesticide resistance early.

Understanding Pesticide Mode of Action

MoA influences the development of resistance in pests and refers to a cellular process interruption of a particular function in the pest. It involves how a pest ingests or absorbs the toxin, how it metabolizes it, and how it physiologically responds to the poison. Site of Action (SoA) is another resistance-related term, used by weed scientists, to describe the specific "site" or area in a weed where the herbicide interferes with the plant's growth and development.

Most pesticide labels contain a numerical resistance code to manage your pesticide choices. This helps to discourage resistance development. Pesticides are grouped by the MoA codes. These codes are determined by three international bodies of scientists and pesticide manufacturers based on the pesticide's "mode of action" and the specific site or target on the pest. The international MoA codes are located on the front panel of all pesticide product labels. Pesticide applicators use the designations to help them avoid purchasing and using pesticides from the same group. Rotating MoA groups is one of the best tactics to prevent pesticide resistance. MoA and SoA codes are available online through the PNW Handbooks or Resistance Action Committees (see "Resources").

FORMULATIONS

The pesticide formulation is a mixture of active and other (inert) ingredients designed to prevent, kill, or repel pests. Pesticides are sold in many different types of formulations to make the products easier to measure and use. Most liquids are concentrated and require dilution in your spray tank before application. Those that are ready-to-use, however, do not require dilution. The "ready-to-use" products have a very low percentage of active ingredients, making them much more expensive than the concentrates. These products are convenient for some homeowners who may have small areas to spray and who do not like to mix pesticides or clean out the sprayers.

Dry pesticide products include dusts, powders, granules, and baits; some require mixing with water to apply as a spray mixture and some are ready-to-use. Weed and feed products are a common example of ready-to-use granules. Whichever type you choose, look for one that will control your problem pest but is the least toxic to humans, pets, bees, other beneficial organisms, and the environment. See Table 2 for the advantages and disadvantages of formulations.

Accurate measurements must be precise when using concentrations. An efficient and effective application must be measured and mixed according to the label directions. For liquid formulations, measure by volume in the proper graduated measuring container.

Conversely, for dry formulations, measure by weight using a scale for accuracy. Ready-to-use products reduce the need to purchase specialized equipment and the incidence of mixing errors.

A home-brewed remedy is not labeled for pesticide use and MGs cannot recommend them. See the Idaho MG Pesticide Policy training module housed on the Idaho MG Pesticide Safety Education course site at **https://campus.extension.org/course/view.php?id=926**. This must be successfully completed prior to MG certification.

MASTER GARDENER TIP

If you purchase only what you need, you will save money, reduce storage issues, and rotate through the products more easily.

BIOPESTICIDES

Another type of pesticide that is gaining popularity in the marketplace are biopesticides. These products are registered pesticides with an active ingredient derived from some type of biological organism.

Although naturally occurring, the biologically based ingredients require research data, similar to conventional pesticides, before they become commercially available as a pesticide product. The US EPA still evaluates and registers them in a similar manner as conventional pesticides. An example of a biopesticide is *Bacillus thuringiensis* (Bt), a microbe that is toxic to certain insects.

MASTER GARDENER TIP

There are many subspecies of Bt, so understand each type, particularly the different pests it treats or targets.

PEST CONTROL FOR ORGANIC SYSTEMS

All pesticide products used in organic systems are derived from natural sources and must be registered with the US EPA and ISDA. The US EPA's role is to assist the United States Department of Agriculture National Organic Program (NOP) by assuring that the NOP's policies are implemented regarding organic

Table 2. The advantages and disadvantages of different pesticide formulations.

	Formulation	Definition	Advantages	Disadvantages
Ready-To-Use	Dusts	Pesticide + finely ground dry carrier	Ready-to-use	Drift hazard
	Granules	Like dusts, but larger particles and organic or mineral particles impregnated with pesticide	Reduced drift hazard vs. dust	Calibration
	Aerosols	Pesticide + volatile petroleum solvent + pressurized propellant	Ready-to-use convenience	Fine droplets, extreme low-percent active ingredient = inhalation hazard and high relative cost; plus drift hazard
	Ready-to-Use Sprays	Liquid in a trigger hand pump	Convenient (no mixing nor spray equipment)	Low-percent active ingredient = high relative cost
	Baits	Pesticide + food source	Ready-to-use	Must be in a bait station to reduce access to children and pets
Concentrated	Emulsifiable Concentrates	Petroleum-soluble pesticide + solvent + emulsifier	Very little agitation needed	More readily absorbed through the skin than dry or water-based formulations; may cause plant injury
	Flowables (liquids)	Water-soluble pesticide mixed with water	No agitation needed	None
	Wettable Powders	Water-insoluble pesticide impregnated on a finely ground organic or mineral particle +/- a wetting agent	Easy to store, handle, and transport	Requires agitation, may leave visible residues. Sometimes difficult to mix in cold water.
	Water-Dispersible Granules	Water-insoluble pesticide impregnated on finely ground organic or mineral-aggregated granular	Reduced inhalation hazard from the powders	Requires agitation, may leave visible residues

claims made by registered pesticide producers. The products that meet the criteria defined by NOP, for both active and inert ingredients, use labeled language approved by the US EPA. Examples of labeled language include "For Organic Production" or "For Organic Gardening." An organic system integrates organic pesticides with cultural, biological, and mechanical pest management practices.

MASTER GARDENER TIP

Certified organic produce is a regulated food production system.

Safety

HAZARDS AND HEALTH

Toxicity

Chronic toxicity is long-term toxicity and usually occurs from exposure over an extended period. Acute toxicity ensues within 24–48 hours of exposure. Reference the signal word on the pesticide label — it identifies a product's acute toxicity. For example, the signal word "CAUTION" indicates low toxicity of 5000+ mg/kg, meaning that 5000+ milligrams (mg) of pesticide (per kilogram [kg] of body weight) kill 50% of the tested population of animals. The research data for toxicity is complex, however, so you won't find it on a product label.

To better understand the science behind the rating system, the signal word is determined by a pesticide's LD50. The acronym LD stands for lethal dose and 50 represents 50% of the animals tested, meaning that in the tested population of animals, 50% die when exposed to a dose of pesticide through oral ingestion. Consequently, the higher the LD50, expressed in milligrams of chemical per kilogram of animal body weight (mg/kg), the less toxic the pesticide. Minimize hazards by choosing an effective product that is least toxic to users, children, pets, and the environment.

MASTER GARDENER TIP

Signal words = acute toxicity

PESTICIDE LABELS

It is important for you to understand the directions on the pesticide label so that you may assist homeowners with questions they may have. Indeed, the pesticide product label is the law. It is a binding contract between the pesticide registrant and the user. By purchasing and using the product you agree to follow the label directions. This means the application site or crop must be stated on the label. For instance, if you are treating aphids on your kale patch, then the label must list kale as a crop.

MASTER GARDENER TIP

When assisting homeowners with pesticide label questions, be sure that you are looking at the same pesticide product label. The best way to ensure consistency is to verify the US EPA registration number found on the front panel of the label.

Here are some guidelines to understanding a pesticide label (see fictitious pesticide label and corresponding sections at end of chapter, Reading the Label Activity):

1. Product or brand name

The name given by the pesticide registrant. Several products may have the same active ingredient but are sold and distributed by different companies — thus they will have different product or brand names.

2. Product type

The pesticide type (for example, an insecticide to control aphids on ornamental plantings; a herbicide to control broadleaf weeds in lawns).

3. US EPA registration number (EPA Reg. No.)

Each product has a unique registration number, somewhat comparable to a person's Social Security number. This number makes it easy to inquire about a specific product. Look for the US EPA Reg. No. on the front panel of the label.

4. Ingredient statement

The ingredient statement is found on the front panel of the label of the pesticide product. The label also lists active and other ingredients listed by percentage of the total product. For science-based information, contact the National Pesticide Information Center (see Resources).

Active ingredient(s)

The pesticide ingredient that provides the controlling action in the product stated as the chemical and common name(s).

Other ingredients

The **other ingredients**, also called inert ingredients, are mixed with the active ingredient(s) to enhance

their performance and ease of use (e.g., easier to handle, measure, mix with water, spray, or spread). These ingredients include solvents, surfactants, dyes, etc., they are usually "trade secrets," and are thus just listed as other or inert ingredients.

5. Signal word

The **signal word** indicates the acute toxicity (toxicity that occurs 24–48 hours after exposure) and hazards of skin and eye injury from the pesticide. It provides a quick way to determine the toxicity of the product to humans and animals. Signal words include the following:

- *Caution*: Indicates slight toxicity. Found in labels of common homeowner and ornamental products.
- *Warning*: Indicates moderate toxicity and acute eye hazards.
- *Danger*: Indicates severe toxicity or severe irritation to one exposure pathway. There are few products that are available to gardeners and homeowners that display this signal word.
- *Danger-Poison*: Indicates high toxicity. This is the most toxic group of pesticides and all labels must have a skull-and-crossbones icon. These products require a pesticide license to purchase and apply.
- Some pesticide labels do not list a signal word because they impart no acute effects on humans and animals.

6. Precautionary statements

Declarations about the hazards a pesticide presents to humans, pets, wildlife, beneficial insects, and the environment. One of the larger sections in a label, it contains instructions on PPE to protect the user plus instructions on protecting pollinators, endangered species, water resources, and avoiding drift, etc.

MASTER GARDENER TIP

If not explicitly stated on the product label, protective clothing required for any application is, at a minimum, long pants, long-sleeved shirt, shoes, and socks. It is always good practice to wear chemical-resistant gloves and protective eyewear too!

If you have a choice, compare products and avoid using those that may be harmful to bees and other environmental resources. Follow the instructions in this section to avoid any problems with off-site movement and unwanted pesticide residues.

7. First aid statement

Provides instructions on what to do in case of exposure. It is good practice to read this section before purchasing and using a pesticide product. When seeking emergency medical help, bring the product label with you. Also, contact the pesticide company or the NPIC for any questions.

8. Directions for use

This information indicates where, how, and when to apply the product. Be sure the site or crop for application is clearly stated on the label. You will also find the application rates, allowable by law, in this section. Both the restricted-entry interval (REI) — the time to remain out of the treated area after treatment — and the preharvest interval (PHI) — how long to wait before you harvest the plants — are found in this label section. It may also include other directions regarding restrictions, such as how to apply the product, how many times it can be applied per year, etc.

9. Storage and disposal

Provides information about the proper storage and disposal of the product. Read each product label section carefully, but some rules of thumb include the following:

- Keep the product in its original container with the label attached (required by law).
- Store it out of the reach of children and in a temperature-maintained, well-ventilated box/cupboard (required by law).
- Mark all measuring utensils "Pesticides Only!" Do not store pesticides with food, feed, or seed.
- Rinse an empty container three times and use the rinsate (the mixture produced from cleaning pesticide containers or application equipment) as directed by the label. Place the clean, empty container in a waste bin. If the extra product needs to be disposed, contact your city or county government or the ISDA Pesticide Disposal Program for dates and times of hazardous materials collection.

PESTICIDE EXPOSURE GUIDELINES

Do not eat, drink, or smoke while handling pesticides. Wash your hands with soap and water after each use. Stay clean and free of spills. Just in case, place decontamination supplies nearby, including jugs of water, soap, and towels. There are four ways you can be exposed to pesticides: through the eyes, airways (inhalation), mouth (ingestion), and skin (dermal absorption). Be mindful that the risk of a pesticide is equal to the toxicity of a pesticide times the exposure. Always follow pesticide label directions. See Figure 1 for the different routes of pesticide exposure.

In the eye

Flush eye(s) with water for at least 15 minutes.

In an airway

Immediately leave the area. In the mouth flush mouth out with water for at least 15 minutes.

If swallowed

Follow label directions; if no first aid is applied, take the victim to the nearest medical facility.

On clothes

Remove clothes and wash skin with soap and water.

When seeking medical attention, always take the product label with you so you can provide healthcare specialists with the proper treatment instructions. However, do not transport the pesticide product to the medical facility; remove its label and take that along instead.

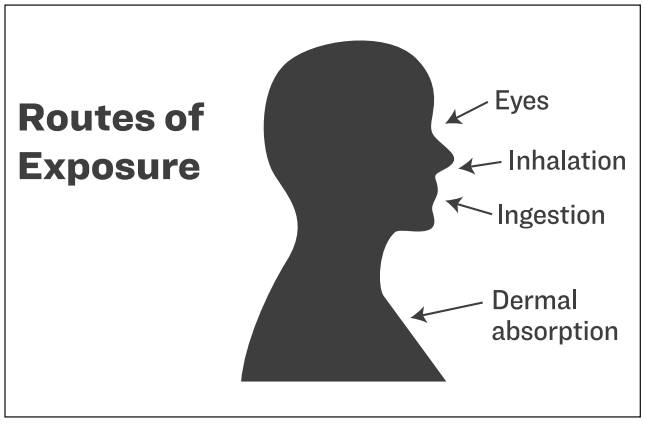


Figure 1. Pesticide routes of exposure to an individual. Graphic credit: Lynna Stewart, University of Idaho Extension.

Stewardship

It is the responsibility of the product user to maintain personal and environmental protection practices. Uphold all restrictions and requirements listed on the product label. Keep a good attitude while handling and applying a pesticide — it is essential. For example, always read a product label prior to purchase. The habit will ensure that you have the correct product for the job at hand and will indicate the time you need to wait before it's safe to harvest any edible garden or landscape (the PHI).

HANDLING

Always use the recommended and mandated PPE listed on the pesticide label. Calculate the correct amount of pesticide for one application. Only mix the amount of pesticide and spray mixture needed for the job to eliminate the need for disposing of unused spray mixture.

In preparation for a pesticide application, evaluate the treatment area to be sure you are aware of ponds and other water features before spraying. Check that bees are not visiting the plants during the application times. It is a good idea to close windows, doors, and household air intakes and to remove objects and pets from the area to avoid creating unwanted exposures.

Follow REI requirements on the label for each product, listed in hours or days. This time period is set to keep humans and pets safe from accidental exposure to any pesticide that may still be on the plants. Some pesticide labels may only require you to wait until the applied sprays are dry. But be sure by reading and following the specific pesticide label instructions.

MASTER GARDENER TIP

If pets have access to the area, barricade half of the area before application. This allows pets to traffic an untreated area. Once the REI has passed, relocate the pets and repeat the procedure in the other half of the area.

When handling edible landscaping, know the PHI for the pesticide that you have used. This is the actual timeline you MUST follow before picking the fruits and vegetables. The PHI provides enough time for the pesticide residues to break down under natural conditions, ensuring that residues are at or below

the regulated pesticide tolerance level set by the US EPA. Remember, the PHI is always listed on the pesticide label, under directions for use.

HANDLING PERSONAL PROTECTIVE EQUIPMENT (PPE)

It is best to remove protective clothing and equipment in a certain order to reduce exposure.

1. Keep your gloves on (they are the last thing you remove!).
2. Find an area where you can safely gather your clothing (e.g., garage or mudroom).
3. Wash gloves with soap and water.
4. Remove shoes or boots. Use one shoe to push the heel from the second shoe while keeping the shoe on the second foot. Use the same procedure with the second foot to release the heel from the first shoe. Step out of both shoes.
5. Remove respirator (if applicable).
6. Remove goggles.
7. Remove long pants.
8. Remove socks.
9. Remove long-sleeved shirt.
10. Remove gloves.
11. Using a washing machine, launder the pesticide application clothes separately from other laundry. Use heavy-duty detergent and hot water. If a clothesline is available, hang the clothes in the sun to further the pesticide breakdown process. After removing the clothing from the washing machine, be sure to run a rinse cycle to thoroughly rinse the machine.

PESTICIDE PROPERTIES AND MOVEMENT

The Idaho Pesticides and Chemigation Law maintains that pesticide applications must not damage nor endanger humans, animals, property, or the environment. To uphold this law, it's important to understand how to recognize the fate of a pesticide — how it travels and how it degrades.

MASTER GARDENER TIP

Remember to apply pesticides with accuracy and responsibility and to always follow label directions.

Absorption

Pesticides are generally absorbed by plants or the pests themselves. The organisms' metabolism over time helps break them down.

Adsorption

Pesticide molecules can be adsorbed to soil particles and/or minerals in the soil or water. To adsorb means to adhere tightly to the soil or minerals, like nails attracted to a strong magnet. When pesticides are tightly adsorbed to soil or minerals, they become "tied up" or unavailable for pest control. For example, soils that are high in clay and/or organic matter have a negative charge. Pesticide products that adsorb will be attracted to the adsorption sites and "lock" to the soil. If adsorbed to soil particles, the pesticide will not be available to the pest.

Drift

According to the US EPA, "Pesticide spray drift is the movement of pesticide dust or droplets through the air at the time of application . . . to any site other than the area intended." To reduce drift, understand these factors: weather, application equipment, and applicator skills.

Weather

Temperature inversion, wind, and humidity are negative weather conditions. An inversion develops when the trapping of cool air at ground level by the warm air above it creates a horizontal airflow. The atmospheric phenomenon may cause pesticides to move horizontally with the layers of air, casting the pesticides off-site and possibly endangering the surrounding environment.

High wind is the perfect conduit for carrying a pesticide away from its target. Idaho state law prohibits applying pesticides in sustained wind speeds that exceed the label directions. However, if a pesticide label does not list a specific wind speed limitation, that pesticide must not be applied in sustained wind conditions exceeding ten miles per hour. Desirable plants, beneficial insects, domestic animals, and other desirable natural features can be damaged by pesticides moving off target with wind drift or other movement caused by inversions. Check your local weather conditions prior to any application to reduce drift and off-target pesticide applications.

Volatilization occurs when either a solid or liquid pesticide product changes into a gas. This happens

in conditions of high temperatures and low humidity. These weather factors cause your pesticide product to change form and either be lost or vaporized into the air and drift off-site, potentially causing unwanted pesticide contamination.

MASTER GARDENER TIP

Consider the environment of your spray zone. It may include a neighboring garden or landscape border.

Runoff

Many pesticides are water-soluble, meaning that any water that courses through a treated area may carry off these pesticides. The term runoff refers to the movement of pesticides with water over surfaces. Thus, the degree of water solubility may be a factor for off-site movement of the pesticide and unwanted pesticide residues in surface waters (ponds, streams, lakes, etc.).

Leaching

Highly soluble pesticides may move downward through the soil profile, especially in sandy soils. This downward movement of pesticides with soil water is called leaching. Along with possibly compromising groundwater sources, leaching also removes effective pesticides from their intended site.

Plant Removal

When a treated crop, such as grass clippings, is removed and taken to another location, the pesticide residues may still be present on that plant material. This is considered an off-site movement of pesticide. Residue on the grass clippings risks causing unwanted pesticide contamination at the new location and in your compost.

MASTER GARDENER TIP

Composting is an example of plant removal. If you hired an applicator to manage the pesticide applications in your landscape, know what they are spraying, especially if you are composting or mulching your grass clippings.

WATER-QUALITY IMPACTS ON PESTICIDE PERFORMANCE

Our beautiful Idaho rivers and streams are fed through local watersheds. As the water travels, minerals are weathered and transported into our water supplies. Quite often these minerals are in our well water and irrigation canals, impacting the water hardness and pH (acidity and alkalinity). Are you irrigating from a well or are you using city water? Let us address how this influences pesticide applications.

MASTER GARDENER TIP

If mixing pesticides, test your water source for hardness and pH.

Hardness

The amount of minerals in a water sample are called total dissolved solids (TDS). These minerals are not visible in the water but can adsorb to a pesticide in the spray mixture, causing it to become unavailable and ineffective for pest control. Water containing a high level of minerals or TDS may need a buffering agent to reduce the hardness, before mixing with pesticides.

pH

Many pesticides perform best when the water pH is in the 4–6.5 range. Test your water source to determine the pH of the water you plan to use for the spray mix. You can easily test your own water by using do-it-yourself water-testing strips purchased at your favorite garden or hardware store. If the pH is above 7, use an adjuvant or buffering agent to adjust the water's pH (though the pesticide label will also let you know if one needs to be added). If the water is too alkaline (high pH) or too acidic (low pH), the pesticide will begin degrading or hydrolyzing, neutralizing the pesticide in a short period of time. Remember, adjust the water's pH before adding the pesticide product to the spray mixture.

SETTING UP THE APPLICATION EQUIPMENT

Hose-End Sprayers

Hose-end sprayers attach to the end of a garden hose. Some come preloaded with pesticide; others you'll need to add to the sprayer tank yourself after measuring the pesticide. All hose-end sprayers have a built-in anti-syphon device to prevent backflow into your water source. Ensure you have a consistent water pressure prior to attaching the hose-end sprayer. For example, that there are no kinks in the hose.

Small Sprayers

Use a small, hand-operated spray tank (generally 1–3 gallons) for formulations that require dilution. Calculate and measure the pesticide product, add it to the tank, and top it off with water. Mix the solution by shaking; maintain sprayer pressure by hand pumping. For uniform coverage, mix the concentration thoroughly and apply consistent pressure. If using a dry formulation, frequent agitation is necessary to avoid separation and sedimentation. These sprayers are best for applications on lawns, vegetables, bushes, and dwarf trees. It is difficult for them to generate sufficient pressure to reach the limbs of tall trees and get good pesticide coverage.

Broadcast Spreaders

These are handheld devices or walk-behind hoppers on wheels that apply fertilizer and pesticide granular products. They need to be calibrated so that you can determine how much product to apply. Spreaders allow for a certain amount of adjustment by changing the opening size on the bottom of the spreader.

CALIBRATION

As you prepare for spring and the garden season, calibrating your equipment is like tuning up your tools. It should be done every year. So, gather your measuring tools, a stopwatch, a calculator, your notebook, and flags for marking certain distances. Your calibration rate is specific to the type of application equipment, your travel speed, and the flow rate.

Example Using Small Sprayers

Prior to calibrating your equipment, confirm your equipment is in the proper working order. This includes checking the sprayer for the proper nozzle size by cross-referencing the product label. Clean the nozzle tips and screen. Fill up your sprayer with water, pressurize the tank, and verify the spray volume delivery rate has consistent pressure.

Example Calculating Your Calibration Rate — Using Small Sprayers

1. *Measure your swath width*. Walk on the driveway or sidewalk spraying (with only water) from side to side. Use a measuring tape to measure the spray distance from left to right. This is your swath width and will be the width measurement in the calculation of the test plot area. Example: 4 feet.
2. *Calculate the test plot area*. The test plot is a demonstration space where you can record the required time for an application. Select a size for your test plot area (e.g., 100 ft^2) and divide it by your swath width from step 1 (4 feet). Example: 100 ft^2 ÷ 4 ft = 25 ft. The length of your test plot will be 25 feet. Flag the length of this test plot.
3. *Determine your travel speed/stride*. Record your time while simulating an application in the marked test plot (spraying water with your 4-foot swath width). Repeat the simulation to calculate your average travel speed (example: 100 ft^2 in 30 sec). Practice this pace; it is essential to maintain the same travel speed for a consistent application. The time will be used for the collection of the nozzle output.
4. *Collect the nozzle output*. Collect the water spray in a properly sized, graduated measuring container for the time you recorded in the previous step (example 30 seconds). Repeat the collection to calculate your average nozzle output. This quantifies the amount of spray that was distributed over the test plot area (example: 6 fl oz in 30 seconds).
5. *Compile your calibration rate*. Assess your travel speed and flow rate. This is the distribution of spray over the fixed area. Example: 6 fl oz per 100 ft^2.

To calibrate a hose-end sprayer or drop spreaders, visit the Pesticide Environmental Stewardship website (see Resources).

MASTER GARDENER TIP

Calibration should be compiled for each person using the application equipment.

Maintenance

Frequently check your equipment for leaks or holes. Keep equipment clean.

PESTICIDE APPLICATION MATH

Once you know the best pesticide to use to control your pest, you need to calculate how much to apply. Purchase only what you will need for one growing season.

Before each application, use the formulas on the following page to (a) calculate the treatment area and (b) calculate the total amount of the pesticide mixture required for the treatment area. Gather your measuring tools, the product label, and specific calculations to perform your investigation. Prior to

any application of a pesticide, consult the label to determine the amount of product to use and what protective clothing you should wear.

Math Review

If you are using pesticides, you need to know how to calculate unknown factors, which involves multiplying fractions. The following is a short primer. You can determine the unknown factor if

$$\frac{a}{b} = \frac{c}{d} \text{ “and only if” } ad = bc$$

Cross multiply the values by taking the first numerator and multiplying it by the second denominator. Conversely, multiply the second numerator by the first denominator. Remember,

$$\frac{\textit{numerator}}{\textit{denominator}}$$

Let’s practice cross multiplying with unknown factors. You are hosting a party and you have fifty friends to feed. How many bags of chips do you need, if one bag feeds four people? Start by setting up your known factors and their units. Then designate the unknown factor as x. In this case, x represents the unknown number of bags of chips. Whether the unknown factor, x, is in the numerator or denominator, you can cross multiply and divide the fractions.

$$\frac{x}{(50\ people)} = \frac{(1\ bag)}{(4\ people)}$$

$$(x \times 4\ people) = (1\ bag \times 50\ people)$$

$$4\ people\ x = 50\ bags/people$$

$$x = \frac{(50\ bags/people)}{(4\ bags)}$$

Note that if the unit is the numerator and the denominator, they cancel each other out.

$$x = 12.4\ bags\ or\ 13\ bags$$

So, for a party of fifty you will need thirteen bags of chips.

Calculate the Treatment Area

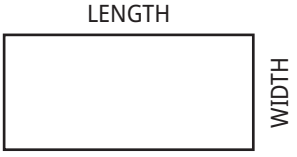
Calculating the size of the treatment area is an important step in using pesticide products correctly.

Rectangular

length × width = area

For an area that is 20 ft by 40 ft,

20 ft × 40 ft = 800 ft²

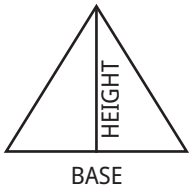


Triangular

(base × height)/2 = area

For a triangle with a base of 30 ft and height of 50 ft,

(30 ft × 50 ft)/2 = 750 ft²

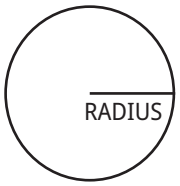


Circular

π (pi = 3.14) × radius² = area

For a circle with a 15 ft radius,

3.14 × 15 ft² = 706.5 ft²



Calculate the Total Amount of the Pesticide Mixture

Reading the product label, you learn that you need to dilute 2 fl oz of product into 1 gal of water and apply the resultant mixture at the rate of 5 gal per 2000 ft² (5 gal/2000 ft²). Your treatment area is 490 ft², so calculate how much water you need for this application in the following way:

1. 5 gal/2000 ft² = x/490 ft². Solve for x. Cross multiply and divide.
2. 2000 ft²x = (490 ft² × 5 gal)
3. 2000 ft²x = 2450 ft²/gal
4. x = 2450 ~~ft²~~/gal ÷ 2000 ~~ft²~~ (note that square-feet units cancel out)
5. x = 1.225 gal

For the 490 ft² treatment area you will use 1.225 gal of water.

Now you can calculate how much product is needed to add to the 1.225 gal of water.

1. With x the amount of pesticide you will dilute into water, solve for x: 2 fl oz/1 gal = x/1.225 gal. Cross multiply and divide.
2. 1 gal x = (1.225 gal × 2 fl oz)
3. x = 2.45 ~~gal~~/fl oz ÷ 1 ~~gal~~ (note that gallon units cancel out)
4. x = 2.45 fl oz or 2.5 fl oz

Answer: You will need to add 2.5 fl oz of product to 1.225 gal of water and apply the result to your 490 ft² treatment area.

Recordkeeping

What was your biggest pest last year? Logging your experiences and careful planning will help you to prevent the same infestation or outbreak.

Evaluate the pesticide you used — was it effective? Be sure to document the pesticide name and US EPA registration number to help you keep track of proper pesticide rotation.

MASTER GARDENER TIP

Capture your landscape issues, follow plant/insect life cycles, and allow patterns to unfold.

STORAGE

Always store pesticides in their original containers and always with the label attached. Indicate on your equipment and measuring tools that they are "Pesticide Only!" This includes measuring cups and spoons. Stow these items with your pesticides in a locked container.

Make sure the locked container or box is in a cool, well-ventilated environment. Keep it out of the reach of children and store it separately from feed, seed, and fertilizers. If shelving it, place dry formulations above liquids (in case of leaks) and secure tightly.

MASTER GARDENER TIP

Buy small quantities for the season (or only what you need) to eliminate storage problems altogether.

DISPOSAL

If you've mixed more product than you need, apply the extra mixture to another area that is listed on the label. For expired pesticides, discard them at designated pesticide collections (sponsored by your county or the ISDA). **Do not dump pesticides!**

After disposal, triple rinse the empty containers. Begin by adding water to the pesticide container, sealing the lid tight, and shaking it (to ensure that the water "rinses" the container's side walls). Handle its by-product (rinsate) as you would the product. Repeat three times (hence triple rinsing). Remember, by triple rinsing you are using the rinsate as you would the product. Be sure to thoroughly clean the application equipment using either a commercial tank cleaner or water and spraying the cleaning solution through the system.

MASTER GARDENER TIP

For any question about where to find your local pesticide collection sites, contact the ISDA.

PESTICIDE SPILLS

When a pesticide spill occurs, practice the 3 *C*s: control, contain, and clean up. Control the spill by simply picking up the pesticide container and placing it upright to stop further spillage. Contain it by installing a small dike around the spilled area (the dike can be a small barrier of soil or other absorbent material). Clean up the spill by using the following recommendations:

Liquid Product Spillage

- These types of spills can be more difficult to clean up, so begin by absorbing the pesticide with sorbent granules (e.g., Floor-Dry brand) or cat litter. Then sweep it up and dispose of it in a plastic bag.
- Wash the area with an appropriate cleaner, such as household bleach.
- If the spill has contaminated other materials that you may have used to contain or soak up the pesticide, discard that material.

Dry Product Spillage (these spills can be simpler)

- Sweep up the product and use it.
- Or place it in a heavy plastic bag for disposal. In either case, if you have any questions, read the product label's disposal instructions or contact ISDA Pesticide Disposal Program.

HOW TO HIRE A PROFESSIONAL

Professional pesticide applicators are licensed and certified by the state of Idaho to apply pesticides properly and safely. There are many advantages in hiring a professional pesticide applicator. They are knowledgeable about local pest problems and outbreaks. They are skilled at reducing pesticide exposure and have experience using the best practices to obtain good pest control while reducing potential contamination. Professional pesticide applicators are required to follow the state's regulations, plus they must obey pesticide product label directions and safety precautions.

Before deciding to call a professional, gather information from your local Extension office on the pest's identification, life cycle, treatment, and environmental effects. Determine whether your client has the time, knowledge, and equipment to complete a pesticide application. If not, suggest they contact a licensed professional pesticide applicator to do the work.

Table 3. Professional urban pesticide–licensing categories in Idaho.

AF	Space (Area) Fumigation
AP	Aquatic Weed and Pest Control
CA	Commercial Apprentice
IP	Industrial, Institutional, and Structural Pest
OP	Ornamental Pest
PH	Public Health Pest

The ISDA provides a searchable database of certified applicators (see Table 3 for the licensing categories). To find a licensed professional applicator in your area, search the database by your county of residence. Below are suggested questions to ask a potential professional applicator.

1. What is your reputation and business rating?
2. What is the name of your insurance or bond company?
3. Will you provide a copy of the pesticide application paperwork, including
   a. the pesticides name(s)
   b. the rate applied
   c. application weather conditions
   d. the reentry interval (when you can reenter the area)
   e. the PHI (when you can harvest any fruit or vegetables, if treated)
   f. the applicator's name
   g. the applicator's license number
   h. the company's name

MASTER GARDENER TIP

If a client comes into your plant diagnostic lab looking for a professional applicator, suggest they contact their favorite garden store for references or consult the ISDA website. It is recommended that they collect more than one bid for a competitive market price.

IMPORTANT NUMBERS AND INFORMATION

Be prepared for accidents or unintended circumstances that put you in harm's way. For your convenience and safety, we have included a poster on which you can enter your emergency contact information (see end of chapter). Post the completed poster for easy access. If you have an emergency, it will give you a head start on finding assistance.

Resources

America's Poison Centers
https://www.poisonhelp.org/ or (800) 222-1222

Fungicide Resistance Action Committee (FRAC)
http://www.frac.info/

Herbicide Resistance Action Committee (HRAC)
http://www.hracglobal.com/

Idaho State Department of Agriculture (ISDA), Organic Certification Program
https://agri.idaho.gov/main/about/about-isda/ag-inspections /organic-certification-program/

ISDA, Pesticide Disposal Program
https://agri.idaho.gov/main/pesticides/#Pesticide-Disposal-Program/

ISDA, Pesticides Programs
https://agri.idaho.gov/main/pesticides/

Insecticide Resistance Action Committee (IRAC)
http://www.irac-online.org/

National Pesticide Information Center (NPIC)
http://npic.orst.edu or 1-800-858-7378

Pacific Northwest Insect Management Handbook
https://pnwhandbooks.org/insect

Pacific Northwest Plant Disease Management Handbook
https://pnwhandbooks.org/plantdisease

Pacific Northwest Weed Management Handbook
https://pnwhandbooks.org/weed

Pesticide Environmental Stewardship (PES)
https://pesticidestewardship.org

US Environmental Protection Agency (US EPA), "Pesticides," **https://www.epa.gov/pesticides**

Further Reading

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Tharp, C., and A. Sigler. 2013. *Pesticide Performance and Water Quality*. Montana State University Extension, 1213SA. 4 p. **https://www.montana.edu/extension/lewisclark/documents/MSU_Pesticide_Performance_and_Water_Qual.pdf**.

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United States Environmental Protection Agency. 2005. *Citizen's Guide to Pest Control and Pesticide Safety. Prevention, Pesticides, and Toxic Substances* (7506C), EPA 735-K-04-002. 53 p. **https://www.epa.gov/sites/default/files/2017-08/documents/citizens_guide_to_pest_control_and_pesticide_safety.pdf**, accessed 11 August 2017.

Whitford, F., G. Ruhl, S. Mayer, J. Orick, R. Lerner, and K. L. Smith. 2015. *What Gardeners Should Know about Pesticides: A Practical Guide for Home Use*. Purdue University Extension, PPP-109.

Acronyms

FIFRA – Federal Insecticide, Fungicide, and Rodenticide Act

IPM – Integrated Pest Management

ISDA – Idaho State Department of Agriculture

MG – Master Gardener

MoA – mode of action

NPIC – National Pesticide Information Center

PHI – preharvest interval

PNW Handbook – Pacific Northwest Handbook

PPE – personal protective equipment

REI – reentry interval

SoA – site of action

TDS – total dissolved solids

US EPA – United States Environmental Protection Agency

Glossary

active ingredient. The chemical in a pesticide product that controls the organism.

drift. The movement, through the air, of a pesticide application.

organic. A regulated standard of food production that can involve the use of pesticides derived from naturally occurring substances.

pesticide. A product whose application intends to prevent, destroy, repel, or mitigate an unwanted organism.

pesticide resistance. The decreased susceptibility of a pest population to a pesticide that develops from repeated exposure; the offspring, in turn, inherit the tolerance.

signal word. Terminology on a pesticide label that indicates the level of acute toxicity to pesticide exposure. Identifies the product's degree of toxicity to humans.

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

Important Numbers and Information

UI EXTENSION
Find information about the University of Idaho Extension Integrated Pest Management program at uidaho.edu/extension/ipm.

EXTENSION HEADQUARTERS
(208) 885-5883
extension@uidaho.edu

IDAHO STATE DEPARTMENT OF AGRICULTURE
(208) 332-8500
www.agri.idaho.gov/main

MARK UTILITY LINES
Before you dig, have utility lines marked. Call 811 or visit www.call811.com

NATIONAL PESTICIDE INFORMATION CENTER
(800) 858-7378
http://npic.orst.edu/

COUNTY EXTENSION OFFICE
Phone: _____

Address: _____

EMERGENCIES
Primary Emergency Contact: _____

Poison Control Center: _____

Fire: _____

Police: _____

PERSONAL DOCTOR
Name: _____

Phone: _____

Office Address: _____

HOSPITAL
Name: _____

Phone: _____

Physical Address: _____

_____

MEDICAL HISTORY
Name: _____

Allergies: _____

Medications: _____

Other: _____

VETERINARIAN
Name: _____

Phone: _____

Office Address: _____

_____

ADDITIONAL NOTES
_____

_____

_____

_____

_____

Reading the Label Activity

Review the pesticide label guidelines on pages 6–7. Using this fictitious label, answer the following questions:

Part 1. Choose the best answer.

1. What is the EPA Registration Number?
   a. 5888-8888
   b. 1234-5678
   c. 1800-222-1222
   d. 8765-4321
2. What is the signal word?
   a. Danger
   b. Warning
   c. Caution
   d. No signal word
3. What is the active ingredient?
   a. Reliocard
   b. Insecticide
   c. Bugz B-Gone
   d. Imaginary Products
4. What is the required protective clothing?
   a. Shoes, socks, and goggles
   b. Long-sleeved shirt, long pants, shoes, and socks
   c. Long-sleeved shirt, long pants, shoes, socks, and goggles
   d. Long-sleeved shirt, long pants, shoes, socks, and gloves
5. What is the application rate for 1000 ft²?
   a. 64 fl oz
   b. 8 fl oz
   c. 2 fl oz
   d. 4 fl oz
6. What is the total percentage of Bugz B-Gone inert ingredients?
   a. 10%
   b. 20%
   c. 100%
   d. 90%
7. What is the application rate for one-tenth of an acre (1 acre = 43,560 ft²)?
   a. 12.4 fl oz
   b. 4.3 fl oz
   c. 17.4 fl oz
   d. 14.6 fl oz

Part II. Answer yes or no.

8. Spray Bugz B-Gone during wind speeds above 15 mph.
   a. Yes b. No
9. Apply Bugz B-Gone on new transplants.
   a. Yes b. No
10. Use Bugz B-Gone on ornamental plants.
    a. Yes b. No

Answers: 1 b, 2 c, 3 a, 4 b, 5 d, 6 d, 7 c, 8 b, 9 b, 10 a

Net Contents: 64 fl oz

1 **BUGZ B-GONE**

2 *Fictitious Insecticide Label*
For Control of Beetles and Weevils
3 **EPA Reg#: 1234-5678**

Active Ingredients: Reliocard 10%
4 **Inert Ingredients: 90%**
100%

5 KEEP OUT OF REACH OF CHILDREN

CAUTION
Bugz-b-Gone Reliocard insecticide kills Blister beetles, Black vine weevils, Elm leaf beetles, Flea beetles, Ground beetles, Hollyhock weevils, Japanese beetles, Pea leaf weevils, Root weevils and Western spotted cucumber beetles. Bugz-b-Gone Reliocard insecticide liquid formulation is ready-to-use on ornamental plants, trees, shrubs, flowers, and vegetables.

6 **PRECAUTIONARY STATEMENTS**
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
Caution. May cause slight eye irritation. Avoid contact with eyes.

ENVIRONMENTAL HAZARDS
To protect the environment, do not allow pesticide to enter or run off into storm drains, drainage ditches, gutters, or surface waters. Applying this product in calm weather when rain is not predicted for the next 24 hours will help to ensure that wind or rain does not blow or wash pesticide off the treatment area.

USER SAFETY INFORMATION
Wash hands with thoroughly with soap and water after handling. Wash hands thoroughly with soap and water after handling. Wash any pesticide contaminated clothing separately.

Applicators must wear long-sleeved shirt, long pants, shoes, and socks. Eye protection is recommended.

7 **FIRST AID**
IN EYE: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Call a poison control center or doctor for treatment advice.
ON SKIN: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
IF SWALLOWED: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

Have the product container or label with you when calling a poison control center or doctor or going for treatment. For medical emergencies, call the poison control center at 1-800-222-1222.

8 **DIRECTIONS FOR USE**
It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Read entire label before using this product. Do not use Bugz-b-Gone on new transplants.

Spray on infected areas when the insect population reaches an unacceptable level and are causing damage to the ornamental plants. Product is best sprayed early morning or late afternoon when temperature is between 50°F and 80°F. Do not apply if wind speed is above 10 MPH to reduce spray drift. APPLICATION RATE: Mix 4 fl oz every 1,000 ft².

9 **STORAGE AND DISPOSAL**
DO NOT CONTAMINATE WATER, FOOD OR FEED.
Do not store with fertilizer, food, or feed. Keep away from children and pets. Store in original container in a dry, secure storage area. Keep container tightly closed when not in use with label secured. If using measuring utensils, mark 'Pesticides Only!' and keep in storage.

Pesticide Disposal: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or spray mixture is a violation of Federal Law and may contaminate ground water. Do not pour down kitchen or sewer drains.

Container Disposal: Triple rinse pesticide container and use as directed. Then offer for recycling or puncture and dispose of in a sanitary landfill.

Imaginary Products
555 Main St., Suite 100
Hometown, Georgia

This is a fictitious pesticide label created for educational purposes only.

Figure 1. The fictitious pesticide label for the purpose of understanding how to read the statements and directions. Courtesy of Mike Cameron, National Pesticide Safety Education Center.

CHAPTER **TEN**

BASIC ENTOMOLOGY

Vickie J. Parker-Clark
Former District I Extension
Director, Coeur d'Alene

Contents

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Moths and Butterflies — Lepidoptera
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Aphids, Scales, Leafhoppers, Cicadas — Homoptera
Grasshoppers, Crickets, Cockroaches, Camel Crickets — Orthoptera
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Garden Centipede or Symphylan — Symphyla

FURTHER READING 10

10 BASIC ENTOMOLOGY

Learning Objectives

- Learn the basics of entomology
- Gain an understanding of basic insect anatomy
- Learn the development stages of insects
- Learn the classification of insects and how to identify the major orders
- Learn about the other insect-like creatures in the garden

Introduction

The animal kingdom contains many distinct groups called phyla. Each phylum is divided into a number of classes. The insects are in the class Insecta (subphylum Hexapoda — "six feet") within the phylum Arthropoda (jointed foot). The insect class is further divided into orders, families, genera and, finally, species.

Approximately 1 million species of insects have been identified. The greatest numbers of these species belong to the beetle, fly, and wasp-bee-ant groups. We generally associate insects with crop loss or disease transmission; however, insects fulfill a useful function in our environment.

Only a small percentage of insects are considered pests of humans and of their animals, crops, or fiber. However, this small number can cause serious crop losses or transmit serious diseases to humans or animals.

Most insects appear to be beneficial or harmless. Many are predators, such as ladybugs, which live by feeding on pestiferous aphids. Others are parasitic, such as wasps. Still others, such as honeybees, act as pollinators of crops and also provide us with honey. Many insects are responsible for the decomposition of plant and animal matter. A good example is the carpenter ant. Obviously, when it attacks the timber of our home it is a pest; however, when it is in the forest mining the wood of old, fallen trees, it is part of nature's recycling program.

Size is quite variable throughout the insect world. The extremes include tiny wasps that are less than a millimeter long and some of the larger long-horned beetles that are as much as 6 inches long.

Except for a few common structural features, insects are also variable in appearance. Some have bizarre horns and spines, while others may resemble dead leaves. Some insects are quite attractive like the butterfly, but "beautiful" is hardly the word for a cockroach.

All of this makes insects a fascinating group to investigate, but it also makes the study of insects and their classification somewhat complex. It is important to learn the main differences among insects so that we can distinguish one group from another. Then we can suggest adequate control procedures and provide quality management suggestions.

Insect Anatomy

Insects are animals, however, unlike many animals, they have no backbones. They have an **outer** skeleton (**exo**skeleton) instead of the inner skeleton (**endo**skeleton) of most large animals. The following characteristics separate insects from other animals (Figure 1):

- Insects have three body regions — head, thorax, and abdomen.
- Many adult insects have wings and insects are the only flying invertebrates.
- Adults possess three pairs of legs, all located on the thorax.

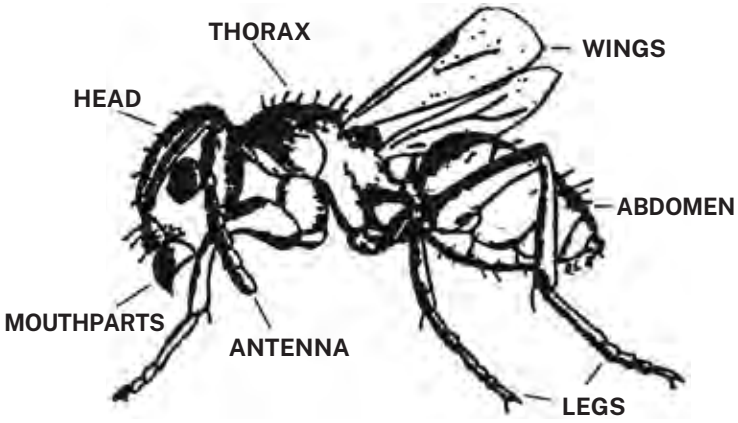

Figure 1. Parts of an insect.

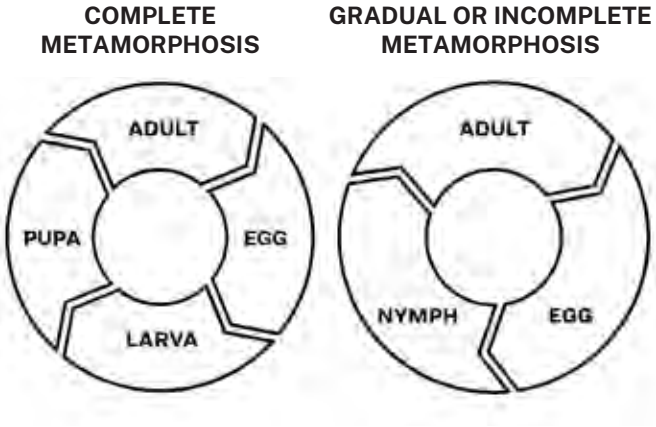

Figure 2. Metamorphosis stages in insects.

Insect Development

All insects change during growth by a process called metamorphosis (Figure 2). Insect near-relatives such as spiders, mites, and centipedes also undergo metamorphosis.

The more highly developed insects make the most complete changes. Beetles, moths, butterflies, wasps, and ants all go through four stages. These are the egg, larva, pupa, and adult. The larva is usually the damaging stage, although adult feeding can be destructive. Also, it is not unusual for the larval and adult stages of a species to feed on different hosts or different parts of the host. The pupa is a nonfeeding stage; in most cases it is also very inactive.

The lower forms or less-developed kinds of insects change only slightly during metamorphosis. True bugs, aphids, grasshoppers, termites, earwigs, stone flies, etc., go through only three stages. These stages are the egg, nymph, and adult. Except for size, the nymph and adult closely resemble each other. The major difference is the lack of fully formed wings in the nymph. The nymph and adult generally feed on the same host or host parts.

Insect Classification

There are several methods of separating or categorizing insects.

- The professional uses body parts for identification and observes differences in these parts through a microscope. He or she tracks down an insect's identity by using a written insect "key." The anatomy of an insect will place it into a specific insect group called an **order**. If you are around entomological activities much, you will

often hear the phrase "keying out." This simply means identifying the insect.

- Insects are also classified by the type of damage they cause. Some examples include "root maggot," "twig girdler," or "crown borer." Destructive insect activities help narrow down the multitude of possible identities and often make insect identification quicker and simpler.
- Some insects can be categorized as predators or parasites. Predators and parasites account for much of the reduction of pest insect populations in nature, and, for this reason, are also called beneficials.

  Beneficials can be useful, but they usually need some cultural encouragement. Their use requires careful crop management and a degree of tolerance for some crop loss.

  1. **Predators** kill and feed on their prey; they are generally larger than their prey.
  2. **Parasites** are usually smaller and often weaker than their prey; they gradually kill by injecting eggs that develop on, within, or near the insect over a period of time. They may sting and paralyze their prey in order to stock their nests with food for the developing larvae or eggs. The immature parasites will then consume the paralyzed insect at their leisure.
- Another form of categorization is by feeding mechanism or mouthpart. The broadest grouping is defined by chewing or sucking mouthparts (Figure 3).

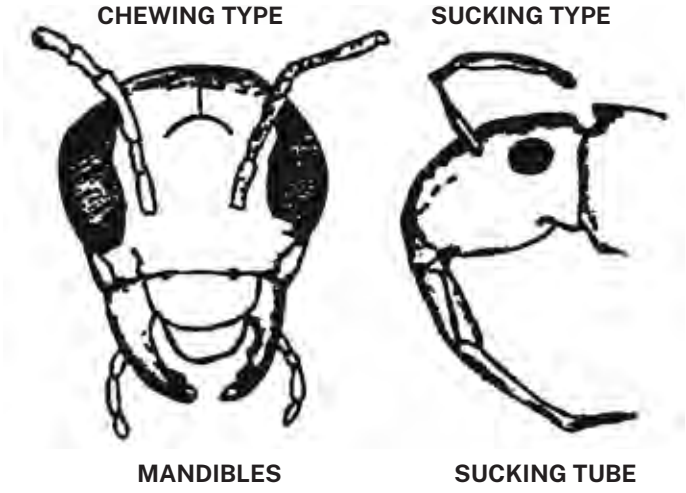

Figure 3. Insect feeding mechanisms.

Although this manner of separation is somewhat helpful for identification, its greatest value is in determining if a certain kind of pesticide will work. For example, systemic insecticides "generally" do not work as well on chewing insects as on sucking insects.

Proper identification is extremely important. If a beneficial insect or a nondamaging insect is improperly identified as a pest, a pesticide application will usually disrupt a natural control agent. The disruption of this beneficial's activity may induce the need for the chemical. Chances are you may have made an application that did no more for you than cost you money.

NOTE

Do not make recommendations based on the verbal description of a pest by a client. Too many misidentifications are made this way leading to ineffective control measures and unnecessary expense or problems. Insist on seeing the pest, or at least its damage, before you volunteer anything.

Major Orders of Insects

Major insect groupings under the class level are called orders. Some representatives that you will see are beetles — Coleoptera; moths and butterflies — Lepidoptera; flies — Diptera; bees, ants, wasps, hornets — Hymenoptera; true bugs, such as stink bugs — Hemiptera; aphids, scales, and leafhoppers — Homoptera; grasshoppers, crickets, and cockroaches — Orthoptera; termites — Isoptera; and earwigs — Dermaptera. There are many other insect orders, but these are representatives of economic importance.

Separating groups of insects may be quite difficult unless you have closely studied examples of the various types. It is important to recognize the structural characteristics that distinguish one insect from another (see "Further Reading"). Use all of the characteristics listed in Table 1 to distinguish each order.

BEETLES AND WEEVILS — COLEOPTERA

Some of the typical beetles that you may see are long-horned beetles and flatheaded borers that bore into trees, logs, and lumber. These beetles are variable in color. Long-horned beetles usually have long antennae and are strong fliers. Ladybugs are

Table 1. Major order of insects.

Name of order	Common examples	Wings/mouthparts
Coleoptera	Beetles, weevils	2 pairs wings or wingless; chewing
Lepidoptera	Moths, butterflies	2 pairs wings; chewing (larvae), sucking, or siphoning (adults)
Diptera	Mosquitoes, flies, and gnats	1 pair wings; chewing (larvae), piercing-sucking, or sponging (adults)
Hymenoptera	Wasps, bees, ants, and sawflies	2 pairs wings or wingless; chewing
Hemiptera	Bedbugs, stink bugs, and cinch bugs	2 pairs wings; piercing-sucking
Homoptera	Aphids, leafhoppers, scales, mealybugs	2 pairs wings or wingless; piercing-sucking
Orthoptera	Grasshoppers, crickets, and cockroaches	2 pairs wings or wingless; chewing
Isoptera	Termites	2 pairs wings or wingless; chewing
Dermaptera	Earwigs	2 pairs wings or wingless; chewing
Thysanura	Silverfish, firebrats	Wingless; chewing
Thysanoptera	Thrips	2 pairs wings or wingless; rasping-sucking
Collembola	Springtails	Wingless; chewing
Psocoptera	Barklice, booklice	2 pairs wings or wingless; chewing
Mallophaga	Chewing lice	Wingless; chewing
Anoplura	Sucking lice	2 pairs wings or wingless; piercing-sucking
Siphonaptera	Fleas	Wingless; chewing (larvae), piercing-sucking (adults)

about ¼-inch long and are usually red or orange, generally with spots. They are beneficial as larvae and adults, since they feed on aphids and other soft-bodied insect and mite pests. Some other common beetles are the pea weevil, an important pest of peas, and click beetles, whose larvae are known to some of you as wireworms.

1. Adults have a hardened, horny outer skeleton.
2. Adults have two pairs of wings; the outer pair is hardened and the inner pair membranous.

NOTE
A few beetles are practically wingless and some have only an outer hard pair of wings.

3. Beetles have chewing mouthparts.
4. Adults usually develop noticeable antennae.
5. Coleoptera larvae have a head capsule and three pairs of legs on the abdomen.

NOTE
Weevil larvae lack legs on the thorax.

6. Both beetles and weevils go through a complete metamorphosis as shown in Figure 4.
7. Some authorities consider beetles to be the largest group or order of insects in nature.

MOTHS AND BUTTERFLIES — LEPIDOPTERA

The moth and butterfly group has several damaging members. Cutworms damage many crops. For example, corn earworm larvae, which are greenish or tannish with some stripes and about 1 ¼-inch long when fully grown, cause severe damage to corn and attack a variety of vegetables. Alfalfa, celery, and cabbage loopers have injurious larvae. They are often known as measuring worms because of their looping action, which gives the impression that they are measuring the plant on which they are feeding.

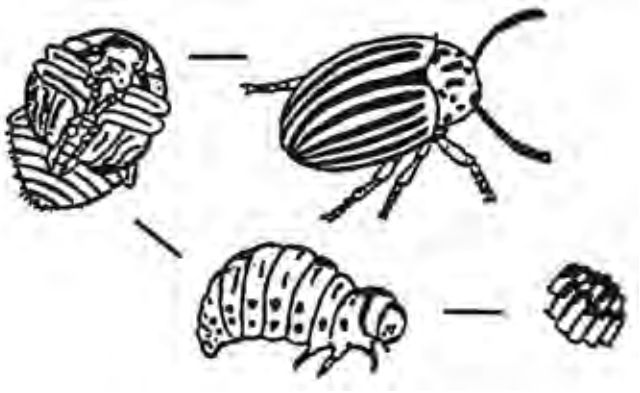

Figure 4. Metamorphosis of a beetle.

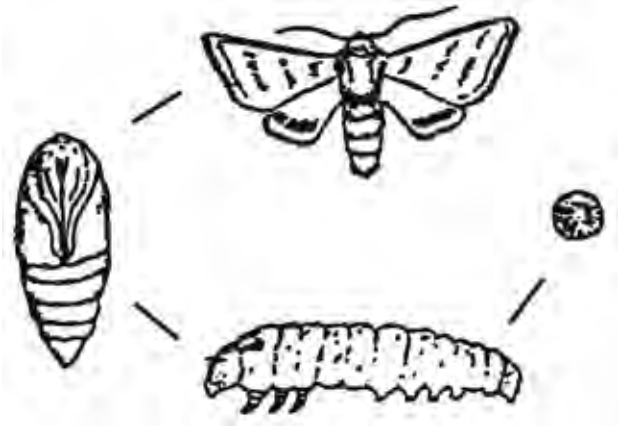

Figure 5. Metamorphosis of a moth.

Another Lepidoteran is the codling moth, which damages apples. The peach twig borer is a severe pest of peaches, prunes, plums, and apricots.

1. Adults are soft-bodied with four well-developed, membranous wings covered with small scales.
2. Adult mouthparts consist of a coiled, sucking tube; adults feed on nectar and other liquids.
3. The larvae are caterpillars that are worm-like and variable in color; they are voracious feeders.
4. The larvae have chewing mouthparts.
5. The larvae have true legs on the thorax and a variable number of prolegs on the abdomen.
6. Lepidopterans undergo complete metamorphosis as shown in Figure 5.

FLIES, MOSQUITOES, GNATS, MIDGES—DIPTERA

Flies are an important group in terms of their medical effects on humans and animals. Some, such as bot-flies, are parasites as immatures on mammals. Some flies, such as the face fly, disrupt or annoy livestock, causing the cows or other animals to stop feeding. Fly maggots or larvae are generally found in manure or other decaying matter. The flies most commonly encountered are the housefly, the lesser housefly, and the face fly. The grayish adults infest homes, poultry houses, and livestock. The housefly has been suspected of mechanically transmitting such diseases as polio to food surfaces.

Commercial agricultural insect pests in this order include the cherry fruit fly, walnut husk fly, onion and cabbage maggot, and carrot rust fly. Others are often disease vectors, such as mosquitoes or deerflies. Vectors can transmit such diseases as malaria.

Mosquitoes are small, slender, long-legged, frail flies. The larvae are elongate and live in water. The adult female is the injurious stage. She feeds by sucking human and livestock blood by piercing the skin with her long stiletto-like mouthparts.

1. Adults have only one pair of wings and are rather soft-bodied and hairy.
2. Adults have sponging (housefly) or piercing (mosquito) mouthparts.
3. Diptera larvae may have mouth hooks or chewing mouthparts.
4. Most larvae are legless.
5. The larvae of advanced forms, such as the housefly and relatives, have no head capsule, possess mouth hooks, and are called maggots. Lower forms such as mosquito larvae and relatives have a head capsule.
6. Diptera undergo complete metamorphosis as shown in Figure 6.

BEES, WASPS, ANTS, SAWFLIES, ETC.—HYMENOPTERA

This group is a large one. Many of its members are important pollinators of agricultural crops, such as the honeybee, leafcutter bee, and alkali bee. Some are important predators, parasites, and scavengers; others are injurious to humans and their crops.

Pear Slug

The adult is black with yellow markings. The larva is small, slug-like, and feeds on leaves of pear, cherry, and plum.

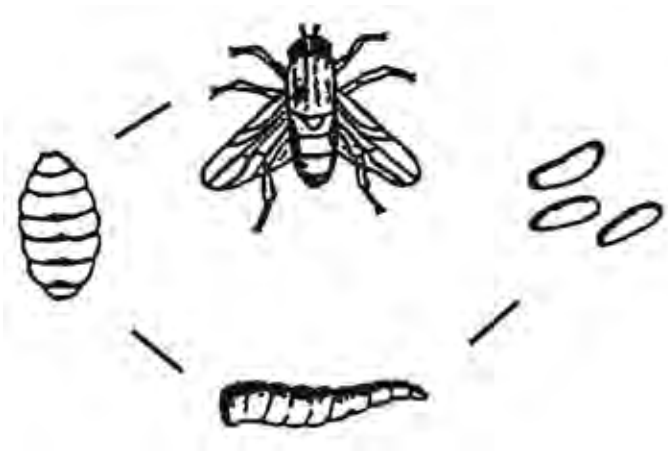

Figure 6. Metamorphosis of a fly.

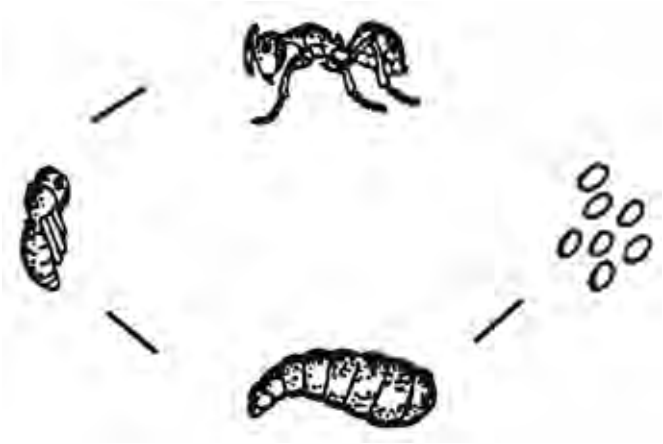

Figure 7. Metamorphosis of an ant.

Yellowjackets

The adults have black and yellow markings. They build nests in the ground or papery structures on trees or under eaves. Their stings are painful and dangerous if you are allergic to them. Many species are beneficial predators.

Leaf-Cutting Bees

These are small- to medium-sized bees, variable in color. They are noted for their long tongues. One species is an excellent alfalfa pollinator. Leaf-cutters may defoliate some trees and shrubs.

Common Ants

Several ants, such as carpenter ants and house ants (including the pavement ant and odorous house ant), are in this group. Many are beneficial predators or decomposers.

1. The adults have two pairs of membranous wings.
2. The adults generally have chewing mouthparts.
3. The adults are rather soft-bodied or have slightly hardened bodies.
4. The larvae have no legs (wasps, bees, ants) or have legs on the thorax and the abdomen (some sawflies).

5 Hymenoptera undergo complete metamorphosis as shown in Figure 7.

TRUE BUGS — HEMIPTERA

Consperse Stink Bug

A gray or brownish plant bug that is shield shaped. The stink bug feeds on many fruits and vegetables.

Box-Elder Bug

This bug is gray brown to black with red lines on the undersurface and on the lower portion of the outer wings. It feeds primarily on box elder and can invade homes in early summer or fall.

Lygus Bug

These bugs are greenish or brownish black and occasionally yellowish or gray; they are rather slim plant bugs about 1/4-inch long. The head is blotched with black. They are probably the most injurious bugs of seed crops in the United States.

1. The adults have two pairs of wings; the second pair is membranous, the first pair is membranous and thickened on the basal half. The nymphs are not fully formed and are called “wing pads.”
2. Adults and nymphs usually resemble one another.
3. True bugs have piercing-sucking mouthparts.
4. Adults and nymphs both are damaging stages.
5. True bugs have a gradual metamorphosis (Figure 8). The stages are egg, nymph, and adult.

APHIDS, SCALES, LEAFHOPPERS, CICADAS — HOMOPTERA

Aphid

There are many types, sizes, and shapes of aphids. The giant willow aphid is a large, black species. The pea aphid is a rather large, green species found on alfalfa, peas, clover, sweet clover, and other herbaceous legumes. It may also be pinkish in color. Several species of aphids attack vegetable and tree crops, including the green peach aphid, which carries the leaf roll virus of potatoes and sugar beets. The rose aphid, both green and brown forms, are found on many ornamentals. Apple aphids and green, rosy, and woolly aphids all cause severe damage to apples.

Scales

Scale insects are usually quite small and are usually circular or football shaped. During most of their life cycle, they are protected by a hardened scale covering. San Jose scale is a pest of many fruit trees and ornamentals. Oyster shell scale is a brown cornucopia-shaped scale (horn of plenty) found on ornamental trees and shrubs. Lecanium scale is a large, brown, hemispherical-shaped scale found on trees and woody plants of several types.

1. These insects are generally small and soft-bodied, though cicadas are larger and hard-bodied.
2. Members may be winged or wingless.
3. All stages have sucking mouthparts.
4. Many members are carriers of plant pathogens.
5. Homopterans have a gradual metamorphosis as the aphid in Figure 9.

GRASSHOPPERS, CRICKETS, COCKROACHES, CAMEL CRICKETS — ORTHOPTERA

Some examples of grasshoppers and their allies are migratory and two-striped grasshoppers and the red-legged grasshopper. These are damaging pests of crops and rangeland. The camel cricket, the Jerusalem cricket, and the German roach are also commonly encountered. Crickets also can damage crops. The German cockroach is a metropolitan pest.

1. Adults are moderate to large and are often rather hard-bodied.
2. Adults usually have two pairs of wings. The forewings are elongated, narrow, and leathery; the second pair of wings are membranous with an extensive folded area.
3. Adults and nymphs have chewing mouthparts and are damaging.
4. The hind legs of forms other than cockroaches and walking sticks are enlarged for jumping.
5. Immature stages are called nymphs and, except for being wingless, resemble adults.
6. Orthopterans have a simple metamorphosis as shown in Figure 10.

TERMITES — ISOPTERA

Injurious termites are generally placed in two groups: the dampwood and subterranean types. Both feed on wood and wood products. The dampwood types are usually not primary feeders on sound wood in buildings, while the subterranean types are found in large numbers in sound structures where they may do considerable damage if not detected early and controlled quickly. Colonies of the subterranean type must have a connection with soil to obtain moisture.

1. These are so-called white ants.
2. Termites are distinguished from true ants by their thick “waists” and their white or light brown color.
3. Termites have thin, straight antennae; ants have elbowed antennae.
4. Termites have chewing mouthparts.
5. They possess many forms or castes such a worker, soldier, and queen.
6. Termites have a gradual metamorphosis as shown in Figure 11.

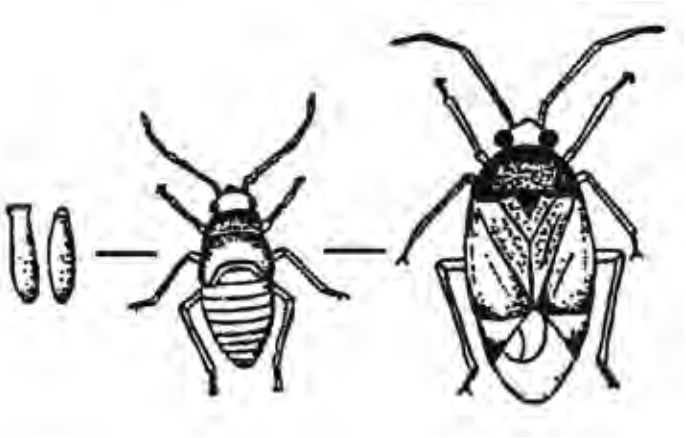

Figure 8. Metamorphosis of a bug.

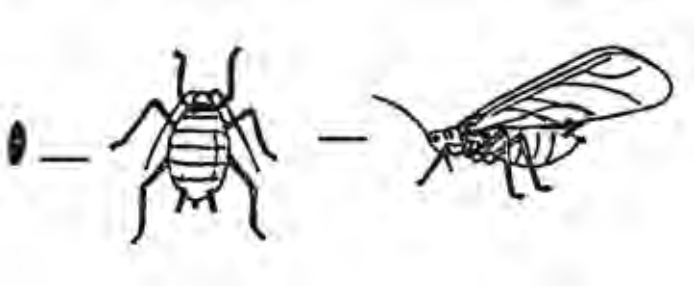

Figure 9. Metamorphosis of an aphid.

EARWIGS — DERMAPTERA

The European earwig is our only species of earwig. It is occasionally a pest of gardens, ornamentals, small trees, and houses throughout the state of Idaho, but it may also be beneficial since it often preys upon other insects.

1. Adults are moderately sized.
2. They have chewing mouthparts.
3. Earwigs are elongated, flattened, and have strong, movable forceps on the rear end.
4. They have short, hardened outer wings and cover folded, membranous inner wings.
5. Earwigs have a gradual metamorphosis (Figure 12).

THRIPS — THYSANOPTERA

1. Thrips are small with sucking mouthparts that are assisted by a single mandible that aids in rasping the plant tissue.
2. Wings may be present or absent. If present, they are long and narrow and fringed with long hairs.
3. Many feed on ornamentals and some on vegetable crops such as peas and onions. Many are predators on other insects. A few species bite humans.
4. Thrips have a gradual metamorphosis.

SILVERFISH AND FIREBRATS — THYSANURA

1. Group members have chewing mouthparts.
2. Thysanura is one of the few insect orders whose members do not possess wings.
3. These insects have bristles on the tip of the abdomen.
4. They are household pests and feed on such items as paste, paper, and crumbs.
5. They have a gradual metamorphosis.

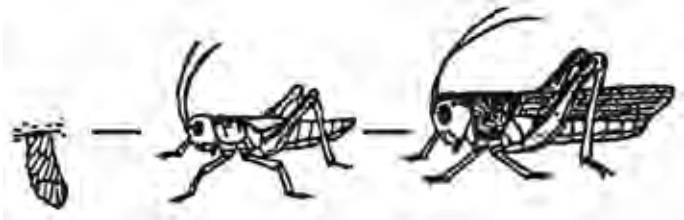

Figure 10. Metamorphosis of a grasshopper.

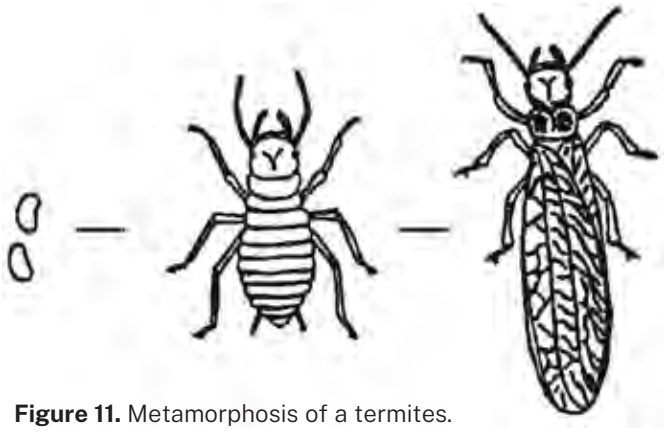

Figure 11. Metamorphosis of a termites.

SPRINGTAILS — COLLEMBOLA

1. Springtails are minute insects with chewing or piercing mouthparts.
2. They possess an appendage on their ventral (under) side; it operates as a spring to aid the insect in quick escape.
3. These insects are abundant in moist areas, hence the reference to “moving piles of soot” in backyards during the wetter seasons.
4. They feed on decaying organic material primarily but will on occasion attack plants, particularly in greenhouses.
5. Springtails undergo a gradual metamorphosis.

OTHER ORDERS

Many other insect orders are of no real concern in the home garden. Some of the more common ones are stone flies — Plecoptera; caddis flies — Trichoptera; dragonflies and damselflies — Odonata; and mayflies — Ephemeroptera. These orders are all associated with aquatic habitats.

Some others you should be aware of include the nerve-winged insects — Neuroptera, many of which are beneficial predators; book-or barklice — Psocoptera, basically scavengers, but with some

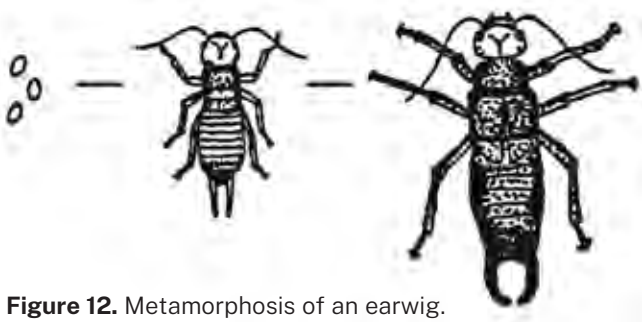

Figure 12. Metamorphosis of an earwig.

species that are stored-products pests; animal lice and sucking lice — Anaplura; and chewing lice — Mallophaga.

Other Insect-Like Creatures

Several noninsect pests may be found in the field and home and include those listed in Table 2.

SPIDER MITES, SPIDERS, TICKS, AND SCORPIONS — ARACHNIDA

Spider Mites

These tiny, soft-bodied animals have two body regions, thick waists, four pairs of legs, and lack antennae. Common species include the following:

The two-spotted spider mite and its near relatives, the Pacific, Atlantic, and McDaniel spider mites. These mites have two spots on the back and have tail-end spots in some species. They may be clear, green, orange, or red. They are usually hard to observe without a hand lens.

European red mite. This mite is carmine red with white spines.

Brown mite and the clover mite. These mites are brownish or grayish, flat, and have very long front legs.

Spiders

Spiders resemble mites except that most are larger and the two body regions are more clearly distinct from one another (thin waist). Most spiders are beneficial predators. Common pest species include

Black widow spider. Shy and likes dank, dark places. This spider spins a characteristically messy web. It is normally a shiny black, moderately sized spider with a reddish or orange hourglass marking on the underside of the abdomen. Males and immature females can have stripes of red, yellow, and black on the abdomen.

The hobo spider, sometimes called the aggressive house spider. A common light brown spider that is often found in basements. This spider has a painless bite, but sometimes the skin sloughs off in the bite area.

The brown recluse spider. A poisonous spider which, fortunately, does not occur in the Pacific Northwest, yet is a potential threat. It is often confused with harmless wolf spiders and other hunting spiders. The brown recluse spider can be recognized easily by a distinct, brown "fiddle case" on a light brown or grayish background.

Ticks

Ticks resemble large mites and are important in agriculture and medicine. They are parasites of humans and animals.

MILLIPEDES — DIPLOPODA

Millipedes are generally inoffensive creatures that feed on fungi and decaying plant material. At times, they can be fairly destructive to vegetables or other plants in greenhouses. They are elongate invertebrates with two visible body regions: a head and a body. They generally are rounded in cross section. With the exception of the first four or five segments, all of the body segments possess two pairs of legs. They are relatively slow moving.

CENTIPEDES — CHILOPODA

Centipedes strongly resemble millipedes. They are different in that they have longer antennae, are flattened in cross section, have only one pair of legs

Table 2. Noninsect pests.

Class	Example	Description
Arachnida	Spiders, ticks, mites, scorpions	4 pairs legs; 2 body regions — cephalothorax and abdomen; no antennae; chewing or sucking mouthparts
Chilopoda	Centipedes	15 or more pairs of legs with only 1 pair of legs per body segment; 1 pair of antennae; 2 body regions — head and trunk; body flattened; chewing mouthparts; fast moving
Diplopoda	Milipedes	2 pairs of legs per apparent body segment; 1 pair of antennae; 2 body regions — head, trunk; body rounded; chewing mouthparts; slow moving
Crustacea	Sow bugs, pill bugs	1 pair of legs per body segment; 1 pair of antennae; 2 body regions — head and trunk; chewing mouthparts; roll into ball when disturbed
Symphyla	Symphylan, garden centipedes	11 or 12 pairs of short legs; centipede-like animals

on each body segment, and move rapidly. They are beneficial because they prey on other arthropods.

SOW BUGS AND PILL BUGS — CRUSTACEA

Sow bugs are highly dependent on moisture, which accounts for their common association with damp habitats. Generally, they feed on decaying plant material, but they will attack young plants in greenhouses and gardens. They are oval with a hard convex outer shell made up of a number of plates.

GARDEN CENTIPEDE OR SYMPHYLAN — SYMPHYLA

Members of this group resemble tiny centipedes. Generally, they are a pest of vegetables and found in damp soils rich in organic matter.

Further Reading

CDS, BOOKLETS, AND PAMPHLETS

University of Idaho Extension

PNW 550 *Encouraging Beneficial Insects in Your Garden*

Chapter 10 published 1993.

CHAPTER **ELEVEN**

INSECT MANAGEMENT

Vickie J. Parker-Clark
Former District I Extension Director, Coeur d'Alene

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11 INSECT MANAGEMENT

Learning Objectives

- Understand the definition of insecticide
- Understand the advantages and disadvantages of choosing chemical insect control
- Understand the preharvest interval when using an insecticide
- Understand how to use mechanical practices for insect control
- Understand how to introduce biological insects to your garden
- Understand how to practice good gardening techniques
- Understand why plant quarantines are enforced
- Understand how to include all types of management within an integrated insect control program
- Understand specific insect pests and when to apply an insect control method

Terms and Definitions

insecticide. A chemical used to control, repel, suppress, or kill insects.

preharvest interval. The amount of time that must elapse (legally) after application of pesticide before harvest takes place.

Why Worry About Insect Control?

- The average insect population per square mile is estimated to be equal to the world human population.
- Destruction of crops by insects in the United States ranges from $4–$15 billion annually.
- Forest insects destroy more useful timber than do forest fires.
- Termites consume about $100 million worth of wood structures annually.

Methods of Insect Control Available to Homeowners

MECHANICAL INSECT CONTROL

Can be used on all insect pests.

Manual removal of insects and eggs from infested plants.

- **Two-block method**. Place the insect on one block (wood or stone) and strike with second block. Repeat as needed.
- **Soap and water spray** (or water alone). Sometimes helpful for control of aphids and similar insects.
- **Light traps**. Be careful not to use lights that may attract insects to your garden.

Advantages

Extremely selective; can be slightly to extremely effective, depending upon the species of insect and the crop.

Disadvantages

Time consuming. Many insect species can fly away or drop to the ground and therefore escape control efforts.

CHEMICAL INSECT CONTROL

Specific insecticides control only certain insect species. It is important to know the target species and the crop affected before selecting an insecticide.

It is particularly important to apply the insecticide properly. This includes carefully measuring the chemical, carefully diluting the solution with the correct amount of water, and taking care not to apply too much or too little spray.

Apply insecticides only to plant species listed on the product's label. Failure to follow label directions may result in damage to desirable plants or create unhealthy residues in foods.

Always determine the safe preharvest interval for a crop you plan to spray with a given insecticide. This information can be found in one of two written formats on pesticide labels:

- Written out on a pesticide label. For example, Ortho Sevin 5 Dust states that the product should not be applied to cole crops (several vegetables in the mustard family) within three days of harvest.
- Written as a number between parentheses immediately after the crop listing on the label. For example, Lilly Miller Fruit and Berry Insect Spray has the listing Apples (7), indicating a preharvest interval for apples of seven days.

Always read and follow label directions carefully.

Advantages

Good to excellent control of insect pests; a minimum of labor is required.

Disadvantages

Special application equipment needed; spray programs are often rather inflexible regarding harvest times; beneficial insects often are killed.

BIOLOGICAL INSECT CONTROL

Use of beneficial insects can be difficult to assess for the homeowner. Many insects are offered for sale (particularly ladybugs, lacewings, and praying mantis), but success with these introduced predators is often inconsistent. Also, these insects may have to be reintroduced each year in order to maintain a garden's population after winterkill or migration.

It is a good idea to be able to identify beneficial insect species in all their growth stages, so as to prevent their unintentional destruction as pests.

Advantages

No labor is involved; after the initial release, the population can be self-perpetuating. You can establish biological control, as the predator will target only the pest. For example, *Bacillis thuringiensis* is useful for caterpillars.

Disadvantages

Only selected insect species will be controlled; control may often be cyclical or incomplete.

CULTURAL INSECT CONTROL

For homeowners, the most important cultural control is to maintain good plant health with proper care through an effective water and nutrition system. A healthy plant is better able to withstand insect infestations.

Crop rotation breaks plant/insect pest relationships. By varying the location of crops within a garden (when possible) or by not growing certain crop types for a number of years, certain insect pest populations can be drastically reduced.

Highly organic soils provide attractive habitat for many soil insects. In addition, insecticides are more rapidly broken down in these soils.

Companion crops are often used to repel insect pests or to attract them away from crops. Don't rely on these methods without constant observation. If they do not work, be prepared to spray, plow, dig up, etc.

- Repellent crops are specific as to which plants they protect and which insects they affect. For example, marigolds are useful in repelling cutworms. At best they can be marginally effective; at worst, they will attract unwanted insects to your garden.

NOTE
Marigolds often attract leaf miner butterflies.

- Trap crops can quickly become overrun with insects. For example, nasturtiums can attract cabbage aphids away from cole crops. If aphids are not controlled on the trap crop, they will eventually move to the crop you are trying to protect.

Weed and volunteer crop control prevents them from becoming an alternative food for insects, particularly before crop emergence. Weed residues can also harbor insect pests.

Sanitation in your lawn and garden area is very important, as many insects are attracted to, and overwinter in, plant debris or trimmings. Nonproducing vegetable plants should be removed or turned under as soon as possible after harvest to deny insect pests a "free lunch" or an overwintering site. Clear away planks, cardboard boxes, and overgrown areas; these provide an excellent habitat for pests such as slugs, sow bugs, and earwigs.

Resistant crop varieties are sometimes available to the homeowner, although most resistance involves plant diseases and not insects.

Using transplants or adjusting seeding dates to avoid emergence of the plant during peak insect populations may help reduce damage.

Advantages
Often simple to perform; often accomplished through other good gardening techniques.

Disadvantages
Generally incomplete.

REGULATORY INSECT CONTROL (QUARANTINES)
Generally, quarantines take two forms:

1. **No movement of the host crop allowed out of an area.** This method keeps the insect more localized where control programs can be implemented more effectively.
2. **No movement of the possibly contaminated host crop is allowed into a "clean" area.** This keeps the insect out of an area where infestations could be disastrous.

Under quarantine laws, government agencies may be allowed to use a part of chemical control under emergency use guidelines.

Advantages
By requiring a control effort, the spread of certain pestiferous insects can be slowed, once infestation is identified.

Disadvantages
Laws must be enforced to do any good and geographical situations may limit control.

INTEGRATED INSECT CONTROL
The best insect control plans start with the simpler methods, then progress to include aspects from all types of control. For example, a control program for the cabbage maggot may begin with transplants. This approach allows older, more vigorous seedlings to escape infestation.

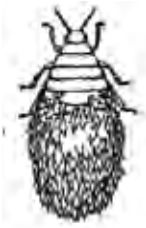
Transplanting is followed by the destruction of plants immediately upon harvest of cole crops. Quick destruction after harvest prevents maggots from completing their life cycle.

If cabbage maggots continue to be troublesome, placement of Lorsban or Diazinon granules around transplants may be attempted. This method prevents infestation of roots.

If maggots still remain a problem, it may be necessary to stop growing cole crops for a season or two or to only grow them every other year. Allowing the field to lie fallow, or switching to another sort of crop, may reduce the population of cabbage maggots in the garden.

Specific Pests

ORNAMENTAL PESTS



Balsam Woolly Adelgid

Appear as white, woolly masses on limbs and trunks of all firs. All active stages have sucking mouthparts and cause damage. Spray timing is important. Spray to ensure adequate control. Sprays may stunt or kill trees. Organic phosphate aphid pesticides do not adequately control adelgids.

Spruce Aphids

These aphids are dull green with sucking mouthparts. All active stages damage spruce trees and the damage is frequently very serious. For example, they can cause severe needle drop. Spray in February or late winter.

Cooley Spruce Gall Adelgid

Appear as white, cottony masses on firs. They have sucking mouthparts and all stages cause damage. They tend to alternate between spruces and Douglas fir. They cause galling on spruces and yellowing and needle distortion on both types of trees. Organic phosphate aphid pesticides do not adequately control adelgids. Treat spruce as the new growth is unfolding in the spring. Treat Douglas fir in early spring.

Rose Aphid

Many species of aphids attack the rose, particularly when there is new growth. They cause **chlorosis** (yellowing green tissue) and they may produce a toxin that kills leaf tissue. Rose aphids excrete honeydew and cause sooty molds. Some people hose plants periodically, but hosing may lead to other problems such as diseases. Check any chemicals suggested for treatment. Some may adversely affect the plant.

Root Weevil

May be ¼–½ inch long. They can be black, brown, or gray. They have chewing mouthparts. Root weevils often attack ornamentals, such as azaleas and rhododendrons, and many garden groups. The white larvae are C-shaped. When the larvae feed on the roots, the plant becomes spindly. Feeding allows entry by root rots. Larvae may also girdle crowns, particularly in containerized plants. Adults appear in June and feed until September. Their effect is less serious. They tend to notch leaves. Though they rarely kill the plant, the result is unsightly. They usually feed at night. Root weevils' fall migrations into homes may cause some owners alarm, but their purpose is hibernation. Spray for adults at regular intervals starting in late June.

Elm Leaf Beetle

Characterized by black and yellow stripes on wing covers of the adults and bodies of the larvae. They generally appear April through August. These beetles live through two generations and may overwinter in homes. They have chewing mouthparts. Both larvae and adults cause damage to elms. The adults chew small holes in leaves, while the larvae skeletonize leaves. They can cause complete defoliation.

NOTE
Destroy if found.

Leafhopper

Small torpedo-shaped insects with wings held roof-like over the body. Found in a variety of colors. Leafhoppers are active jumpers. They attack a variety of ornamentals, fruit trees, and garden plants and may be found throughout the growing season. They have sucking mouthparts and feed on the undersides of leaves, which causes white speckling on leaves (hopperburn). Leafhoppers can transmit virus diseases.

Cotoneaster Webworm

Small, dark-brown to black caterpillars are the damaging stage. They have chewing mouthparts and hide in dense webs. They tend to skeletonize cotoneaster leaves and can kill or severely damage plants.

Fall Webworm

Adults are pure white moths, though they occasionally have a few black spots. The larvae are yellowish brown with long, whitish hairs arising from orange and black bumps. They can be identified quickly because they form unsightly tents enclosing entire branches. The chewing mouthparts are damaging. Webworms tend to cause problems only as larvae and primarily for ornamentals and fruit trees. The larvae are present from midsummer to fall. Treatment is a problem, because if you remove and burn the branch and the tent, you may destroy the symmetry of the shrub or tree.

Juniper Webworm

The larvae are light brown with dark brown stripes on the back; they grow to a length of ½ inch. The larval stage is the most damaging. Larvae have chewing mouthparts and they tend to attack junipers and red cedar. They feed in early spring. Webworms can be identified easily because they web the foliage together. Mechanically destroy the larvae when possible.

Mourning Cloak Butterfly

Larvae are large and black with orange spots on their spiny backs. The larval stage is the most damaging. Larvae attack willow, elm, and poplar. They are foliage feeders with chewing mouthparts. These caterpillars are gregarious feeders and are easily controlled by clipping twigs with groups of caterpillars. Simply burn the clippings. Spraying is not necessary if the problem is caught early enough.

Tent Caterpillars

The larvae are rather attractive, dark, fuzzy caterpillars. The forest tent caterpillar has diamond- or keyhole-shaped spots in a row along the back. The western tent caterpillar is yellow with blue lines. Tent caterpillars congregate in small tents during the day. The larval stage is the damaging stage, seriously defoliating trees of many kinds. Larvae have chewing mouthparts. Tent caterpillars are troublesome in early spring and into summer. Sometimes you can deal with them by clipping tents and by burning. Forest tent caterpillars overwinter as eggs in bands around twigs. Destroy these by crushing them. Or you can spray in early spring; later they may be tough to kill with chemicals.

Birch Leaf Miner

Only the larvae of the birch leaf miner are damaging. They mine and blotch the leaves of birch trees. They have chewing mouthparts. To deal with them, spray just after the leaves unfold in the spring. There are two generations. The second is in mid-July, but if you do a good control job on the first, the second will need only a minor use of spray to control.

Scales

Scales are small, with a soft or hard coat surrounding the insect. The covering takes on various forms from hardened armor to soft, cottony masses. They often promote sooty molds and all active stages are damaging to many plants. They have sucking mouthparts and are stationary (sedentary) feeders. They kill plants or plant parts. In order to treat, find out what scale is present and at what time the active crawling stage is present. Spraying with an insecticide will be effective at that stage. Oil and sulfur dormant sprays are usually the most effective.

LAWN PESTS

Lawn Moths

Damage may be mistaken for thatch or fungus problems. The larval stage is the most damaging. Lawn moths have chewing mouthparts.

Earthworms, Night Crawlers

These are not insects, but annelids. They are normally considered to be beneficial; however, in certain instances, intense earthworm activity leads to castings being thrown up on the surface, leaving an unsightly lawn.

HOUSEPLANT PESTS

See chapter 24, section Insect Pests.

TREE FRUIT PESTS

Codling Moth

The larvae have chewing mouthparts and bore into fruit. Apples and pears are the main hosts. The larval stage is the most damaging. It is extremely important to time sprays properly. Use recommended materials about 10 days after full petal fall and repeat as necessary, depending on materials used and local recommendations.

Aphid (Woolly Apple Aphid)

These reddish aphids are covered by white woolly wax. They have sucking mouthparts. All active stages are damaging. They are bark feeders and their damage interferes with the growth of the tree, often killing a young tree. They also attack roots. Their attacks cause the most serious injury in apple trees, but occasionally they are problems for pear trees.

Aphid (Not Woolly Species)

They have sucking mouthparts and all active stages cause damage. They include the green peach, plum, rosy apple, and green apple aphids. A toxin in the saliva causes various plant reactions: leaf curl, leaf cupping, stunting, lumpy fruit, etc.

Apple-and-Thorn Skeletonizer

The larval stage is the damaging stage; the larva has chewing mouthparts and skeletonizes leaves. The adult stage is a moth.

Fruit Leaf Rollers

The larval stage is the most damaging. Larvae are usually shiny green with a black or brown head. They have chewing mouthparts and feed on the fruit and the leaves of many ornamentals and fruit trees. They tend to bind leaves together with a webbing to form a hiding place.

Blister Mite

Blister mites are arachnids, not insects. They have chewing mouth-parts. The only evidence of their presence is the circular blisters within which these tiny microscopic mites reside. They may become so numerous as to cover an entire tree. Young shoots suffer the most. Blister mites cause malformation of pear fruit; they also attack apple and cotoneaster trees. The blistered surfaces later turn into scab-like areas. They are best controlled during the delayed-dormant period (February or March).

Pear Psylla

Related to aphids and leafhoppers, pear psylla have sucking mouthparts. Feeding is done by all active stages. The pear psylla secretes honeydew, which may kill leaf tissue and which russets fruit. A sooty mold develops in honeydew and blackens affected tissue, which leads to “pear decline.” Other problems from psylla include reduced vigor, fruit loss, poor fruit set, and occasionally the death of the tree.

Pear Slug

A relative of the sawfly bee group, several species of the pear slug are known. The larvae are covered with a slimy material, making them sluglike in appearance. The larval stage is the most damaging. Pear slugs have chewing mouthparts that skeletonize the leaves. Pears, cherries, and roses are hosts commonly attacked by the pear slug or one of its relatives.

Cherry Fruit Fly

The larval stage is the most damaging; the larvae have rasping mouthparts. The adult is a small picture-winged fly. Eggs are laid in fruit starting when the fruit changes to pink or yellow (depending upon the variety). The larvae proceed to feed internally. Breathing holes in fruit point out the presence of the maggots.

Walnut Husk Fly

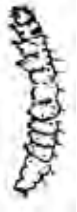
The larval stage is the most damaging. Larvae attack mainly walnuts, but occasionally attack late peach varieties. The adult is a picture-winged fly. In walnut trees the damage to the husk results in the staining of shells and, at times, the darkening of the kernels. Bitter, shriveled kernels may occur.

Peach Tree Borer

The adult is a clear-winged moth. The larvae are damaging to peaches, nectarines, and plums. Larvae have chewing mouthparts. Their injuries are recognized by jellylike gum mixed with dirt and small pellets of frass excreted by the borers at ground level. This damage can seriously injure a tree or even kill it. Heavily infested trees are so devitalized that the leaves turn yellow in a manner similar to nitrogen deficiency.

Peach Twig Borer

The adult is a small, gray moth. The damaging larvae are light- to dark-reddish brown with a black head and yellow-white, ringlike segments around the abdomen. Larvae have chewing mouthparts. They attack developing twigs and burrow down the tender shoots, causing them to wilt and die. Later broods attack fruits. The oriental fruit moth causes similar damage, but is not as widespread in Idaho.



GARDEN PESTS

Cutworms

The adult is a miller moth. The larvae have chewing mouthparts and are the most damaging stage for garden produce. Many kinds of cutworms exist and damage all kinds of plants. Control with chemicals when they are young. The more mature cutworms are difficult to control with chemicals. If cutworms have been a problem, vigorous disking or rototilling in the spring, before planting, will help destroy them. Also avoid persistent weed patches as this is a good source of cutworms.

Wireworms

Have rather hard, shiny, golden colored, elongated larvae. The adult stage is a click beetle. The larval stage is the most damaging. Wireworms have chewing mouthparts. They are a soil pest; their feeding stunts crops. They may kill the plant or cause produce to be inedible. Potatoes and bulb crops are particularly hard hit by this pest; however, corn and other crops may be damaged.

Garden Symphylan (Insect Relative)

These are soil pests with chewing mouthparts; they tend to attack underground parts of all vegetables, small fruits, and many flowers. All stages of the garden symphylan are damaging; infestations are sporadic. Control of this pest is difficult for the home gardener. When the attack is severe, plants wilt and die.

Earwigs

Often merely a nuisance, though all active stages cause damage. Earwigs have chewing mouthparts and attack many sorts of plants. They can be scavengers or predators also. The best control methods are various dusts. Apply dust recommended in your area to soil surfaces when you first notice the problem. Repeat if necessary.

Flea Beetles

There are several species of flea beetles, all of which have chewing mouthparts. Both the larvae and the adults cause damage. The adults attack leaves of many vegetables. The larvae attack roots and tubers. The adults are very tiny beetles and, like fleas, are good jumpers. Use chemical control if necessary.

Aphid

All active stages cause damage. The peach aphid is one of the most important aphids. It affects not only peaches but also potatoes. It is a vector of the potato leaf roll virus, which discolors tubers. The asparagus aphid is also becoming important.

Pea Leaf Weevil

The adult is the damaging stage. The larvae feed on root nodules of peas. Pea leaf weevils have chewing mouthparts. While peas are the preferred host, this weevil will attack other plants such as beans.

Colorado Potato Beetle

Although mainly a pest of potatoes, Colorado potato beetles can feed on tomato, eggplant, and nightshade weeds when potatoes aren't available. Both the larvae and the adults are damaging. These beetles have chewing mouthparts.

Asparagus Beetle

Rather small beetles with chewing mouthparts, asparagus beetles are steel blue in color with reddish margins and a few yellowish spots on wing covers. Larvae and adults damage young shoots, but they are chiefly a pest of mature plants, which may be completely defoliated.

NOTE
The spotted asparagus beetle is somewhat elongated and red orange with black spots.

Carrot Rust Fly

The larvae have rasping mouthparts. The larval stage is the damaging one. The adult is a small, nondescript fly, while the larvae are small maggots that burrow into the crowns or roots of carrots, parsnips, and certain weeds. Only highly organic or humus soils harbor this insect. Remove carrots as soon as possible, since the damage will increase if they are left in the ground. A Diazinon application will reduce, but not eliminate, the carrot rust fly. However, mid–late June plantings tend to reduce damage.

Onion Maggot

The adult is a fly. The larval stage is the most damaging. Larvae cause damage with their rasping mouthparts and create problems similar to those caused by the cabbage maggot, except that onion maggots attack only onions, garlic, and shallots.

Cabbage Maggot

The adult is a fly. The larval stage is the most damaging. The larvae are small, whitish maggots with rasping mouthparts; they bore into the roots and stems of cabbage, broccoli, cauliflower, brussel sprouts, and kale, often killing them. The fleshy roots of radish and turnips may be riddled with holes. Control consists of Diazinon or chlorpyriphos (Dursban) treatments at the time of transplant or planting.

NOTE
Be careful. Highly organic or humus soils tend to tie up insecticides such as Diazinon and Dursban.

Cabbage Looper

The adult is a moth. The larvae have chewing mouthparts. They attack many cruciferous plants, as well as fruits, weeds, and ornamentals. They are defoliators.

HOUSEHOLD PESTS

Stored Products

Many pests go after stored products. They include the carpet beetle, cigarette beetle or drugstore beetle, Indian meal moth, sawtooth grain beetle, and cockroach. Sanitation is the best control.

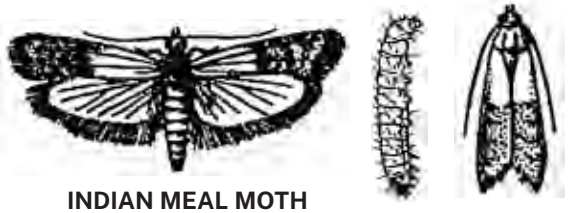
Locate the pest sources and clean them out thoroughly. Destroy infested material or heat to 140°F. Vacuum infested drawers and cupboards.

Spray with pyrethrum in and around possible hiding places, but not on or around food.

Maintain a regular spring cleaning program.

CARPET BEETLE

SAW-TOOTHED GRAIN BEETLE



INDIAN MEAL MOTH

COCKROACH

Structural Pests

Termites. These pests are ant-like, but they do not have constricted waists. They usually attack only damp or rotting wood and are an indication of an already existing problem. It is important to treat these pests properly.When carpenter ant or subterranean termite infestations are apparent, it would be wise to contact a reputable PCO (exterminator) to kill these damp wood termites.

Ants. The most common ant pests are carpenter ants.

Nuisance Pests

Flies. Flies are common, especially in the summer and the fall. Tight seals around windows and screen doors help. It also helps to maintain general cleanliness, as fly larvae can breed in any kind of refuse. Keep garbage containers clean. Pyrethrum sprays will kill the adults.

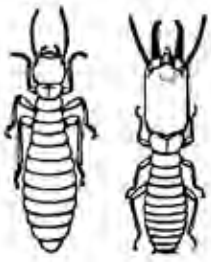
Mites. Many mite species, including the clover mite, enter homes in large numbers, causing the inhabitants great alarm. Some scavenging mites, such as grain mites, can get into stored foods. House dust mites can be a source of allergies.

Centipedes and Millipedes. Though centipedes are normally beneficial, these elongated, multilegged insect relatives often enter homes and cause annoyance. Centipedes can inflict painful bites, while millipedes can become pests in greenhouses.

Other. Careful calking, screening, and patching will prevent many problems with wasps, bats, and other home invaders. Many true bugs such as box-elder bug, sage bug, grass bug, and others will invade homes and other structures in the late summer and fall. While they're capable of biting, the true bugs normally are considered nuisance pests. Several beetles are also invaders and become severe nuisance pests. Control is difficult; sweeping or vacuuming is normally recommended. These include grass weevils, root weevils, and the elm leaf beetle (overwinters in large numbers in attics).

SPIDERS

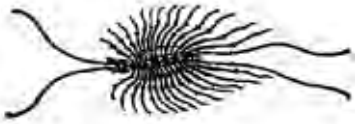
Most spiders are harmless. The black widow is the most dangerous spider in the Northwest. (The brown recluse spider has not been found in Idaho.) The hobo or "aggressive" house spider is common and can cause skin sloughing.



TERMITES

CARPENTER ANT

MITE



CENTIPEDE

MILLIPEDE

Spiders can become numerous in the fall as they seek out overwintering spots. Be sure to seal up basement entries (holes, cracks).

Further Reading

BOOKS

Berry, R.E. 1978. *Insects and Mites of Economic Importance in the Northwest.* Corvallis, OR: Oregon State University Bookstores.

Smith, M., and A.C. Carr. 1988. *Rodale's Garden Insect, Disease and Weed Identification Guide*. Rodale Press.

BOOKLETS AND PAMPHLETS

University of Idaho Extension

CIS 1133 *Management of White Pine Weevil in Spruce*

CIS 1147 *Tuxedo Bug: A New Home-Invading Insect in Idaho*

CIS 1155 *Boxelder Bug: Nuisance Management for Homeowners*

CIS 1169 *Homeowner Guide to Pillbugs and Sowbugs*

CIS 1170 *Homeowner Guide to Centipedes and Millipedes*

CIS 1221 *Hobo Spiders in Idaho*

CIS 1223 *Managing Elm Seed Bugs around Your Home*

PNW 624 *Identification and Habits of Key Ant Pests in the Pacific Northwest*

PNW 729 *Pantry Pest Guide: Common Insect Culprits in Homes and Kitchens of the Pacific Northwest*

Washington State University

EB0818E *Carpenter Ants: Their Biology and Control*

EB0970E *Root Weevil Control on Rhododendrons*

EB1206E *European Earwig Prevention and Control*

EB1380E *Bronze Birch Borer*

FS020E *Snailcase Bagworm*

To view and download visit: **https://pubs.extension.wsu.edu/extension-publications**.

Acknowledgment

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CHAPTER **TWELVE**

RODENTS, BIRDS AND OTHER PESTS

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Learning Objectives

- Learn how to safely identify and handle larger pests
- Learn about rodents, mammals, birds, and others who are pests in the home, yard, and garden

Introduction

Some gardeners worry about critters while others consider them part of nature's plan. One gardener's wildlife habitat or sanctuary is another gardener's nightmare or problem. Over the years you spend tending a garden, you come to realize there are a few shortcuts to preventing animal and other pest problems. Some you need to control; others you learn to live with; and others you learn to share with other gardeners.

In all cases, you need to consider personal pest management objectives, the environment (city or country) in which you are gardening, your neighbors, and how treatments will impact the individual plant as well as the environment. Proper identification, timing, persistence, and diversification will play an important role in successful pest management plans.

Safety in Handling

Recently in Idaho, hantavirus has become a concern for anyone handling vertebrate pests. Also of concern are several other animal-human transferred diseases and parasites including rabies, plague, Lyme disease, and Rocky Mountain spotted fever.

If you handle equipment and work in areas where vertebrate pests are a problem, wear or use masks, gloves, and other protective clothing when implementing control measures.

Identification

Gardeners often become frustrated with the diverse creatures described in this chapter. Unlike many garden pests that remain in place or move around slowly (described in other chapters), these pests are marauders, staging hit-and-run attacks on desirable plants, yards, and gardens.

To find acceptable solutions, you must accurately identify the target pest. Most creatures have predictable needs and activities and you may be able to control or deter them by understanding their habits. This chapter covers only a few of the most common pests.

Your best source for specific species management is the Nebraska Cooperative Extension System's *Prevention and Control of Wildlife Damage Handbook*. This resource publication covers more than 80 species.

You can obtain more information about specific pests from the US Fish and Wildlife Service, United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) Animal Damage Control Specialists, the Idaho Cooperative Extension System, or the State of Idaho Fish and Game Department.

It is unlawful in Idaho to gas, poison, shoot, trap, or otherwise harm any endangered, wild animal, or wild bird species without special permits. Hunting seasons, the Migratory Bird Act, and the Eagle Protection Act regulate other animal harvesting. Before starting a vertebrate pest management program, be sure it is legal. Check with a local game warden for any local shooting and trapping limitations.

Always read the labels of federal-and state-approved pest control products before implementing control measures. It is illegal to use any pesticide not listed on a label. The user is responsible for checking the label to see that the site is listed.

Some pest-control measures are traditional or involve folklore repellents. The Cooperative Extension System does not have scientific data to support the use of most, but you may wish to try them.

Vertebrate Pests—Rodents

GENERAL RODENT INFORMATION

Most methods used in controlling rodents are aimed at destroying them. Poisoning, shooting, exclusion, destruction of habitat, trapping, and fumigating are among the methods used. Of these, poisoning is the most popular and probably the most effective and economical. Because rodent control is a diverse and complicated subject, it is beneficial to learn the life cycle of each rodent pest as you encounter it and before attempting its management.

Rodents is a rather all-inclusive and perhaps a bit deceptive term, because all rodenticides or repellents are not registered for all species. Their management thus requires accurate identification of the particular pest and careful selection of control materials.

Rodenticides differ widely in their chemical nature. Strychnine, indandiones, coumarins (anticoagulants), zinc phosphide, and several others are labeled for commercial use. Of the rodenticides available, anticoagulants are safest to use around the home, provided you follow label directions and pets don't accidentally ingest them. This is of particular concern with cats that are good "mousers." Sold as baits, rodenticides must be ingested for several consecutive days before they are effective. Several other restricted-use rodenticides are available for trained and licensed applicators. Rodent repellents Biomet-12 naphthalene, paradichlorobenzene, polybutenes, polyethylene, R55, and thiram have been used with some success against specific rodent species.

GROUND SQUIRRELS, CHIPMUNKS, AND CHUCKS

These rodents are voracious feeders on lawns, bulbs, and leafy succulent plants during spring and summer. Ground squirrels (Figure 1) may dig a burrow system with entrances 2–3 inches (5–8 cm) in diameter. They are particularly troublesome in gardens that border fields or wild lands.

- The simplest removal method is to fill burrows with water. Reflooding may be necessary to keep them discouraged.
- Also consider live traps (check daily for relocation), gas bombs (place well back in the burrow after plugging all entrances), and poison baits.

Figure 1. Sometimes, the Richardson ground squirrel (from top to bottom), the 13-lined ground squirrel, vole, and mole are called gophers.

- Protect bulb beds aboveground with a cover of fine mesh chicken wire.
- Repel rodents by placing mothballs or moth flakes in the runs or holes where they enter buildings.
- Chief natural enemies are foxes, snakes, hawks, and owls. Dogs and cats are also viable players in a pest management plan.

POCKET GOPHERS AND VOLES

Pocket gophers burrow through the ground, feeding on root crops and roots of garden plants and do surface damage to lawns and gardens. Voles, as in Figure 1, primarily damage the surface of grassy areas and may girdle woody plants.

Gopher runways are parallel to the ground surface and are located 6–10 inches (15–25 cm) below ground level. Control is usually easiest in early spring or fall when fresh mounds indicate activity.

Place poison baits, fumigant type pellets, or traps in their runs. Locate the burrow with a long screwdriver or probe. Carefully follow the control product or trap label instructions. If trapping efforts fail, line the sides of planting holes with light gauge chicken wire or hardware cloth.

Eliminating ground cover reduces population. Soil cultivation destroys burrows and reduces cover.

MICE AND RATS

Mice or rats can spread disease and viruses, consume and contaminate stored products, and may girdle woody plants by chewing bark (particularly in the winter). Mice eat seed and grain products and grass and create runways and bare patches on lawns. Damage to lawns can be severe in winters when snow covers the ground for months.

Sanitation is your first line of defense. Conduct a general cleaning, eliminate food sources, and destroy rodent nests. Get rid of rock piles, old boards, and junk. Keep piles of wood and lumber off the ground. Mow lawns regularly and remove long grass and vegetation from adjacent areas. Keep areas around the base of trees and shrubs free of grass and loose mulch where mouse damage is a problem. Store all dried and bagged food in rodent-proof containers. Proper composting of kitchen waste is important. Keep seeds and livestock or pet food in sealed containers.

Diligently apply taste and smell repellents to the problem areas. Use live or spring traps or place bait boxes or poison baits where other animals and children cannot reach them. Some rats may become bait shy and others may develop an immunity to anticoagulants, so change the types and active ingredients of poisons when confronted with extended problems. Immunity develops over time and constant exposure to anticoagulants. It may be necessary to prebait. After completing sanitation measures, create bait stations. Place the baits in runways along a wall or fence where rodents often travel or places where rats or mice seek shelter. Check baits frequently to ensure they are fresh, dry, and free of mold.

In orchards, field mice feed on trunks of trees, rarely burrowing belowground. If the orchard is mulched, pull the mulch back a few feet from tree trunks in the fall. To deter field mice, place wire cylinders, tree collars, and plastic or paper wraps around the base of fruit trees.

RABBITS

Rabbits will girdle young trees, chew off bark and young twigs of woody plants in winter, and consume leafy plants during the summer (Figure 2).

You can livetrap and relocate rabbits. Reduce the rabbit habitat by removing overgrowth on ditches, bushy fencerows, or brush piles within or near garden areas. Rabbits don't like to be far from cover so mowing, brush cutting, and general cleanup can help control them.

Place guards made of fine mesh (¼ inch) screens around the base of trees to protect them from rabbit damage. Form the guards into cylinders about 2 inches larger than the diameter of the tree trunk and long enough to protect the tree above the snow line. Tightly woven (no larger than 1-inch mesh wire and at least 30 inches high) fences, well anchored to the ground, also work well.

Plant "trap" crops like beans away from the garden to divert rabbits. This may provide extra food, however, resulting in more rabbits. Also, onions seem to repel them, so it may help to interplant an occasional row with your crops.

Also effective are commercial repellents containing thiram or Ziram fungicides or other materials sprayed or painted on tree trunks, plants, or shrubs. Blood dust, nicotine, and other repellents are labeled for rabbit control.

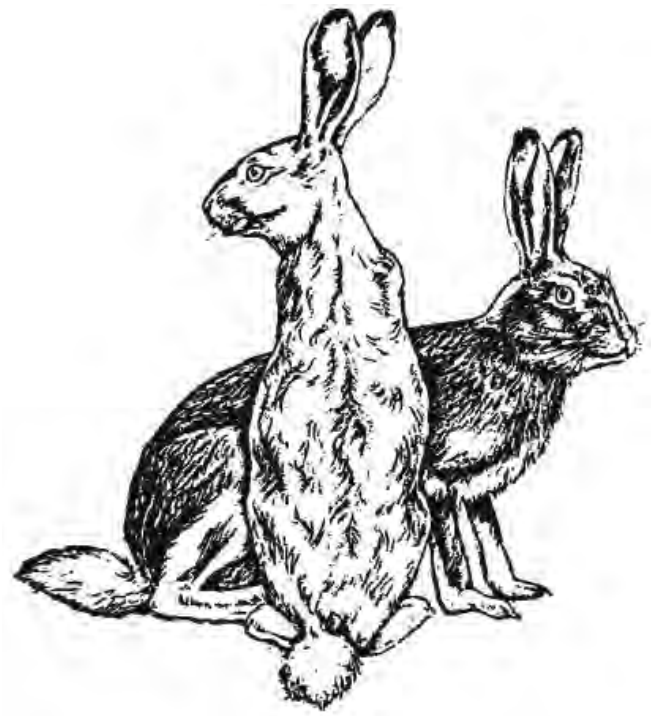


Figure 2. Cottontails and jackrabbits can become serious, year-round pests.

Some gardeners sprinkle dried blood meal around plant roots or spray a cow manure and water solution to reduce a rabbit's interest in particular plants. Others apply powdered rock phosphate, powdered aloes, red cayenne pepper, or fish tankage with bonemeal to seedlings as they emerge or as a dust on plants. Some gardeners spray or place coyote, fox, or other animal urine mixtures around garden areas as repellents.

BATS

Bats are beneficial insect-eating animals. Occasionally bats get into buildings or attics where they foul the area with odorous feces or guano and disturb the occupants with their nocturnal activities. Bats can carry rabies. Always vaccinate your pets. Do not handle bats. If you must handle them, wear heavy leather or rubber gloves.

One or two bats in a house is a problem. Usually, a bat will find its way out by detecting fresh air movement, so the simplest solution is to open windows or doors leading outside. Bats have day and nocturnal roosts that they return to daily. Each species selects roost sites with specific temperatures. If the roosting area is too hot, too cold, or too drafty, they will leave. A single light bulb in the space where they roost may keep it too hot for bats. Another solution is to create a draft by opening doors and windows and using an electric fan. To discourage bats from roosting in one place, scatter 3–5 pounds of moth flakes over the floor or hang them in mesh bags from the rafters.

The best time to batproof a building is in the fall or winter when bats migrate to wintering areas. As soon as they leave, seal the openings in eaves and attic louvers with ¼-inch mesh, narrowly spaced, parallel tightwires or fishing-line screen, or boards. Seal narrow cracks with caulking compounds. If you are bat proofing a building, be sure all bats are outside before plugging the last opening. Not all bats will leave at the same time. Consider installing a one-way device to allow bats to leave but not return. Building bat houses for excluded bats may help with the problem the next season.

Placing floodlights in the attic or directing them at openings for several nights will not discourage entry. Instead, the lights will attract nocturnal insects such as moths, providing a ready food source for bats.

Figure 3. Raccoons become especially bothersome near harvest for corn, melons, and other fruit.

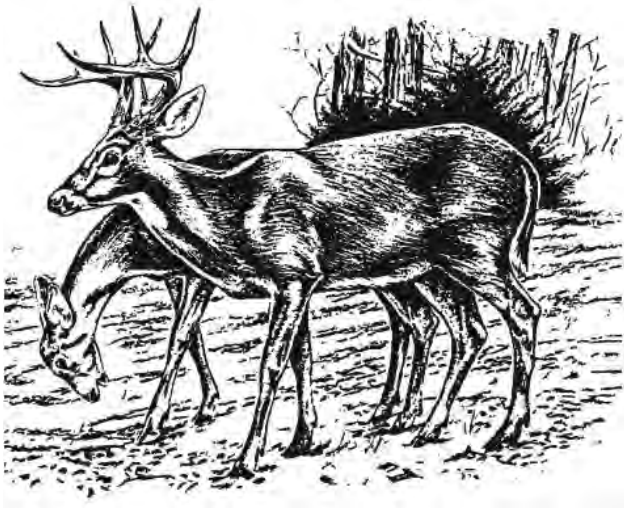


Figure 4. To learn more about controlling deer damage and deer-resistant plantings, see the various publications in the "Further Reading" section at the end of this chapter.

Vertebrate Pests—Other Mammals

RACCOON

Raccoons have adapted to urban and suburban areas, feeding at night at "garbage can" restaurants or from pet dishes (Figure 3).

Raccoons are easy to catch with box traps. Normal fencing will not keep raccoons from your garden; however, electric fencing is particularly effective.

Sprinkle black pepper on corn ears before they are ripe. Installing motion lights and leaving radios on in the garden at dusk and dawn may help repel raccoons.

DEER

Deer can damage herbaceous and woody plants by browsing (Figure 4). Orchard and vegetable crop damage are a concern, too.

Base your landscaping on deer-feeding preferences to avoid using expensive chemical repellents. Planting resistant or less palatable vegetables, annuals, perennials, trees, and shrubs in landscapes will discourage browsing.

An inexpensive way to exclude deer is to construct a wire-mesh fence, 7–10 feet (2–2½ meters) high, around small gardens or orchards. A horizontal outrigger — a fence extension — makes it harder for deer to jump fences. Some gardeners have had success with two parallel 5-foot fences with a 5-foot "no deer" area between them. In some areas, electric fences work if constructed with at least five wires. Tightly strung piano wire in the Australian fashion of crossbeams forming an "X" at three heights also works. Deter deer by placing welded-wire fencing around individual trees or plants or types of plants or use other mechanical devices such as rigid tubes (Vexar, Tree Shelters, and Tubex), flexible sleeves, and bud caps.

Several commercial repellents are registered and may be partially successful. They require repeated applications, particularly after rain or watering. Spray contact or taste repellents such as thiram, Ziram, and capsaicin (derivative of chili pepper) on the lower trunks and lower limbs of trees at 2-week intervals.

Other methods include sport hunting to reduce populations; live traps for removal by conservation officers or professional biologists; temporary frightening devices such as gas exploders, tethered dogs, fireworks, or a radio left on at night; human hair balls or deodorant soap bars hung at close intervals around valuable plants or around the garden; and blood meal, coyote, or other animal urine sprayed or placed around garden areas as repellents.

SKUNK

Skunks are protected by law in most states and frequently are found to carry rabies. If possible, avoid handling them because they can eject their scent 6–10 feet. The persistent odor on clothing, in gardens, or buildings is highly offensive (Figure 5).

One method of control is to exclude skunks from their sleeping or nesting quarters. Sprinkle a thin layer of flour around holes or building entrance areas to form a tracking patch. Examine the area after dark, when the tracks lead out of the entrance. Close off the space with lumber or fencing or consider livetrapping and relocating the skunk. Leaving a radio on all day in the skunk's nesting area may disturb sleep patterns enough to cause them to relocate.

A chemical known as Neutroleum Alpha is probably the most effective odor neutralizer available. A tablespoon in a water bath works well for pets and humans unfortunate enough to be "hit." Use 2 ounces in each gallon of water to scrub walls, outbuildings, basements, outdoor furniture, and the like. You also can use chlorine bleach or household vinegar (diluted 1–10 parts water) with a little detergent. Tomato juice is not as effective.

DOGS AND CATS

Male dogs urinate and kill parts of leafy plants, especially conifers; female dogs' urine may cause dead patches in a lawn. Dogs leave feces on lawns or flower beds and dig in garden beds. Cats can severely damage bark on young trees where they sharpen their claws. They dig in garden soils and leave fecal matter that may transmit parasites or diseases to humans. Cats are the number one enemy of songbirds in the garden.

Controls include fences; scolding; clapping hands; waving brooms; or spraying the cat or dog with water from a garden hose. A screen around the tree base will obstruct cats as will clipping the cat's claws. Cats will avoid resting or walking on walls or fences with moth crystals sprinkled at regular intervals.

Repellents are almost too numerous to mention, including allyl isothiocyanate, amyl acetate, anethole, Bitrex, bone oil, capsaicin, citrus oil, cresylic acid, eucalyptus, geranium oil, lavender oil, lemongrass oil, menthol, methyl nonyl ketone, methyl salicylate, nicotine, pentanethiol, pyridine, sassafras oil, and thymol.

Vertebrate Pests—Birds

GENERAL BIRD INFORMATION

All birds, in one way or another, are beneficial to man. They can, however, create problems singly or in groups. Birds are important in preventing insect outbreaks and their control of other garden pests benefits most gardens. Man considers birds as pests when they consume and destroy fruit and seed crops such as strawberries, sweet cherries, and sunflowers; contaminate foodstuffs or buildings with their feces; and transmit diseases directly or indirectly to man, poultry, or dairy animals.

Avicides registered by the Environmental Protection Agency for specific species often require prebaiting for several days and the quick removal of dead birds at regular intervals to be effective. Chemosterilants, birth control agents, and repellents are also available. There are three repellent categories: (1) olfactory (odor), (2) tactile (touch), and (3) gustatory (taste). In the olfactory category, gardeners have used naphthalene (mothballs) granules or flakes to repel all domestic animals. Tactile repellents are made of various gooey combinations of caster oil, petroleum, or solvents and applied as thin strips or beads to roosts, window ledges, and resting areas. Taste repellents are varied and have multiple uses. For example, fungicides applied as seed treatments sometimes inhibit seed-pulling birds.

To protect sprouting seedlings and maturing vegetables, floating row covers are easy to use and need no supports. Drape cheesecloth, nylon netting, or other mesh materials over garden crops or fruit trees susceptible to bird damage during ripening. Put these up 2–3 weeks before ripening. Place screen or cloth over strawberries and other small fruits.

Commercially designed noisemakers are partially effective but not very popular in populated areas. Stakes and flags, continuous string flagging or netting, spiral twirlers, shiny propellers, and other objects that flash in the sunlight or rustle or rattle as they spin are useful in small areas until birds become accustomed to them.

Figure 5. Skunks are kin to weasels and are not afraid of humans.

Poisoning is effective but not selective. Invariably, poisons kill songbirds or birds that are protected, so using them is not recommended.

YELLOW-BELLIED SAPSUCKER

A member of the woodpecker family, sapsuckers drill horizontal rows of squarish holes through the bark of spruce, Scots pine, birch, nut trees, and Siberian elm. They feed on sap and sapwood. Hummingbirds feed on this sap and, like the sapsucker, take advantage of the insects attracted to the ooze. Girdled trees may die.

Because sapsuckers are a protected species, it is unlawful to kill them; so wrap the damaged trees in burlap and treat with pruning paint. Painting a mixture of cayenne pepper and petroleum jelly on affected areas may discourage continued damage. Noisemakers also may scare birds away.

STARLINGS

Exclude starlings (Figure 6) by closing all openings to less than 1 inch (2.54 cm). Use boards or metal coverings at 45° angles and metal prongs or sticky repellents on ledges or rafters. Attach netting to prevent roosting on buildings or rafters. PVC strips work well to cover door openings. Frightening devices, including alarms, distress calls, lights, and bright objects, may work. Repellents to protect ripening fruit and poison baits also are available.

Figure 6. Starlings can cause damage because of their prolific numbers and flocking habits.

Invertebrates and Arthropods of the Home Yard and Garden

NEMATODES

Nematodes or eelworms are tiny, unsegmented worms that may be as small as 1/125 inch in length. An impermeable cuticle covers and protects them. They survive during unfavorable periods of cold or heat in protective eggshells. Accurately identifying this pest and learning its specific life cycles (eggs may remain viable in cysts for several years) is the key to proper management.

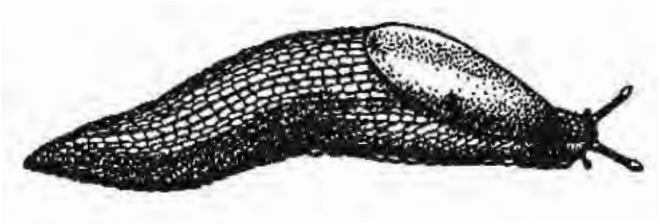
Nematodes cause their greatest damage when soil moisture and temperature are suitable for germination. They frequently pierce roots and feed on them. They may lay their eggs on roots causing knots to form. Nematodes can transfer diseases between plants. A plant attacked by parasitic nematodes loses nourishment and may appear stunted or die. There are a number of beneficial free-living, nonparasitic nematodes associated with the root systems of many plants; therefore, finding root knots does not always indicate nematode injury.

Control culturally by selecting nematode-free planting stock or resistant plant varieties. You can kill considerable numbers of nematodes by soil solarization, flooding the soil for extended periods, or by permitting the soil to completely dry out. Maintaining high fertility levels or adding organic amendments (peat, manure, and green chop) to garden soils decreases the pest's impact. Some commercial preparations of organisms (bacteria, sporozoa, fungi, viruses, protozoa, predatory nematodes, tardigrades, mites, and springtails) that prey on nematodes are available.

Crop rotation is perhaps the most inexpensive, yet effective way to control nematodes. Nematode-suppressive plants such as French marigolds (*Tagetes patula*), asparagus, garlic, and onions have been reported to abate nematodes if they are planted in blocks and used as part of a rotation.

Orchard floor management through the use of cover crops in orchards or vineyards can have a significant impact on nematode infestations. Sanitation, preventing the movement of soils or water from an infested area of the garden, and planting or harvest dates based on soil temperature (with an understanding of nematode life cycles) also may help.

Gardeners seldom use nematicides unless they encounter greenhouse or cold-frame problems. Most of today's chemical nematicides are soil



fumigants or volatile halogenated hydrocarbons. There are no nematicidal agents registered for use in the home garden. If this pest problem occurs, contact a commercial applicator. To avoid damaging other plants, the products must be applied before planting. Chemical applications must have high vapor pressure to spread through the soil and successfully contact nematodes in the water film surrounding soil particles.

SLUGS AND SNAILS

These are mollusks, not insects. Both have soft bodies and secrete a silvery mucus that appears as trails across the garden. Snails carry a shell about with them. They spend the winter in the soil as eggs. Young and adult slugs often rest in night crawler tunnels. They appear in early spring and multiply rapidly under moist conditions. There are several kinds, but all are similar in appearance. Their color varies from white to pale yellow to lavender purple to nearly black with brown spots, specks, and mottlings. They have rasping mouthparts. Slugs are humidity-loving animals that attack all kinds of garden and ornamental plants. They may eat irregular sections or consume entire leaves. There is only one generation per year.

Culturally control slugs by eliminating cool, moist, dark hiding places (low-growing weeds, stones, trash, and ground covers) where slugs seek daytime shelter. Keeping the garden dry and plants well spaced can help. Regularly hand picking slugs from plants at night, maintaining a border of bare soil, and building copper screens or copper strip barriers that they cannot crawl over may also help. Commercial traps are also available. Shallow pans placed at ground level and filled with stale beer are good homemade alternatives. Shingles, boards, and flowerpots placed on the ground as hiding places also make good traps; check traps daily and scrape off and destroy the slugs. Commercial preparations of diatomaceous earth can be effective as a protective barrier if kept dry. Among their natural enemies are ladybug larvae, ducks, chickens, snakes, and turtles.

You can chemically control slugs by using molluscicides such as metaldehyde baits. Note these baits may attract and be toxic to pets. Improve the bait's effectiveness by placing it under a protective cover such as a 5-inch-diameter pie pan. Fresh baits are most effective. Do not allow bait to come in contact with edible parts of plants. Methiocarb (Mesurol) is the most effective of the insecticides registered for use against snails and slugs on ornamentals. Other registered insecticides include Carbaryl and Mexacarbate.

Do not use salt because it contaminates soil and kills plants. A solution of one-half household ammonia and one-half water in a spray bottle may destroy slugs and snails without harming the soil. Keep the spray solution off leaf surfaces because it can damage plants; however, it leaves nontoxic residues.

A mulch of oak leaves or tobacco stem meal will repel slugs and snails. A drenching of wormwood tea will deter them. Hellebore has long been used to keep slugs from grapevines.

EARTHWORMS OR NIGHT CRAWLERS

Earthworms need a moist environment. They are headless, eyeless, toothless, bisexual (have both male and female reproductive organs), and lack antennae. Soils with high worm populations often have high organic matter levels. Saline soils, sandy soils, and soils with a pH of 4.5 or lower usually have few worm problems. Earthworms are normally found in the top 6–30 inches of the soil. They come to the surface at night and after heavy rains.

Earthworms can grow to 10 inches in length. Most gardeners feel they are beneficial, but for some their burrowing and hard casts make a lawn lumpy and difficult to mow. They burrow through soil, feeding on organic matter and dead leaves or stems at the soil surface. They decompose thatch, mix organic material through the soil, and aerate the soil with their tunneling.

Culturally some lawn maintenance professionals use heavy lawn rollers in the spring before the mowing season, or when problems occur, to level the ground.

No chemicals are registered for earthworm control.

Further Reading

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University of Idaho Extension

CIS 1041 *Conduct Your Own Garden Research*

Oregon State University

EC 987 *Controlling Moles*

EC 1255 *Controlling Pocket Gopher Damage to Conifer Seedlings*

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Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

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CHAPTER **THIRTEEN**

PLANT DISEASE DIAGNOSIS AND MANAGEMENT

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Learning Objectives

- Learn the history of plant diseases in the United States
- Learn the basic disease concepts, including signs and symptoms
- Learn the disease cycle
- Learn the difference between biotic and abiotic agents

Introduction

Plant pathology or phytopathology is the study of plant diseases and their control. Plant pathologists study plant diseases caused by biotic (living) agents like fungi, bacteria, viruses, nematodes, and parasitic plants, but they also study plant disorders caused by abiotic (nonliving) agents like nutrient imbalances, air pollution, and other unfavorable growing conditions. Learning how to diagnose plant disease involves more than just matching pictures of plant symptoms on the internet or in a book with those afflicting the plant sample in your hand. Many plant conditions cause symptoms that look similar. Being able to diagnose plant problems is a skill developed over time. Indeed, building knowledge about plants and plant diseases is a trial-and-error progression, one heavily reliant on repetition.Learning the process helps a Master Gardener make the correct diagnosis, which likely will resolve an Extension client's plant issues.

As a Master Gardener, your primary goal is to educate. The diagnosis you arrive at is an opportunity to help Extension clients understand proper plant growth requirements and to suggest sustainable measures to prevent plant disease.

History of Plant Disease

As evidenced by biblical references to the blasting and mildewing of plants, plant diseases have had profound effects on humankind throughout the centuries. Secular

observers documented the effects more systematically. For example, Greek philosopher Theophrastus (370–286 BC) was the first to describe maladies of trees, cereals, and legumes that we currently classify as leaf scorch, rot, scab, and cereal rust diseases. The Romans were also aware of rust diseases in their grain crops. They celebrated Robigalia (an agricultural festival that honored the growing season) by sacrificing reddish-colored dogs and cattle in an attempt to appease the rust god Robigus.

Subsequent technological discoveries proved more beneficial. After the microscope's invention in the early seventeenth century, naturalists began investigating fungi and bacteria associated with plants. In 1665, Robert Hooke illustrated rust in a drawing that had developed on a rose leaf, the first published illustration of the disease. Despite artistic contributions like these, as well as his and others' improvement of the optical tool, belief in the theory of spontaneous generation hampered advances in the study of diseases until as late as the mid-eighteenth century. Adherents of this theory believed that pathogenic or disease-causing microorganisms were symptoms of disease rather than its origin.

Plant diseases have caused widespread famine and displaced millions throughout history. Potato late blight fungal epidemics so devastated Ireland from 1845 to 1848 that death and migration accounted for the loss of nearly one-third of the Emerald Isle's population between 1845 and 1860. In 1861, a German botanist, Anton de Bary, proved that a fungus (*Phytophthora infestans*) was the causal agent. This was a milestone in the study of plant diseases since it proved that a fungus indeed caused a plant disease. Two years later, Louis Pasteur proposed his germ theory of disease, which officially disproved the theory of spontaneous generation, forever changing the way modern science investigates disease.

SIGNIFICANCE OF PLANT DISEASE IN THE UNITED STATES

A few examples of plant disease epidemics that triggered devastating plant losses in the United States include the following:

- Chestnut blight, introduced in 1904, virtually eliminated chestnut trees from North America.
- Citrus canker, introduced in 1910 (and a closely related bacterium called citrus bacterial spot discovered in 1984), resulted in the destruction of millions of citrus trees.
- White pine blister rust, introduced in 1912, caused large economic losses in the timber industry.
- Dutch elm disease, introduced in 1930, continues to destroy large numbers of elm trees today from the East Coast to the Pacific Northwest.

Because imported diseased plant materials initiated these epidemics, plant quarantine laws were passed by the US Congress in 1912. The Animal and Plant Health Inspection Service (APHIS) has quarantine inspectors stationed at points of entry into the United States, as well as at certain interstate points, to intercept incoming produce likely to carry new plant pathogens.

Disease Concepts

WHAT IS A DISEASE?

Healthy plants develop and function to the maximum of their genetic potential. When continuous irritation of a disease-causing agent interferes with normal development and plant functions, plants are considered diseased. Thus, a simple way to define a plant disease is a change in the host plant that causes abnormal growth or a disruption of normal plant function. Diseases may be biotic (living) or abiotic (nonliving).

Diseases are among the most important factors that significantly diminish growth and yield. In addition to a reduction in growth, yield, and the economic or aesthetic value of a plant or plant product, diseases may lead to the death of a plant or destruction of an entire crop. Diseases may interfere with absorption and translocation of water and nutrients from the soil, reduce the photosynthetic efficiency of a plant, interrupt the translocation of photosynthetic products, or interfere with reproduction and the storage of food reserves in a plant.

CAUSAL AGENTS OF DISEASE

Diseases in plants are caused by biotic pathogens such as fungi, bacteria, phytoplasmas, spiroplasmas, viruses, viroids, and/or abiotic factors that are environmental (like frost) or chemical (herbicide damage). Plant diseases can be grouped by the causal agent involved (fungal diseases, bacterial diseases, viral diseases, nematode diseases, etc.), the plant part affected (root disease, seedling disease,

leaf disease, stem disease, flower disease, fruit disease, tuber disease, etc.), or the types of symptoms shown (damping off, wilts, leaf spots, cankers, blights, galls, root knots, mosaics, storage rots, etc.).

SIGNS OF DISEASE

Signs are the visible parts of a pathogen or its products seen on a host that help diagnosticians identify a pathogen. Examples of some common disease signs include the following:

bacterial slime, flux, or ooze. Bacterial discharge that oozes out of plant tissue. It may be gooey or dry.

conk. A fungal fruiting structure formed on woody plants.

cyst. The swollen egg-containing female body of certain nematodes; it can generally be seen on the outside of infected roots.

fruiting bodies. The reproductive portion of a fungus that contains the spores.

mycelia. A mass of hyphae (fungal threads).

rhizomorphs. Shoestring-like hyphae found under the bark of stressed and dying trees.

Although not considered a disease, some signs of damage that could lead to plant problems later include girdling roots or bark damage.

SYMPTOMS OF DISEASE

Symptoms are the visible reactions of a plant to a disease that may suggest a causal agent. However, different disease agents can cause similar symptoms on the same host. It is important to remember that insect feeding can also cause disease-like symptoms on plants.

abnormal coloration. Change in the color of plant tissue.

abscission. Dropping of leaves, flowers, or fruit by a plant.

canker. The formation of sharply delineated, dry, necrotic, localized lesions on a stem.

decline. Progressive decrease in plant vigor.

defoliation. Loss of leaves or foliage.

desiccation. Drying out of plant tissue.

dieback. Progressive death of shoot, branch, or roots, starting at the tips.

distortion. Malformed plant tissue.

flagging. Wilting and/or death of plant parts, usually starting at the tips of a branch or stem.

fruit drop. The shedding of unripe fruit from a tree.

gall. Abnormal localized swelling or enlargement of a portion of a leaf, root, or stem.

gummosis. Exudation of gum or sap.

leaf scorch. Drying of leaf tissues, often along the leaf margin.

leaf spot. Spot or lesion on a leaf.

The Disease Cycle

Plant diseases are the exception rather than the rule. For infectious disease to develop, a series of events referred to as the **disease cycle** must occur: inoculation, penetration, establishment of infection (this includes invasion of the host), growth, reproduction, dissemination, and survival. Pathogens in temperate climates must have a way of overwintering when their host plants are dormant or absent. In perennial plants, pathogens can survive in infected plant parts such as roots, bulbs, stems, and bud scales. Because annual plants die at the end of the growing season, pathogens survive within insects and seeds or as resistant spores.

INOCULATION

The first step of the disease cycle is inoculation. This occurs when a pathogen comes in contact with a susceptible host. Pathogens that find susceptible hosts and can cause infections are referred to as **inoculum**. Wind, water, insects, and animals can carry inocula to host plants.

PENETRATION

Following inoculation, penetration of a host may occur. Some pathogens, including many fungi or nematodes, penetrate a plant by mechanical means. Others may enter a plant passively through wounds, stomata, or other natural openings. Penetration does not always result in infection. For penetration to result in infection, three factors — a host, a pathogen, and an environment — must coincide (as represented in the disease triangle, Figure 1).

INFECTION

Infection requires inocula to establish continuous contact with a susceptible host plant to create a parasitic relationship. The interaction between a

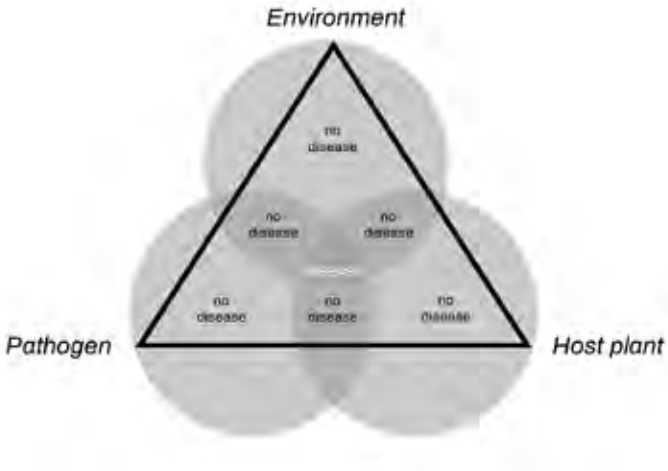

Figure 1. Plant disease triangle.
Adapted from Figure 4 in Moore et al. (2019).

host plant, pathogen, and environment with time will determine the occurrence and severity of a disease.

For a disease to occur, the following three conditions must be met:

1. The host plant must be of a susceptible species or cultivar and at the right stage of development (susceptible host).
2. The pathogen must be of a virulent race or strain and must be present in sufficient numbers (inoculum potential). The presence of appropriate vectors or other agents of dispersal may also be necessary.
3. The environmental conditions must be favorable for disease development. These include temperature and humidity; wind and moisture levels; light; soil texture, structure, and pH; the density of the planting and air movement; and the plant's nutritional status (mineral deficiency or excess).

If these three conditions are favorable and infection does occur, a pathogen may release enzymes which manifest themselves as symptoms in or on a plant. The period between infection and manifestation of symptoms is known as the **incubation period**. This period can last days or even years. Some infections may be localized while others are systemic, affecting an entire plant. Many pathogens reproduce during the infection stage.From there, pathogens disseminate to other plants.

DISSEMINATION

Pathogen dissemination occurs in a variety of ways — through plant debris, equipment, irrigation water, rain, wind, seed, soil, insects, animals, and more. Understanding the various aspects of a host plant, a pathogen, and environment, as well as their interaction, is essential to implement an effective disease management strategy.

Diseases Caused by Biotic Agents

FUNGI

In most areas of the eastern United States that receive ample rainfall (40 inches or more precipitation annually) and develop high humidity, fungi are the most impactful cause of plant disease. Depending on a gardener's location in Idaho, annual precipitation may be only 11–27 inches with low humidity during the growing season; hence, occurrences of fungal diseases are limited.

Fungi are divided into two main types: **saprophytic fungi** that feed on decaying organisms and **parasitic fungi** that feed on living organisms. Fungi have chitin in their cell walls, which adds rigidity and structural support. They lack chlorophyll; consequently, they have no ability to manufacture their own food and must obtain their food from another source. The body of a fungus is a branched filamentous structure known as **mycelium**. One single thread is called a hypha (plural = hyphae). Most fungi reproduce through spores. Many fungi overwinter as fruiting structures on dead plant tissue. Fungi damage plants by killing cells and causing stress to the plant. Examples of plant symptoms caused by fungi are cankers, leaf spots, mildew, and root rots.

BACTERIA AND PHYTOPLASMAS

Bacteria (singular = bacterium) and phytoplasmas are single-celled microorganisms. A bacterium does have a cell wall but does not have a nucleus and reproduces by cell division. Phytoplasmas are a type of bacteria that lack distinct cell walls. Bacteria can infect all parts of a plant but require an opening for entry. Bacteria break down plant cell walls so that the contents can be utilized. Some bacteria produce enzymes that break down plant tissue to create soft rots or water-soaked symptoms that appear as wet, dark, and usually sunken and/or translucent areas. Some common bacterial issues found in Idaho include slime flux and several species of *Erwinia* and *Pseudomonas*.

Table 1. Comparison of fungal versus bacterial symptoms.

Symptom Description	Fungal	Bacterial
Water-soaked appearance	No	Yes
Texture	Dry	Papery
Smell	No	Yes
Pattern	Circular, target-like	Irregular, angular
Disintegration	No	Yes
Color changes	Red, yellow, purple halo	No
Structure of pathogen	Mycelia	No

One simple test to determine if an infection is bacterial or fungal is to place the cut portion of an infected plant stem into a clean clear glass of water. After 30–60 seconds, you may notice oozing or cloudiness emanating from the plant part. This bacterial stream is a sign of a bacterial infection. Refer to Table 1 for other ways to help determine if an infection is caused by a fungal or bacterial agent. Keep in mind that there are exceptions to these generalities.

Under favorable conditions, bacteria reproduce very rapidly and can cause serious damage in a short period of time. Bacterial cells can be spread through rain, irrigation, contaminated seed, insects and animals, or by garden implements such as pruning tools. Bacterial diseases are relatively difficult to control with pesticides because there are very few chemicals registered for use that are effective against them. Some commonly encountered bacterial diseases found in Idaho are crown gall of rose, grape, apple, cherry, and other ornamental plants; fire blight of apple and pear; soft rot of potato; ring rot of potato; and aster yellows.

VIRUSES

Viruses are noncellular crystalline particles composed of protein and nucleic acids which can only be seen with an electron micrograph. Because they are obligate parasites that require a host to survive, viruses are transmitted from one plant to another via a vector. Vectors can be humans, animals, insects, parasitic plants, or nematodes. An example of a virus spread by an insect is curly top virus found in tomatoes and beans. This virus is spread by the beet leafhopper. Viruses cause mosaic-like patterns, spots, mottling, crinkling, and other malformations of plant tissues. Because viruses are systemic, infected plants must be destroyed so that they do not serve as a source for vectors and thus prolong the spread of the virus. There are no chemical cures for viral plant infections.

NEMATODES

Nematodes are microscopic roundworms that live in soil or water; they multiply and survive as eggs or cysts. Most nematodes are saprophytes, but some infect living plants and cause diseases. Most plant parasitic nematodes feed on the underground parts of the plants (roots, tubers, bulbs, etc.), causing lesions or root knots. However, a few nematodes also affect the buds, leaves, flowers, and stems of plants. Some nematodes are vectors of plant viruses. Nematodes can be spread through contaminated planting material, manure, soil, water, machinery, and other garden implements. Some examples of plant parasitic nematodes are root knot nematodes of tomatoes, potatoes, and beans; root lesion nematodes of corn and potatoes; stubby root nematode of corn; stem and bulb nematodes of onion; and foliar nematode of chrysanthemum.

PARASITIC PLANTS (FLOWERING)

Several flower-and seed-producing plants live as parasites on other plants (host plants). They derive their nutrition from their host and adversely affect the host plant's growth and yield. Dodder, for example, parasitizes several garden plants. It begins life as a green plant that photosynthesizes. It parasitizes a host plant by inserting tube-like structures called haustoria to draw nutrition from the host's tissues. It then loses its green color and original shape and grows into a tangled mass of orange or yellow vining strands that entwine and lay on top of the host plant. Dodder produces abundant seeds that ensure its propagation and spread. Another example of a parasitic plant is dwarf mistletoe, which is found on conifers.

Diseases Caused By Abiotic Agents

A variety of environmental and cultural factors can cause diseases in plants. Since these diseases occur in the absence of pathogens, they do not spread from a diseased plant to a healthy plant.

HIGH OR LOW TEMPERATURES

When plants or plant parts are exposed to high temperatures for prolonged periods, symptoms of scorching or scalding may develop. Examples include summer leaf scorch and sunscald on fruits. Similarly, low temperatures can damage sensitive tissues or entire plants. Some common examples of low-temperature damage are southwest injury on young tree trunks; frost damage on vegetables plants or fruit tree blossoms and fruit; russet ringing on apple and pear fruits; and winter injury of evergreen foliage.

HIGH OR LOW SOIL MOISTURE

Too much moisture due to excessive watering, poor drainage, ponding, or flooding may cause plants to turn yellow or show stunted growth. Potted indoor plants, for example, may show poor development or root rots if kept overly wet. Seedlings become vulnerable to damping-off fungi under high-moisture conditions. Overwatered deciduous trees like maples can exhibit premature fall coloration in early to midsummer. With some indoor or greenhouse-grown plants, low temperatures and excessive soil moisture can encourage a condition known as **edema**, an abiotic disease. Edema causes small, corky warts that are rust, tan, or green colored to develop on the underside of leaves and stems. At the other end of the spectrum, low moisture or drought conditions can lead to poor plant development, leaf rolling, wilting, desiccation of plant tissues, and plant death.

HIGH OR LOW LIGHT INTENSITY

High light intensity can cause plant foliage to burn, especially in Idaho's higher elevations. Even when the plant tag recommends "full sun," that location may not be advisable for plants grown at elevations above 2,000 feet. Low light conditions, however, for indoor plants or sun-loving plants grown under the canopies of larger plants, can lead to etiolation, lack of foliage, and spindly or lanky growth.

SOIL OXYGEN

One factor limiting landscape plant growth is low soil oxygen. This condition is naturally found in the dense structure of heavy clayey soils, but it is also seen in soils that have been compacted. Soils can be mechanically compacted by constant foot or vehicle traffic or from water droplets pounding on bare soil for years from sprinkler irrigation. A large percentage of plant disorders in landscapes can be attributed to soil compaction. Low oxygen levels in soils also occur when excess water displaces oxygen in soil pore spaces. Symptoms of soil oxygen deficiency may include chlorotic, wilted, or necrotic leaves and/or leaf drop usually starting from the bottom up or from the interior outward.

AIR POLLUTION

Certain chemicals, such as ozone, sulfur dioxide, and nitrogen dioxide are released into the air from factories, power plants, and automobile exhausts. These chemicals can accumulate in the atmosphere in sufficient concentrations to cause plant damage. Ozone damage, for example, often appears in the form of mottling, chlorosis, spots, and bleaching of young leaves. This problem is common in certain regions where high ozone concentrations exist in city smog. In Idaho, however, plant damage due to air pollution is not common.

NUTRIENT DEFICIENCIES

Plants require sixteen elements to thrive. Carbon, hydrogen, and oxygen are derived from the air and water. The remaining thirteen nutrient elements are taken up by plant roots from the soil. These nutrient elements are divided, depending on the amount used by plants, into primary, secondary, and trace nutrients. The primary nutrient elements are nitrogen, phosphorus, and potassium. The secondary nutrient elements are calcium, magnesium, and sulfur. The trace nutrient elements are iron, boron, copper, zinc, manganese, molybdenum, and chlorine. A deficiency or lack of any one of these essential nutrients will result in an abiotic disease symptom. The specific symptom that presents will depend on the plant species and the deficient nutrient. If not corrected, a prolonged chronic deficiency of any essential plant nutrient can affect growth and yield and can lead to plant death. In home gardens, a calcium deficiency causes, in part, blossom-end rot of tomatoes. In southern Idaho landscapes, alkaline soils instigate iron chlorosis, a common malady often seen on the region's trees and shrubs.

MINERAL TOXICITY

The presence of excessive amounts of certain minerals in the soil can lead to mineral toxicity in plants. The extent of injury will depend on the mineral, its concentration, and the plant species. Excessive amounts of sodium salts in the soil, for

example, can lead to sodic-affected soil. These types of soils, frequently called black alkali, are often hydrophobic and highly alkaline (pH 8.3 or higher), which interferes with a plant's absorption of certain nutrient elements. Plants growing in very acidic soils, however, can be injured by metal toxicity from plant-available aluminum, manganese, or iron.

UNFAVORABLE SOIL pH

Although many plants can grow in a rather wide range of soil pH, plants grown in an unfavorable pH will usually show poor growth and a mineral deficiency or toxicity symptom. For example, iron deficiency symptoms are commonly seen in southern Idaho where the soil pH is mostly alkaline. Under high soil pH–conditions like these, iron in the soil becomes unavailable to plants, thus inducing interveinal chlorosis. If the malady remains uncorrected for a prolonged period, the plant may die. Figure 2 shows the availability of plant nutrients relative to soil pH.

IMPROPER CULTURAL PRACTICES

Any cultural practice performed incorrectly or at the wrong time can result in plant damage. Plant injury can result from numerous erroneous practices, like applying improper amounts of fertilizer, pesticides, or even water. Insecticides applied on a hot sunny day can burn the leaves of some plants. Root damage can result from deep cultivation and from being twisted in a pot-bound condition. African violet leaves, for example, when sprinkled with very cold water, can develop leaf damage in ringed patterns that resemble some virus symptoms.

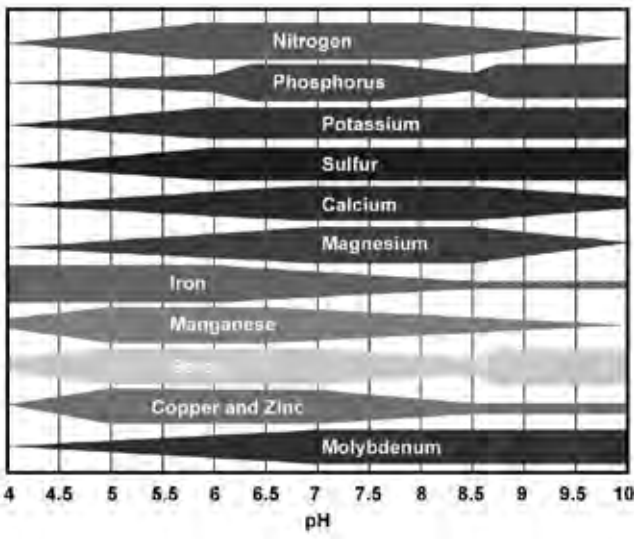

Figure 2. pH effects on nutrient availability. From "Pioneer Talks Crops" 2016.

Further Reading and Resources

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WEBSITES

Oregon State University Extension Service, "Plant Diseases," **https://extension.oregonstate.edu/pests-weeds-diseases/plant-diseases.**

University of Idaho Extension, **https://www.uidaho.edu/extension.**

Utah State University Extension, "Yard and Garden," **https://extension.usu.edu/yardandgarden/index.**

Washington State University Extension, Master Gardener Program, "Gardening in Washington State" (blog), **http://gardening.wsu.edu/.**

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

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CHAPTER **FOURTEEN**

WEEDS

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14 WEEDS

Learning Objectives

- Learn the basics of weed biology and classification
- Learn how to identify weeds by different plant parts
- Learn the basic weed-control methods
- Learn about the different types of herbicide application equipment
- Learn how to calibrate a sprayer
- Learn how to remove a tree stump
- Learn about noxious weeds and why they are classified that way

Introduction

"A weed is a plant that interferes with the management objectives for a given area of land at a given point in time." - J. M. Torell

A weed is any plant that is growing where it is not wanted and is more competitive than the surrounding desirable plants. Time, energy, and money for weed control can be kept to a minimum by planning carefully and choosing wisely in practices and materials. Effective weed management involves learning about the weed, understanding the particular site and situation, and employing a diversity of practices to provide desirable results.

Weeds are not only unsightly but also compete with desirable plants for nutrients, water, sunlight, and space. In addition to competing with landscape and vegetable plants, some weeds secrete toxins into the soil which, much like herbicides, damage or inhibit the growth of desirable plants. Weeds can ruin lawns, gardens, and flower beds. In some situations, weeds can be such a problem that the only practical weed control is to destroy the entire planting.

Weeds can also provide a "bridge" for insects and diseases from one growing season to another. When weeds are present, additional applications of insecticides and fungicides may be required.

Weeds have contributed to several other problems in the home landscape environment. Field bindweed, for example, can grow through asphalt, causing the premature failure of driveways and streets. Weeds contribute to health problems such as hay fever, respiratory problems, and skin irritations. Some weeds puncture bike tires and injure bare feet. Pets also are affected by weeds. Weed seeds may enter their nostrils and ears, causing irritation and infections; weed seeds may become enmeshed in their fur, causing discomfort. Often times a veterinarian is needed to remove the seed.

Most homeowners are concerned with weeds that exist near their homes because weeds are a general nuisance, mar the natural beauty of a home site, and decrease the value or marketability of residential properties. Weeds contribute to fire and safety hazards and reduce property values.

Landscapes and yards overgrown with weeds serve as a reservoir of weed seed that can spread to neighboring yards. As a result, some municipalities have ordinances requiring owners to cut down overgrown, weedy lots. A few imported weeds are so invasive and expensive to control that they have been declared noxious and therefore illegal to grow or go to seed.

Although seeds are generally thought of as uninvited guests, weeds do have some limited beneficial characteristics. Weeds can be a source of feed for domestic animals and wildlife, can help prevent erosion, and can add organic matter to the soil.

Weed Biology and Classification

The classification of weeds is achieved by grouping together those weeds whose similarities are greater than their differences. For preciseness, weeds are grouped botanically by family, genus, species, and variety. For convenience, weeds are commonly classified in categories such as terrestrial and aquatic or woody and herbaceous.

Weeds also are classified as trees, shrubs, grasses, sedges, and ferns. They are also commonly grouped according to similar life cycles, that is the cycle of life from viable seed to mature plant and the cycle of viable seed formation to plant death. On this basis, weeds are grouped as annuals, biennials, and perennials.

Table 1. Seed production for common weeds.

Common name	Number of seeds produced per plant
Barnyard grass	7,000
Green foxtail	34,000
Redroot pigweed	117,000

ANNUAL WEEDS

These complete a life cycle in one year. Annuals germinate from seed and emerge, grow, flower, set seed, mature, and die in one growing season. Annual weeds depend upon the production of large numbers of viable seeds for long-term survival. Many successful weed species produce thousands of seeds per plant (Table 1). In addition, weed seed has varying levels of dormancy that contribute to its persistence (Table 2). This characteristic gives weeds the ability to germinate over a period of many years.

Annuals that complete a life cycle during the period from spring to fall are referred to as summer annuals. The majority of weeds that are found in the garden or in new lawns and landscapes are summer annuals. Examples commonly found in yards include different pigweeds, common lambsquarters, hairy nightshade, common purslane, prostrate spurge, prostrate knotweed, green and yellow foxtail, barnyard grass, and crabgrass.

Table 2. Germination percentages per year of weed seeds buried 8 inches deep.

Common name	Life cycle	1	2	3	4	16	21
	Percentage of germination after (years)						
Canada thistle	perennial	21	35	15	6	3	1
Green foxtail	annual	1	3	6	4	0	0
Quack grass	perennial	21	0	0	0	0	0
Redroot pigweed	annual	9	0	1	11	0	0
Velvetleaf	annual	0	0	45	70	75	57

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Annuals that germinate and emerge in the fall, lie dormant during the winter, resume growing in the spring until maturity, and die in the late spring or early summer are referred to as winter annuals. Some of the most troublesome winter annual weeds are annual bluegrass and downy brome and a number of mustards, such as shepherd's purse and flixweed.

BIENNIAL WEEDS

Biennials require two growing seasons to complete their life cycle. Biennials germinate, emerge, and usually form a rosette (radial cluster of leaves lying close to the ground) the first year. During the second year, the plant bolts (produces a flower stalk), flowers, sets seed, matures, and dies. Biennial weeds are not as prevalent as annual weeds in gardens; but they may appear along property borders, in ground covers, and within perennial planting. Biennials that are commonly found in a home garden–landscape site include: sweet clover, common burdock, common mullein, bull thistle, and Queen Anne's lace.

PERENNIAL WEEDS

These live three years or more and reproduce sexually (from seed) and asexually (from vegetative growth). They may or may not flower the first year. Perennials that reproduce from seed are identical to annuals and biennials in the seedling stage and thus are most susceptible to control when they are young. Within a few weeks or months, however, perennials develop vegetative reproductive organs, giving them the ability to propagate and spread asexually. It is this characteristic that makes perennials so difficult to control. Perennials are classified into three different categories based upon how they reproduce.

Simple perennials have either a large taproot such as a dandelion or a fibrous root system such as bunchgrass. Simple perennials propagate mostly by seed, but if the roots are broken into pieces, each piece is capable of reproducing new plants.

Creeping perennials reproduce by rhizomes (stems) or creeping roots as well as by seed. Quack grass and field bindweed are good examples.

Bulbous perennials reproduce by bulb or nutlike structures and by seeds as well. Purple nutsedge and bulbous bluegrass are examples of bulbous perennials.

Identification

Identification of a weed should be the first step taken in a successful control program. Successful identification of weed species requires that a sample, with as much of the plant as possible, be intact. This includes flowers, stems, leaves, and roots. Careful examination of various plant structures should be used in the identification process to distinguish between "look-a-likes." A knowledge of where and how the weed was growing also will help in identifying which control measures can be used.

FLOWER

This is the structure most commonly used in classifying and identifying plants. However, weed-control measures often must be implemented before flowering. When flowers are present, note the arrangement on the stem, their size, shape, color, the presence or absence of various flower parts, and number of petals. These are all important factors in determining the particular family in which a plant is classified. If the plant has set seed, note characteristics such as size, shape, type of fruit, capsules, pods, burs, hardness, and structure.

LEAVES AND STEM

Weeds also can be identified through careful examination of leaves and stem. Stem woodiness, cross section, and the presence or absence of leaves on the stem should be observed. Stem woodiness is classified as herbaceous (a stem that is not woody), semi-woody, and woody (a perennial stem that is entirely woody such as found in a tree). Cross section of the stem refers to the shape of the stem and is often closely tied to leaf arrangement and leaf shape. Stems may be oval, round, triangular, ridged, square, winged, or grooved. Flowering stem leaves may be absent (dandelion) to uniformly leafy.

WEED STRUCTURE

Leaf arrangement, type, presence or absence of stipules, petioles, and tendrils, venation, length, shape, surface, and succulence are all important clues for identifying weeds.

ROOTS

All the belowground plant parts can also provide information on the plant. Pull or dig up some of the

root system and belowground plant parts. Determine whether it has a fibrous or taproot system and look for bulbs, corms, tubers, or rhizomes.

Identification of the weed before implementing control practices is important but requires more extensive knowledge than what has been covered in this section.

Weeds of the West, *Weeds of Nebraska and the Great Plains*, and *Weeds 2.0 for Identification of Weeds of the Western United States* are several excellent identification references available to help identify weeds. County Extension educators and the University of Idaho departments of Plant Sciences; Soil and Water Systems; and Entomology, Plant Pathology, and Nematology also are available to assist in identifying problem weeds and to provide suggestions for their control.

Weed-Control Methods

Once the weed is identified and biology of the plant is understood, control measures can be considered. "Silver bullets" and "one-shot control programs" that will control weeds without harming nontarget plants are very rare or nonexistent. An integrated approach to weed control is the most efficient and environmentally safe approach. An integrated approach also uses a combination of cultural, mechanical, physical, and chemical techniques to bring weed populations to an acceptable level. Six methods available to the homeowner include prevention, biological control, cultural control, mulches, mechanical control, and chemical control.

PREVENTION

The most effective, least costly weed-control strategy. Avoid the introduction of weed problems through careful examination of materials that will be used in developing the home landscape or garden.

Carefully examine the label on packaged seed and bulk seed. Avoid buying seed containing weed seed. If noxious weed seed is present, return the seed to the supplier and ask for your money back. It is against the law to sell and propagate noxious weeds. Some seed catalog companies sell "wildflower" mixes that may contain noxious weed seed. The scientific names found in the catalog description and on the seed packet should be compared to the list of noxious weeds listed at the end of this chapter. Report the problem to your county weed supervisor who will contact the Idaho State Department of Agriculture to lodge a complaint against the company.

Inspect nursery plants and transplants before purchase to avoid introducing roots, rhizomes, or stolons of perennial weeds. Buy your plants from a reliable nursery that sells only weed-free plants.

Avoid introducing weed seeds, roots, rhizomes, stolons, and bulbs into the garden and flower beds by using weed-free straw, manure, mulch, compost, and soil. Unless these amendments have been sterilized, they probably contain weed seed. Know the source of these amendments before transporting them to your yard. Selecting sources with relatively low weed populations and avoiding sources with undesirable weed species will pay off in the long run.

Tillage equipment can easily spread unwanted weeds to relatively weed-free areas. Clean garden tractors, tillers, hand tools, and other equipment to remove soil, weed seeds, and plant parts.

Irrigation water that flows through canals and streams can transport weed seed to your yard. Screen irrigation water from surface sources.

"One year's seed, seven years of weeds." Control vegetative and seed sources around the yard and garden. Destroy weeds before they become established, set seed, and let them mature.

BIOLOGICAL CONTROL

This type of control uses other organisms to control weeds. It is not a very practical solution to many weed problems found in urban home horticultural settings, but it may be useful on small acreages. Geese can be used to remove actively growing weeds in dormant strawberries, asparagus, peppermint, cane berries, and trees. Hogs will seek out fleshy-rooted weeds in fallow. Sheep and goats can control many weed and brush species in pastures. Insects and diseases also can be used to suppress or kill specific weeds; however, this type of control generally lags behind weed populations. Many gardening enthusiasts have been disappointed in the use of insects and diseases to control weeds.

CULTURAL CONTROL

These practices have been found to be effective and cost-efficient in a home horticultural setting. Integrating cultural control components with other control measures minimizes the impact of weeds on desirable plants, yet provides acceptable control.

Select competitive plants. Use plant competition to minimize weed establishment, growth, and reproduction. A vigorously growing ground cover that is more competitive than the weeds will lessen the weed problem. Generally, weeds are more competitive than the garden crop species during early development. Weed competition during the first 3–4 weeks after the garden emerges will have the greatest effect on the garden yield. Vigorously grown garden crops develop canopies that shade weeds, suppress weed germination, and hinder growth. Garden crops that are slow growing and less competitive should be transplanted. Table 3 shows when selected garden crops are most sensitive to weed competition.

Anything that would encourage vigorous growth of desirable garden plants to compete with weeds should be implemented. Provide moisture to desirable plant roots, using a method that will reduce or eliminate the moisture to weeds. Rotate crops to break the natural cycle of weeds, insects, and disease. A rotation may include fallowing or omitting crop production for one or more years. Growing different types of plants in the area each year may also be effective. Plant winter cover or competitive plants rather than leaving the soil bare.

Alter planting dates. Delay planting until after the first flush of weeds has emerged, then use cultivation techniques to remove small weeds. Plant for optimum growth of desired plants while avoiding growing conditions conducive to weed germination and growth. Seeding lawns in late summer and early fall is a good example of this method.

Place and time fertilizer applications to maximize plant growth by banding fertilizer applications. Band or side-dress fertilizers near desirable plants (while placing nutrients in a less-available position to weeds growing between the rows) to promote optimum crop growth.

Table 3. Weed-competition period for garden crops.

Crop	Critical period for weed competition (number of weeks after emergence or transplanting)
Beets	2–4
Cabbage	3–4
Carrots	4½
Corn	3
Cucurbit family (melons)	5
Onions	12
Peas	3–4
Potatoes	3–4
Row crops not covered	4
Snap beans	4
Spinach and lettuce	3–4
Tomatoes	5

Source: Nelson, J. E., G. McKinney, and J. F. Connor. 1989. *Home Garden Weed Manangement*. Montana State University (Bozeman), EB 58.

MULCHES

These are an extremely effective weed-control tool in the garden and around the home landscape. Mulches are soil coverings such as plastic or straw that prevent sunlight from reaching the soil. A mulch conserves moisture and modifies the microclimate and soil temperature around the plant. They are categorized as natural or artificial: natural mulches are effective in eliminating annual weeds and reducing the competitiveness of perennial weeds; artificial mulches are effective in controlling both annual and perennial weeds.

Natural mulches are applied 2–4 inches deep after weeds are removed through cultivation or with a herbicide. They are composed of materials such as bark, grass clippings, leaves, compost, manure, sawdust, wood chips, straw, hay, crushed corncob, and pine needles. Most natural mulches are considered waste products and are often disposed of in landfills. Many of these mulching materials are free of charge. A visit to your local tree-care expert or gardening store may provide specific suppliers' names.

As with other materials used in the home landscape, the homeowner should examine and avoid mulch material with weed seeds and live vegetative plant parts capable of establishing new weed infestations. The life expectancy of natural mulch will vary from 1–3 years depending on the material used, depth of material, and management associated with the landscape or garden.

Live mulches such as grasses and legumes sometimes are used between perennial plant rows. These live mulches are grown to a predetermined stage, killed, and allowed to remain in place to decompose over time. In the garden, natural mulches such as straw can be used in the planting of asparagus, cabbage, carrots, cauliflower, lettuce, peas, potatoes, turnips, and other cool-season crops to reduce weed competition while maintaining cool soil temperatures.

Artificial mulches include plastic, polyester landscape cloth, and sometimes newspaper and tar paper. When artificial mulches are used in a landscape application, natural mulches are applied 1 inch deep on top. The natural mulch hides the artificial mulch and protects it from solar degradation. Polyester landscape cloth should be used in landscape applications rather than plastic or tar paper. Polyester landscape cloth allows air exchange and moisture percolation through the mulch to the root zone. Natural mulches stay put on polyester landscape cloth but tend to slide off plastic.

In vegetable garden applications, black plastic is the preferred artificial mulch. It increases the rate at which soils warm during the growing season and it modifies the microclimate for improved growth rates of warm-season vegetables such as tomato, muskmelon, watermelon, cucumber, and squash. It is relatively inexpensive and easy to handle. When black plastic is used, irrigation applications need to be modified from surface or sprinkler systems to drip applications that function below the plastic. Other colored plastics may enter the commercial market place in the future. Colored plastic mulches, like those that come in red, have increased tomato yields by 10%–15% over black plastic mulch.

Newsprint also can be used in the garden and can be very effective in reducing weed problems. Newspapers can be turned into the soil at the end of the season, unlike black plastic, which must be taken up before cultivation. Tar paper can be used to mulch around trees and shrubs, but it is more difficult to apply and is rarely used.

A process that has become more popular in recent years is solarization. Solarization uses the sun's energy to raise soil temperatures high enough to kill weeds, including seeds, roots, and rhizomes as well as many other soil organisms. Solarization is accomplished by laying and anchoring the edges of a sheet of clear plastic over the entire fallowed area to be treated. The soil should be moist to conduct and hold heat, to stimulate weed seed germination, and to prevent dormancy of belowground vegetative plant parts. To conduct heat as deeply as possible, the soil should be firm.

Maximum weed kill depends upon the amount of bright, sunny weather and weed species. The longest day of the year and when most direct solar radiation occurs is on June 21, the vernal equinox. Position the plastic by June 1 and leave it in place for about two months. If precipitation is more than 20 inches per year, solarization may need to be extended into mid-summer and may be less satisfactory in such areas.

Late winter and early spring solarization may reduce weed populations before planting, but it is not as effective as late spring and summer solarization. However, the entire growing season is not lost when using this type of solarization. The process for accomplishing this type of solarization is as follows:

1. Till the garden soil and prepare the seedbed in autumn.
2. Place clear plastic over the garden in midwinter or soon after snowmelt. Solar heat warms the soil under the plastic on warm, sunny days, causing seeds to germinate. Sprouted weeds, however, die as daytime temperatures rise to temperatures of 100°F–130°F under the plastic, which should be high enough to kill most species. Weeds may also die from freezing.
3. Leave the plastic in place and continue solarization until planting time. Because tilling the soil after removing the plastic brings more weed seeds near the soil surface, plant without further tillage.

MECHANICAL CONTROL

Includes hoeing, pulling, rototilling, mowing, cultivating, and burning. Mechanical methods are best adapted to eliminating annual weeds depending on the species, the particular location, and the type of implement used. Seedling biennial and perennial weeds also can be controlled mechanically. Once the perennial weed is able to vegetatively reproduce, mechanical control is not very effective. Mechanical methods such as hoeing, mowing, and cultivating

cut the plant off at or just below the surface leaving the root or rhizome behind to send up new growth. Deeper tillage such as rototilling or deep plowing may bring some of the roots or rhizomes to the surface, but even if a small root segment or rhizome remains in moist soil, the weed can reestablish itself.

In some instances mechanical control can spread weeds to infest new areas. Effective mechanical control of perennial weeds will require cultivation every 14–21 days. This repeated cultivation over 2–3 years stimulates root development while depleting stored food (carbohydrates) and eventually the plant dies.

Hoeing cuts the plant at or just below the soil surface. Hoes should be kept sharp to reduce the effort of controlling weeds. Often times gardeners will use the hoe to dig or aerate the soil. This is an improper use of this tool. Use a shovel or rototiller to aerate soil. Deep cultivation has a tendency to bring weed seed to the soil's surface providing an excellent environment for weed seed germination. Deep hoeing or tillage in the garden also can damage desirable plants. A proper hoeing technique disturbs the soil very little while removing the weed. Many different hoe styles are available.

- A **hand cultivator** or **tractor-mounted cultivator** generally consists of V-shaped teeth, which till the soil 1–2 inches deep. The action of this tool is similar to the hoe, in that it cuts the weed off at or just below the soil surface and drags the small weed root to the soil surface to dry. Other implements such as disk harrows, sweeps, rolling cultivators, and finger weeders are in this same category.
- **Mowing** is an effective way of reducing the amount of seed that weeds will produce and eliminating annuals. The practice must be timed to remove the top before seed is produced. Mowing after viable seed has set can be a good way of spreading weeds to new areas. The vigor and stand density of established perennial weeds can be reduced through repeated mowing, although it requires a long period of time.
- **Hand weeding** is effective, but it is a labor-intensive method of removing weeds growing close to desirable plants. Care must be taken that the weed pulling does not damage the roots of desirable plants.
- **Burning or flaming** weeds is generally done with a propane torch. Timing of the operation must be such that control is performed before viable seed set. The most effective control of annual weeds is when they are small (about 3–5 inches tall). The effect of burning perennial weeds is similar to that of mowing. Consider carefully where and when this method is used, since it is more difficult to control in tall dry weeds than previous methods outlined. There have been cases in which out-of-control burning operations have burned a straw pile, barn, or home. Check with local ordinances and regulations before burning perennial weeds.

CHEMICAL CONTROL

This method can save labor while providing acceptable control. When used correctly, chemical control can be an inexpensive weed-control tool. However, it does have some drawbacks. Herbicides can injure or kill desirable plants and are expensive if used improperly.

Extension educators are often asked to investigate injured or dying trees, shrubs, and other desirable landscape or garden plants that "the neighbor sprayed" only to find out that the gardener used herbicide inconsistent with the label's instructions.

Thoroughly read the label of any herbicide. Be sure the beneficial plant to be protected is listed on the label. Timing of the herbicide applications must follow the label instructions. Even an application of 2,4-D for control of weeds in lawns can injure grass if applied during the heat of the summer. **Always read and follow label directions!**

Herbicides usually are not used in vegetable gardens for several reasons:

- No single herbicide can be used safely on all vegetables grown in a garden
- Some herbicides can persist in the soil and injure sensitive vegetable crops the following year
- Spray drift can injure sensitive plants growing in the garden

Herbicides are grouped into families based on chemical properties and how the chemical works to kill the plant. Herbicides also are grouped by when they are applied to control weeds.

Preemergence herbicides are applied before the emergence of the weed or crop. Herbicides in this group kill weeds as they germinate. These herbicides are further classified as preplant and postplant preemergence herbicides. Preplant herbicides are applied to the soil before planting the desired crop and before the weeds germinate. Postplant herbicides are applied after the desired crop has been planted but before the weeds or crop have germinated.

Generally, preemergence herbicides are applied to the surface of the soil and either watered in (precipitation or irrigation) or mechanically incorporated into the soil. Failure of these herbicides to work may be the result of poor incorporation because the weeds have already germinated.

Postemergence herbicides are designed to kill emerged weeds. These herbicides may be translocated (e.g., 2,4-D) or contact herbicides (e.g., paraquat). Translocated herbicides are applied to foliage or soil. Plants absorb the herbicide through leaves, stems, or roots and move it through the plant to the site of herbicidal action (where the herbicide works). Translocated herbicides work well on perennial plants because the herbicide is moved to roots and other belowground vegetative reproductive parts. Contact herbicides are applied to the foliage of the plant. These herbicides kill only where they directly contact the plant and do not move within the plant. Contact herbicides are a poor choice for the control of perennial weeds.

Herbicides are further classified as selective and nonselective. If the herbicide kills the weed but does not injure the beneficial plant, then the herbicide is termed selective. If the herbicide injures or kills the weed and beneficial plant, then the herbicide is known as nonselective.

Herbicides should only be used according to label directions. Registered uses and rates of application are listed on the product label. Improper use or application rate can cause injury or death to nontarget plants even though the product is selective. Selectivity of a herbicide may depend on any one or a combination of the following factors:

1. Some plants may be able to detoxify the herbicide by metabolizing it into a harmless substance while other plants are killed.
2. Foliar-applied herbicides may not be absorbed by leaves or stems because various structures (such as pubescents and thick waxy cuticles) block the absorption of the herbicide.
3. Selectivity of a herbicide may also be due to its placement in the soil. Herbicides such as Casoron, when applied correctly by shallow incorporation, will kill germinating weeds and shallow-rooted weeds. Deep-rooted desirable perennial plants will not absorb the herbicide because the herbicide is placed above the root zone.

Soil sterilants are applied to the soil to prevent the growth of weeds and other plants. Some sterilants may be applied to foliage with desired results, but they will leave a long-lasting residue in the soil. The length of time that a sterilant will be effective depends on the rate applied and the persistence of the herbicide.

Extreme care should be taken when using soil sterilants. Some of these products have a tendency to move with water and can easily be leached from the point of application to root zones of beneficial plants (trees, shrubs, and grass) thus injuring nontarget plants. Soil sterilants are not suggested for use in the yard or garden because they are long lasting and difficult to remove if the homeowner decides to change the use of the treated area.

Fumigants are nonselective and can kill seed and plant parts below the soil surface. Fumigants are not readily available and are only used in greenhouse or commercial operations.

Before product labeling, herbicides undergo a series of tests before they are approved for use by a gardener.These tests evaluate the fate of the herbicide in the environment and potential hazards to the user and non-target organisms. Determining the fate of the herbicides in the environment include how they degrade, how herbicides move with water (leach), how they bind with soil, how quickly they volatilize and drift, and how toxic they are to fish or other nontarget organisms. The label contains most of this information as well as directions for use. Impact to the environment can be minimized by following **all** of the label instructions and environmental warning statements.

Additional information specific to the behavior of herbicides in plants and soils, use precautions, toxicological properties, and herbicidal use can be obtained from your Extension educator.

Herbicide-Application Equipment

Several types of application equipment are suitable for weed control. Application equipment ranges in price from inexpensive canister plastic sprayers to elaborate and expensive power sprayers pulled by garden tractors. The most important consideration is to find suitable equipment for the particular job or situation. Choose dependable equipment that will have a long service life and will do the type of job you need. Types of application equipment include the following:

HAND-SPRAY BOTTLES

Several home and garden herbicides are now packaged in a ready-to-use, disposable applicator spray bottles, much like common glass and window cleaners. They are meant to be used for spot treating small areas or individual weeds.

HOSE-END SPRAYERS

These sprayers attach to the end of a garden hose and may be acceptable for soil drenches and preemergence herbicides with a wide margin of safety. Because they are difficult to calibrate and too variable for proper application, hose-end sprayers are not recommended for most herbicides where precision of application is desired.

COMPRESSED AIR CANISTER SPRAYERS

The most common sprayers used by homeowners are 1- to 3-gallon compressed air sprayers. There are metal and plastic models. Both are equally effective, but the plastic model is less expensive. A compressed air sprayer is ideal for spot spraying postemergence herbicides and will provide a reasonably precise application of preemergence herbicides. Problems encountered through the use of this sprayer include nozzle plugging and spray tank corrosion (this is not a problem with plastic or stainless steel sprayers).

Compressed air sprayers do present a safety problem if the pressure in the tank is not equalized with the outside pressure before opening the tank to refill or clean it. However, some manufacturers now include a pressure relief valve that eliminates this hazard.

BACKPACK SPRAYERS

Several models of backpack sprayers are available. These are usually more expensive; but they are versatile, have up to a 5 gallon capacity, and can be maintained at more uniform pressure than canister sprayers. These sprayers are constructed of plastic or stainless steel, but the inexpensive plastic models are preferred. One of the few disadvantages associated with a backpack sprayer is the tendency for the applicator to leak and then soak the wearer's back with herbicide.

POWER SPRAYERS

These sprayers are a good investment and ideal for large areas. They have a pump and regulator to provide constant pressure and a more uniform spray delivery. The spray tank may consist of plastic, fiberglass, stainless steel, galvanized steel, or epoxy-lined steel. These systems usually have a gun-type nozzle for spot treatments and sometimes a boom for broadcast applications. The disadvantages of power sprayers are similar to those of the backpack sprayers and pressurized canister sprayers.

WICK WIPERS

Various makes and models of "wiper" applicators are available, primarily for use in applying a 33% solution of glyphosate. Wick wipers allow accurate placement of herbicide on unwanted plants, which helps to deter spray drift.

GRANULAR APPLICATORS

These applicators spread granular herbicide formulations of fertilizers. Two general types of granular applicators are available to homeowners:

1. The **gravity** or **drop-type** applicator is best used on level turf areas or on level areas where the soil has been firmed. Use of this type of applicator on a steep hill or loose soil conditions will result in nonuniform applications.
2. The **cyclone** or **whirlybird** will operate under almost any type of condition but is affected by wind and tall vegetation.

Sprayer Calibration

Many people do not calibrate their application equipment and then wonder why their weed-control efforts fail. Calibration for a herbicide treatment differs from an insecticide or fungicide treatment. Insecticides and fungicides are applied at a specific concentration while herbicides are applied at a specific rate of product per unit area (e.g., ounces per 1,000 sq ft).

NOTE

It is best not to use the same sprayer for both insect and weed control. Some herbicides, such as 2,4-D, are difficult to completely remove from sprayers. If you do decide to use the same sprayer, be sure to wash it with detergent after herbicide use. Then, fill the tank and prime the system with an ammonia solution (1 quart of household ammonia in 10 quarts of water) and let stand. After 12–24 hours, rinse and purge the sprayer with clean water until the ammonia solution is totally removed.

Therefore, the amount of water used is not as important as the amount of herbicide used per unit area as long as adequate coverage is obtained with the water used.

Factors affecting the calibration of a sprayer include pressure, nozzle size, condition, number, the viscosity of the spray, and the speed at which the area is covered. Variable pressure will cause variable spraying.

Therefore, maintaining constant pressure or using a pressure regulator will facilitate a consistent application. The rate of speed that an area is covered should be held as constant as possible to improve the accuracy of the application. Gardeners using handheld or hand-operated sprayers will operate their sprayers at different pressures and cover areas at different speeds. Therefore, calibration should be done by the individual who will be making the application.

CALCULATING YOUR SPRAYER

Any kind of sprayer can be calibrated by using the following steps:

1. Check the operation of the sprayer. Check for a clogged nozzle and hose, rust in the tank, and leaks. Thoroughly clean and repair the sprayer before calibrating the sprayer.
2. Mark off 100 square feet. (You may want to use 1,000 square feet for a more accurate calibration.) Use a string or garden hose to mark off the area.
3. Add a known quantity of water to the sprayer that is sufficient to cover the marked-off calibration area.
4. Spray the calibration area exactly as you would spray herbicide. Be sure to walk the same speed and use the same pressure as you would when spraying the herbicide. Remember, you only need to lightly wet the plants. Don't spray until the water drips off.
5. Measure the remaining water in the tank. The difference between what you originally added to the tank and what remains is the amount of water required to cover 100 square feet (or 1,000 square feet).

NOTE

Many recommendations are given per 1,000 square feet. If 100 square feet is used for calibration, multiply the difference remaining in the tank by 10 to calculate the amount of water that would be required to cover 1,000 square feet.

- If you applied 18 fluid ounces to a 100-square-foot area, apply 180 fluid ounces or 1.4 gallons of water to cover a 1,000 square foot area.
- Add the recommended rate of the chemical to the amount of water needed to spray 1,000 square feet.
- Apply the herbicide by walking the same speed and using the same pressure as when you calibrated.

GRANULAR APPLICATORS

These can be calibrated in a similar way as sprayers, but the applicator must use the herbicide granular material in the calibration process. A cement or asphalt driveway or a large plastic canvas sheet can be used to catch the herbicide as it is distributed by the spreader. The surface area of the drive or canvas sheet is measured. Then the applicator is in the same

Table 4. Designation of Idaho noxious weeds.

Black henbane (*Hyoscyamus niger* L.)
Buffalo bur (*Solanum rostratum* Dun.)
Canada thistle [*Cirsium arvense* (L.) Scop.]
Dalmatian toadflax [*Linaria dalmatica*) (L.) Mill.]
Diffuse knapweed (*Centaurea diffusa* Lam.)
Dyer's woad (*Isatis tinctoria* L.)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Field bindweed (*Convolvulus arvensis* L.)
Hoary cress [*Cardaria draba* (L.) Desv.]
Johnsongrass [*Sorghum halepense* (L.) Pers.]
Jointed goatgrass (*Aegilops cylindrica* Host)
Leafy spurge (*Euphorbia esula* L.)
Matgrass (*Nardus stricta* L.)
Meadow knapweed (*Centaurea pratensis* Thuill.)
Milium (*Milium vernale* Bieb.)
Orange hawkweed (*Hieracium aurantiacum* L.)
Musk thistle (*Carduus nutans* L.)
Perennial pepperweed (*Lepidium latifolium* L.)
Perennial sow thistle (*Sonchus arvensis* L.)
Poison hemlock (*Conium maculatum* L.)
Puncture vine (*Tribulus terrestris* L.)
Purple loosestrife (*Lythrum salicaria* L.)
Rush skeletonweed (*Chondrilla juncea* L.)
Russian knapweed [*Acroptilon repens* (L.) DC.]
Scotch broom [*Cytisus scoparius* (L.) Link]
Scotch thistle (*Onopordum acanthium* L.)
Silverleaf nightshade (*Solanum elaeagnifolium* Cav.)
Skeletonleaf bursage (*Ambrosia tomentosa* Nutt.)
Spotted knapweed (*Centaurea stoebe* L.)
Syrian bean-caper (*Zygophyllum fabago* L.)
Tansy ragwort (*Senecio jacobaea* L.)
Toothed spurge (*Euphorbia dentata* Michx.)
Whitetop (*Lepidium draba*)
Yellow hawkweed (*Hieracium pratense* Tausch)
Yellow star thistle (*Centaurea solstitialis* L.)
Yellow toadflax (*Linaria vulgaris* Mill.)

manner that it would be operated for the actual application. After completing this calibration application, the granules are swept up and weighed.

EXAMPLE

You have sprayed 13 ounces on the 100 square feet.

13 oz × 10 = 130 oz (about 1 gallon) per 1,000 square feet

Add the recommended amount of herbicide to 1 gallon of water to spray the 1,000 sq ft area.

Adjustments are made to the applicator until the desired amount has been applied in a consistent manner. The operator should note the setting on the applicator so that calibration is not required before each time an application is made. However, calibration should be done whenever the source of the material changes or at the beginning of the season each year.

Tree Stump Removal

When trees are hewn from a landscape, removal of the remaining stumps often becomes a difficult problem.

MECHANICAL REMOVAL

Using heavy equipment, such as a backhoe, to remove a tree stump can be expensive. It also might result in unacceptable damage to turf, ornamentals, or other adjacent vegetation. Failure to remove the complete stump and roots will often result in a proliferation of new shoots.

Some homeowners use an axe or chain saw to cut away stumps. This generally requires a lot of time and energy but can be successful if the trunk is not too large and if the roots can be removed.

CHEMICAL TREATMENTS

Treating tree trunks with an appropriate herbicide concentrate before cutting (or treatment of live stumps after cutting) will kill stumps and roots and stop sprouts from developing. Use caution when treating trunks or stumps with herbicides. Some herbicides may leach into the root zone of nearby plants. Application of herbicide is usually best accomplished with a paintbrush rather than a sprayer. A dead stump will normally decompose in 1 or 2 years. Then, the rotted wood can easily be removed by hand.

Noxious Weeds

"Noxious weed" means kind of species of any plant having the potential to cause injury to public health, crops, livestock, land or other property, and which is designated as noxious by the director.

Chapter 24, Title 22, Idaho Code, Noxious Weeds

Noxious weeds are weeds that have been declared by law to be noxious. Property owners must not allow noxious weeds to go to seed or propagate on their land. Idaho, through the State Department of Agriculture, determines weeds to be listed as noxious and provides counties the power to administer the law.

Procedures have been set by law and rules promulgated by the State Department of Agriculture which form noxious weed districts. These districts direct noxious weed-control efforts within in their jurisdiction. These efforts may include handling complaints, entering property through an established procedure to control noxious weeds, attaching claims against property to cover control costs, and cooperating with other agencies and organizations in controlling noxious weeds. The weeds listed in Table 4 are officially designated and published as noxious.

It shall be the duty and responsibility of all persons and nonfederal agencies to control noxious weeds on land and property that they own, in accordance with this chapter and with rules and regulations promulgated by the director of the Department of Agriculture.

Chapter 24, Title 22, Idaho Code, Noxious Weeds

Further Reading

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BOOKLETS AND PAMPHLETS

University of Idaho Extension

BUL 775 *Planning an Idaho Vegetable Garden*

CIS 1041 *Conduct Your Own Garden Research*

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

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CHAPTER **FIFTEEN**

TURFGRASS ESTABLISHMENT AND MANAGEMENT

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15 TURFGRASS ESTABLISHMENT AND MANAGEMENT

Learning Objectives

- Learn the characteristics of site and soil considerations for turfgrass applications
- Learn about the different types of turfgrass and how to select the right one for your application
- Learn how to prepare a site for turfgrass planting
- Learn how to establish a lawn from seeding
- Learn how to establish a lawn from sodding
- Learn the basic principles of turfgrass maintenance
- Learn how to deal with the common problems associated with turfgrass

Introduction

Turfgrasses enhance the appearance and utility of home landscapes, parks, golf courses, sports fields, and other greenbelt areas. Lawns improve urban environments by reducing erosion, temperature, noise, dust, glare, and carbon dioxide. Grass is so efficient at converting carbon dioxide to oxygen that an area 50 feet × 50 feet generates enough oxygen to meet the needs of a family of four. A lawn also provides the setting and unity for other landscape elements, such as buildings, patios, water features, trees, shrubs, and flowers.

Everyone knows what a healthy lawn should look like — a uniformly green carpet free of insects, weeds, and diseases. Establishing and maintaining such a lawn is a long-term commitment of labor, money, and other resources. The homeowner faces many decisions. What type of lawn is needed? Will it be a showplace, a recreational area, a backdrop for other landscape plants, or a combination of the above? What level of maintenance will be provided? Will the family perform the maintenance or hire it out? High maintenance usually means greater expenditures of time and/or money. Are both available?

Successful establishment and maintenance of a healthy lawn requires knowledge of climate, soils, and availability of water and other resources. Climate, soils, and topography vary greatly across Idaho. Climate depends on location, ranging from the warm, arid south to the cooler, semiarid north. Idaho's natural vegetation ranges from sagebrush and bunchgrasses in the south to evergreen forests in the north and at higher elevations.

Soil and Site Considerations

EVALUATING THE SITE

Assess your site's limitations. Lack of light or water, poor drainage, or shallow or compacted soils can limit a site's ability to produce quality turfgrass. Turf needs at least 4 hours of direct sunlight a day to thrive. In general, it is best to have at least 1 foot of soil over any hardpan (caliche), dense clay, or gravelly subsoil. If less than a foot of soil exists over hardpan or dense clay, drainage problems and restricted root growth will result in turf failure. However, the limited water- and nutrient-holding capacity of gravelly subsoil will also cause turf to fail. In very low-light areas, on steep banks, and where soil and/or water are inadequate, ground covers, meadow grasses, low-growing shrubs, and mulch are more realistic alternatives to mowed turf.

SOIL TEXTURE AND STRUCTURE

Sand, silt, and clay describe the three basic sizes of soil particles. A soil's percentage of sand, silt, and clay determine its texture. Soil structure refers to the arrangement of soil particles into aggregates. For more information, see chapter 5.

Lawns can grow on essentially any soil texture, from sand to clay, but a fine sandy silt loam is ideal. Sandy or gravelly soils make it difficult to maintain nutrition and moisture levels, while compacted clayey soils can have water infiltration and drainage problems.

Both sandy and clayey soils can be improved by regular additions of organic matter. Humus (finished compost) modifies soil structure to improve aeration and drainage. In addition, humus can improve a soil's ability to hold nutrients and water and it is a food source for beneficial soil microorganisms.

SOIL pH AND FERTILITY

A soil analysis performed prior to lawn establishment will provide valuable information about existing nutrients, pH, and organic matter. Lawn grasses flourish at a soil pH between 6.0 and 7.5. A pH outside of this range can lead to chronic micronutrient deficiencies and poor growth. Soil pH can be adjusted slightly. If adjustment is needed, it's best to do so during soil preparation, before seeding or sodding. See chapter 5 for more information.

Phosphorus is essential for root development. Unlike most nutrients, surface-applied phosphorus does not move readily down into the soil profile, so it's best to incorporate it into the soil before seeding or sodding (see "Soil Preparation").

QUICK TURFGRASS IDENTIFICATION

Bluegrass
- Fine blades, canoe-shaped blade tip
- Rhizomatous growth habit

Ryegrass
- Fine blades, upper side heavily veined, shiny lower leaf surface, pointed tip
- Bunch-type growth

Tall fescue
- Fine- to medium-sized blades
- Upper side heavily veined, lower leaf surface smooth with prominent midvein, pointed tip
- Most have a bunch-type growth habit

Fine fescue
- Very fine needle-like blades, pointed tip
- Bunch-type or rhizomatous growth, depending on species

Choosing a Turfgrass

Cool-season grasses can withstand Idaho's cold winters and perform well under most conditions found in the state. Most turf species have been hybridized to produce **cultivars** (cultivated varieties) with specific characteristics, such as fine texture, high density, and dark green color; early spring green-up; tolerance to cold, drought, or traffic; or resistance to insects and diseases.

During the intense heat of summer, cool-season grasses often turn tan and go semidormant. This condition is a natural survival mechanism. Once the heat of summer ends and more water is available, the grass will resume growth and become green again.

Selecting a turfgrass depends on site characteristics and on how the lawn will be used (e.g., as playing field or perfect lawn). Grass varieties are available for almost any situation. For lawns that receive a large amount of heavy play or foot traffic, turf-type tall fescue or perennial ryegrass is often used. If many trees are present, select grasses that can withstand shade, such as fine fescue. Some recently introduced turfgrasses are more xeric, using 50% less water than older varieties. In some situations, a mixture of species may be the best option. Table 1 lists cool-season grass species and many cultivars. See the sidebar above for quick turfgrass identification. See Table 2 to compare characteristics of different turf species.

Note: Consult your local University of Idaho Extension office for recommended grass species or cultivars for your area.

KENTUCKY BLUEGRASS

Kentucky bluegrass is probably the most common cool-season grass for lawns and it is part of most grass mixtures. A **monoculture** (pure stand) of Kentucky bluegrass is not recommended because of insect and disease problems.

Kentucky bluegrass has a high fertility requirement and a high water requirement. It does not tolerate shade. It is slow to germinate and establish, but it is good at repairing damaged turf areas because of its ability to spread via rhizomes. However, it can spread into flower beds that border lawn areas and is a strong thatch former.

ENDOPHYTES

Perennial ryegrass and most turf-type tall fescue cultivars live in a **symbiotic** (mutually beneficial) relationship with endophytes. These naturally occurring fungi produce a wide range of chemicals with insecticidal properties, the most important being alkaloids. These chemicals move within the grass plant, giving it built-in defense against billbugs, sod webworms, armyworms, and chinch bugs. Some resistance to nematodes has also been documented.

Different species of endophytes infect different grasses. *Acremonium foliar* infects perennial ryegrass, while *A. coenophialum* infects tall fescue. Endophyte levels vary, depending on the grass cultivar.

TALL AND FINE FESCUES

Turf-Type Tall Fescue

Tall fescue is usually planted as a monoculture or mixed with fine fescues. Newer turf-type tall fescue cultivars, especially dwarf cultivars, are thinner bladed than older varieties and, once established, look very similar to Kentucky bluegrass. These turf-type fescues are not the same as coarse pasture fescues.

Tall fescue is resilient and well adapted to a wide range of soil conditions. It tolerates heat and drought better than most cool-season turfgrasses due to its deep root system (4–6 feet). Its fertility

Table 1. Cool-season turfgrass cultivars for Idaho.

Type of turfgrass	Cultivars
Kentucky bluegrass	Award, NuGlade, Bluechip Plus, Everglade, NuDestiny, Nublue Plus, Liberator, Rugby II, Adelphi, Fylking, Parade, Galaxy, Park, Pennstar, Baron, Liberty, Majestic, Touchdown, Freedom, Newport, Victa, Nuget, Challenger, Kenblue, Plush, Chateau, New Blue, New Star, Washington, Classic
Perennial ryegrass	Accent, Caddieshack, Goalkeeper, Top Gun, All Star, Diplomat, Derby, Evening Shade, Fiesta II, Manhattan II, Omega II, Ovation, Pennant, Regal, Saturn, SR 4000, Troubadour, Palmer, Prelude, Patriot II, Yorktown II
Turf-type tall fescue	Inferno, NoNet, Quest, Summer, Watersaver (RTF), Arid 3, Crossfire, Falcon, Jaguar II, Monarch, Mustang, Rebel II, Titan, Bonsai, Twilight
Fine fescues:	
Chewings fescue	J-5 chewings fescue, Banner, Barialia, Cascade, Jamestown
Creeping red fescue	Audubon, Pennlawn, Rainer, Ruby, Wintergreen
Hard fescue	Ecostar Plus, Rescue 911, Biljart, Durar, Reliant, SR 3000, Scaldi
Sheep fescue	Marco Polo

requirement is medium and its water requirement is medium. Many tall fescue cultivars contain fungal **endophytes**, which ward off insect attacks — a major benefit where turf insects proliferate (see sidebar above).

Tall fescue tends to withstand traffic and heavy use and is often used on football and other playing fields. It does not tolerate low mowing. Most tall fescue cultivars are bunchgrasses; they do not spread by rhizomes and thus do not form thatch or invade flower beds. In recent years, a few spreading turf-type cultivars have been developed.

Fine Fescues

Fine fescues include creeping red fescue, chewings fescue, hard fescue, and sheep fescue. These species are often added to mixtures with other cool-season grasses to provide drought tolerance and disease resistance. These grasses have the narrowest leaves of any lawn grass. Sheep fescue is an Idaho native grass with a blue-green appearance.

Fine fescues perform best in shady conditions. Seed mixes for moderate shade should contain 20%–30% fine fescue. These grasses are adapted to well-drained, infertile soils. Their fertilization requirements are low to medium and their water requirement is low to medium.

Fine fescues are excellent for overseeding lawns to improve turf quality. On slopes, they often are left unmowed to create a meadow effect.

Creeping red fescue has a spreading rhizomatous root system that will easily cover open soil areas to create a lawn. Chewings fescue is a bunchgrass that does not spread. It must be planted thickly to ensure dense, even turf. Sheep fescue and hard fescue are also bunch types; they make excellent turf, have extensive root systems, and are very drought tolerant.

PERENNIAL RYEGRASS

Turf-type perennial ryegrass germinates and establishes rapidly, often within 6 days. This bunchgrass is extremely wear tolerant, producing beautiful lawns that do not form thatch.

Ryegrass blends well with other grasses and adds insect resistance due to its symbiotic relationship with endophytes. Mixtures of perennial ryegrass and Kentucky bluegrass create a turf far superior to either species grown alone.

Table 2. Turf characteristics.

Characteristic	Turf-type tall fescue	Kentucky bluegrass	Bluegrass/Ryegrass mix	Fine fescue
Leaf texture	Fine to medium	Fine	Fine with high luster	Very fine
Growth rate	Slow to medium	Medium	Medium	Slow
Rooting depth	Very deep (4–6 ft)	Shallow (6–12 inches)	Medium (18 inches)	Deep (2–3 feet)
Thatch production	None to low	High	Varies[a]	Low to medium[b]
Water requirements	Medium	High	High	Low to medium
Fertilizer requirements	Medium	High	High	Low to medium
Insect resistance	High	Medium	High	High
Disease resistance	High	Low to medium	High	High
Drought tolerance	High	Low to medium	Low to medium	High
Heat tolerance	High	Low to medium	Low to medium	Low
Shade tolerance	Medium	Low	Low to medium	High
Cold tolerance	Medium to high	High	Medium to high	Medium to high
Traffic tolerance	High	Medium	High	Medium

[a]Thatch production depends on the percentage of bluegrass in the mix. Bluegrass is a strong thatch producer, while perennial ryegrass produces
[b]Fine fescue thatch production depends on the grass variety and increases with higher fertility levels.

Like Kentucky bluegrass, perennial ryegrass requires medium to high fertility levels. It has a medium water requirement. Ryegrass leaves are fibrous and require a sharp mower blade to avoid shredding or tearing the grass.

Site Preparation

PREPLANT WEED CONTROL

If perennial weeds or undesirable grasses are present, preplant weed control is critical. A nonselective herbicide, such as one containing glyphosate, can be used. More than one application may be necessary for some perennial weeds. Follow herbicide label directions carefully.

SOIL PREPARATION

Regardless of whether a lawn is established by seeding or sodding, the key to success is proper soil preparation. Following new home construction, debris is often left in the lawn area. Materials such as cement, wood, bricks, nails, sand, and gravel create unfavorable conditions for lawn grasses and usually result in dry spots. They also block root development and can cause mowing hazards. Remove these materials prior to grading and lawn installation.

If possible, remove rocks from the upper 2 inches of soil to provide a uniform medium for grass roots. If tree stumps or other organic debris are present, remove them rather than covering them with soil.

Buried stumps and logs create soil depressions as they decay, often accompanied by fairy ring fungus and other fungi (see “Diseases”).

The only chance to modify soil structure and drainage is before lawn establishment. Apply 1–2 inches of humus before rototilling. Humus can be purchased by the bag or in bulk at nurseries. For more information on composting and producing humus at home, see chapter 8. If a soil test indicates that fertilizer is needed, apply it now, especially if you are using an organic or slow-release fertilizer, as these products need time to break down. This is also the time to adjust pH, if needed. See chapter 5 for more information. Rototill all amendments into the top 8–10 inches of soil.

Contour and slope are determined by the existing landscape and by structures such as buildings, walks, and driveways. Slope the lawn away from the house. Minor surface irregularities will become permanent after grass roots have locked soil particles together.

After establishing the rough grade, rake and smooth the area to fill holes or depressions and reduce high spots. The smoother the area, the better its appearance. Allow 2–4 weeks for settling before planting the lawn. Two or three soaking and drying periods during this time will facilitate settling.

INSTALLING A SPRINKLER SYSTEM

If an in-ground system is desired, install it after final grading and smoothing, but before seeding or sodding.

Establishing a Lawn by Seeding

SEED SELECTION

Always purchase high-quality seed. Although seeding is an inexpensive way to produce a lawn, the cost of seed is a small portion of the total cost of establishment. Quality seed costs a little more, but it is worth it. Saving a few dollars by compromising on seed quality will only jeopardize your overall investment in your lawn. Purchase seed that is labeled as containing “0% weed seed.” Why plant weeds if you don’t have to?

Certified Seed

Buying certified seed is a good practice. Certification ensures that a seed package contains quality seed of the cultivar named on the label. When certified seed is sold in bulk, a blue certification label is attached to the seed bag.

Seed Package Labels

Seed package labels contain valuable information to help you choose wisely (Figure 1). The seed analysis enables you to determine how well the seed should perform and its cost effectiveness compared to other brands. The following terms are used on grass-seed labels:

Figure 1. Sample seed label.

pure seed. Percentage (by weight) that is seed of the specified crop.

germination. Percentage of viable (live) seed

inert matter. Percentage (by weight) of chaff, dirt, trash, and anything else that is not seed.

date of test. Date of the seed analysis; it should be within the past 15 months.

weed seeds. Percentage (by weight) of weed seeds in the sample and the number of noxious weed seeds present (Note: It is against Idaho law to sell seed containing noxious weed seeds. If the label lists noxious weeds, do not purchase the seed and report it to the Idaho State Department of Agriculture.)

other crop seeds. Percentage (by weight) of crop seed other than the crop specified. For example, tall fescue seed might include some orchard grass and annual ryegrass seed. Kentucky bluegrass might include bentgrass, annual ryegrass, tall fescue, or perennial ryegrass seed.

Comparing Cost

When comparing seed lots of similar quality, calculate the cost of Pure Live Seed (PLS). PLS indicates the percentage of seed that will germinate and produce the expected lawn quality. To determine PLS, multiply the germination percentage by the percentage of pure seed and then multiply by 100. For example:

Germination = 85%
Purity = 98%
Calculation: 0.85 × 0.98 = 0.833
0.833 × 100 = 83.3% PLS

Now, to obtain the cost per pound of PLS, divide the price per pound of the seed by the PLS. For example:

Price per pound = $4.00
PLS = 83.3%
Calculation: $4.00 ÷ 0.833 = $4.80/lb

Table 3. Seeding rates for cool-season turfgrasses.

Species	Seeding Rate	
	(lb/1,000 sq ft)	(lb/acre)
Kentucky bluegrass	1–2	40–80
Perennial ryegrass	4–6	160–240
Fine fescue	3–5	120–200
Tall fescue	4–6	160–240

SEEDING RATE

Seeds vary in size, weight, and growth rate, depending on the grass species. For this reason, seeding rates vary. Follow directions on the seed package or the general guidelines in Table 3. Calibrate the spreader to deliver the appropriate seeding rate. See the sidebar, "How Much Do You Need?," to calculate how much seed to purchase.

WHEN TO SOW

It can take 4–6 months to thoroughly establish a lawn from seed. The optimum time for seeding turf is in the fall, from mid-August through mid-September (earlier at higher elevations). Completing seeding during this time frame allows the grass to become well established before winter.

HOW MUCH DO YOU NEED?

Seeding and fertilizer rates often are given as amounts per 1,000 square feet. Follow the steps below to calculate how much to purchase.

1. **Estimate lawn size.** Use one of the following methods.
   - Use a measuring wheel to measure the lawn area.
   - If the lawn is a small square or rectangle, multiply length by width to get the square footage.

     For example, 10 ft × 20 ft = 200 sq ft.
   - If you know the lot size in acres, multiply by 44,000 to get an approximate square footage. For example, 0.5 acres × 44,000 = 22,000 sq ft.
   - Don't include space occupied by nonlawn areas, such as the house or flower beds. In this example, if only one-quarter of the area is lawn, then the lawn is 5,500 sq ft (22,000 sq ft × 0.25 = 5,500 sq ft).
2. **Calculate the amount of product needed.** Multiply the seeding or fertilizer rate (per 1,000 square feet) by the lawn size found in step 1. Then divide by 1,000. For example, 5 lb × 5,500 sq ft ÷ 1,000 = 27.5 lb. This is the amount to purchase.

Fall seeding is much more successful than spring seeding for several reasons. Warm days and cool nights in the fall provide ideal conditions for seedling growth. Also, there is less weed competition. The first heavy frost will kill tender broadleaf weeds and summer annual grasses that germinate with the grass seed. By spring, lawns seeded the previous fall will be well rooted and have good top growth, making them drought-and heat-tolerant by summer.

In some dry or short-season growing areas of Idaho, grass seed is sown on top of the soil just before winter snows to take advantage of the insulating capacity of snow and moisture from snowmelt. The grass will germinate in spring once the snow recedes.

Spring seeding (April through May) is used where rain or early frost prevents soil preparation and seeding in the fall or if the fall seeding time is missed. Seed as soon as the ground is dry enough to be worked without damaging soil structure.

Germination periods depend on soil temperature. For example, an April sowing will take longer to germinate than a May sowing. If seed is sown too early, when the soil is cold and damp, germination will be slow and irregular.

Spring-seeded turf may face strong competition from germinating weeds in some areas. If practical, wait until annual weed seeds germinate, cultivate the soil to kill them, and then sow the grass seed. This option is feasible if seeding can still be done in May to allow the lawn to establish before the heat of summer.

Establishing turfgrass by seeding in midsummer (July and August) is difficult due to high temperatures, evaporation, and drought conditions. Summer seeding can be successful only if supplemental irrigation is available. The seeded area must be kept moist during the entire germination period. If the surface dries before seedlings emerge, the percentage and rate of germination will be severely reduced.

SEEDING METHODS

Only very small spots can be effectively seeded by hand, as it is difficult to distribute seed evenly using this method. Lawns usually are seeded with a drop spreader or rotary (cyclone) spreader. Drop spreaders are more accurate than rotary spreaders. They also work better along driveways, sidewalks, and flower beds because they do not drop seed where it is unwanted.

To ensure uniform distribution of seed, divide the recommended amount of seed into two equal parts. Sow half of the seed in one direction and the second half perpendicular to the first. Lightly rake the seed into the soil surface (about ¼ inch). Do not rake heavily, as doing so will cover the seed too deeply.

You can enhance germination by using a roller to improve seed-to-soil contact.

TOP-DRESSING SEEDED AREAS

Grass seed can take 1–3 weeks to germinate, depending on species. Top-dressing means applying a thin layer (⅛–¼ inch) of some material to the surface of a newly planted seedbed to encourage germination. A layer of top-dressing reduces seed displacement by wind, rain, and irrigation. It also prevents birds from eating seeds, raises humidity at the soil surface, and reduces soil crusting. While top-dressing is not essential, it is helpful, especially on sloped sites. Humus, peat moss, chopped straw, dried grass clippings, and clean topsoil are com-monly used for top-dressing. Choice of material depends on the site, availability, cost, and ease of handling.

WATERING AND FERTILIZING

Failure to provide sufficient moisture is a major cause of unsuccessful turf establishment. After seeding, the top 1 inch of soil must be kept consistently moist. If rainfall is inadequate, irrigate a short amount of time twice each day for the first 3 weeks. Summer-seeded turf may require three or more irrigations per day. After seedlings have grown enough to mow, reduce irrigation frequency (see “Irrigation”).

If a fertilizer was applied before planting, there usually is no need to fertilize a lawn before it is 4–6 weeks old. If no fertilizer was applied prior to seeding, use a cyclone spreader to apply a half-rate application of starter fertilizer (e.g., 5-10-10 or 15-15-15) after the lawn is mowable.

MOWING

Start mowing as soon as the grass is tall enough to cut (more than 2 inches). Frequent mowing helps control annual weeds and limits clipping accumulation, which might smother the new turf.

Set the mower at the proper cutting height for your grass species, and keep the mower blade sharp. See Table 4 for recommended mowing heights. Follow the one-third rule; remove no more than one-third of

the leaf growth at each mowing. Avoid mowing when it is muddy, as mud on mower wheels may adhere to seedlings and pull them out of the ground.

WEED CONTROL

To avoid turf damage, do not spray weeds until the new lawn is at least 6 weeks old. Following fall seeding, the first heavy frost may eliminate most weeds, thus reducing the need for herbicides.

OVERSEEDING

The potential for a lawn to provide a quality surface depends on the species and cultivars of grasses present. The best maintenance program is not likely to produce a quality lawn if inferior grasses dominate the stand. Over time, most lawns eventually become invaded with less desirable grass species, such as bent grass and pasture fescues. Periodic infusion of new, improved cultivars into an existing turf will increase the chances of maintaining a high-quality lawn. Reseeding bare spots or thickening up sparse turf are additional reasons to overseed.

Overseeding is usually done in late summer or early fall. However, small areas can be overseeded at any time, as long as they are kept moist during germination.

Spot Seeding

If seeding a small area, work the area with a hard-tined rake or shovel. If the area is compacted, add some humus and incorporate thoroughly. Mix fertilizer into the soil, if needed (see "Soil Preparation") and sow the grass seed. Rake the area lightly following seeding to incorporate the seed into the soil. This will increase soil-to-seed contact and enhance germination.

Changing Grass Species

Changing to a more desirable grass species without removing the old grass is a type of overseeding. First, use a nonselective herbicide such as glyposate to kill the old lawn. More than one application may be necessary.

After the lawn dies, mow as closely as possible. Then dethatch the area with a vertical mower or dethatching machine (see "Thatch Management"). Rake up the accumulated debris and dethatch again in a perpendicular direction. Rake up the remaining debris.

Keep in mind that if a soil problem existed before the original lawn was seeded (e.g., dry, compacted soil), the problem will remain after the new turf is seeded. Where underlying soil problems exist, complete renovation may be needed (see "Turf Renovation").

Finally, seed the area with the new grass species. Rake lightly to incorporate the seed into the soil. Apply a thin layer (⅛–¼ inch) of topsoil or humus and begin watering as you would a newly seeded lawn.

Establishing a Lawn by Sodding

BENEFITS OF SOD

Sod offers the instant beauty of a lush, weed-free lawn that can be used in as few as three weeks after installation. Sod may be the solution for a family in a new home where children need a safe, clean place to play or where a steep slope increases the risk of erosion. Other advantages of sodding include the following: (1) an instant increase in property value, (2) elimination of the need for top-dressing, (3) reduced need for weed control and water during establishment, and (4) reduced effort to nurture a new lawn to full establishment.

However, sod costs about six times more than grass seed and installion may involve additional expenses, such as labor to remove the old turf and install the sod.

PURCHASING SOD

Several types of sod are available for residential landscapes, with each type suited to a particular environment or use. The most common types are Kentucky bluegrass blends, bluegrass-perennial rye-grass mixtures, tall fescue-fine fescue mixtures, and turf-type tall fescue monocultures. If possible, examine the sod before ordering. Sod should be of uniform color and thickness, with minimal weeds.

PREPARING FOR SOD DELIVERY

Prepare the site before scheduling delivery of the sod. Soil preparation for seeding and sodding are essentially the same (see "Site Preparation"). Do not skimp on soil preparation or site grading.

Do not lay sod on dry soil. Even if sod is watered immediately after installation, root growth will be hindered. Water to a depth of 6–8 inches 24–48 hours before installation. It is important to allow

enough time between watering and sod installation so that the site is not muddy when installation begins.

Sod is heavy; it weighs about 50 pounds per 10 square feet. Piece size varies, depending on the cutting machine used. Pieces typically are 18 inches wide by 80 inches long or 24 inches wide by 60 inches long. Each piece makes up 10 square feet. Sod is shipped on wooden pallets, each stacked with 500–700 square feet of grass.

Be on-site when the sod arrives so that the pallets can be positioned to minimize the distance that sod rolls must be carried. Examine several rolls before accepting the sod.

Plan to lay the sod immediately. If you must wait a day, keep the rolls moist (not soggy) and in a shaded location. For a delay of up to a week, it is best to unroll the sod on a plastic tarp or cement to avoid having it root into itself or into the soil where it's stacked. Make sure to keep the sod moist.

SOD INSTALLATION

Sodding can be successful during every season except winter. Sodding in the spring or fall, when cool-season grasses grow rapidly, allows quick rooting. In dry areas or during hot weather, frequent irrigation is necessary.

The easiest way to install sod is to hire a landscape contractor, but you can save money by doing the job yourself. Be prepared to squat or kneel on the soil surface as you work. Wearing a pair of rubber kneepads is a good idea.

Handle sod with care to avoid tearing or excessive stretching. Lay the first strip along a straight edge, such as a driveway or sidewalk. If no straight edge is available, lay sod at a right angle to a curve or use a string to establish a straight line. On the second and succeeding rows, stagger the joints similar to the way bricks are laid. Fasten the butt joints tightly together to prevent the roots from drying out, but do not overlap the pieces.

Water within 30–60 minutes of laying the first piece. If you wait until the whole lawn has been sodded, the first-laid strips may dry out. Continue to lay sod and water previously sodded sections until installation is complete.

Use a sharp knife to cut sod to fit curves, edges, and sprinkler heads. Try to avoid using short or narrow left-over pieces, as they tend to dry out rapidly. If an edge does not abut a curb, sidewalk, or another strip of sod, mound soil against it to protect the roots from drying.

When sodding a sloped site, start at the bottom and work upward. If the slope is steep, tack sod strips down with wooden pegs (available at construction supply stores). Leave the pegs in place until sufficient rooting has occurred to stabilize the soil and turf.

ROLLING AND WATERING

After all of the sod is laid, the lawn can be rolled. Rolling eliminates irregularities and establishes good contact between the sod and soil. Rollers are available at equipment rental centers.

Finally, water the sodded lawn thoroughly. Moisten the soil to a depth of 6–8 inches. Irrigate daily until the sod becomes rooted, about 10 days. Keep people off the lawn until the grass is well anchored, usually in 3 weeks.

After the sod is established, decrease irrigation frequency, but increase the amount of water per application. Deep but infrequent irrigations (10–12 inches deep once or twice a week) are best for developing a healthy, deep-rooted turf (see "Irrigation").

MOWING AND FERTILIZING

Begin mowing after the sod is well rooted and growing. Make sure your mower blade is sharp. Use the one-third mowing rule; remove no more than one-third of the shoot growth at each mowing.

Ten days to two weeks after installation, apply a fertilizer with a high proportion of phosphorus and potassium (e.g., 5-10-10, 10-20-20, or 15-15-15) to encourage root growth. Organic and slow-release fertilizers should be applied during soil preparation to allow time for breakdown and nutrient release to occur. The fertilizer package will indicate the amount to apply (see "Fertilizing" and the sidebar "How Much Do You Need?").

Turf Maintenance

A healthy lawn should last many years if properly maintained by watering, fertilizing, mowing, and weed control. Dethatching, core aeration, top-dressing, and disease or insect control may be needed in some years.

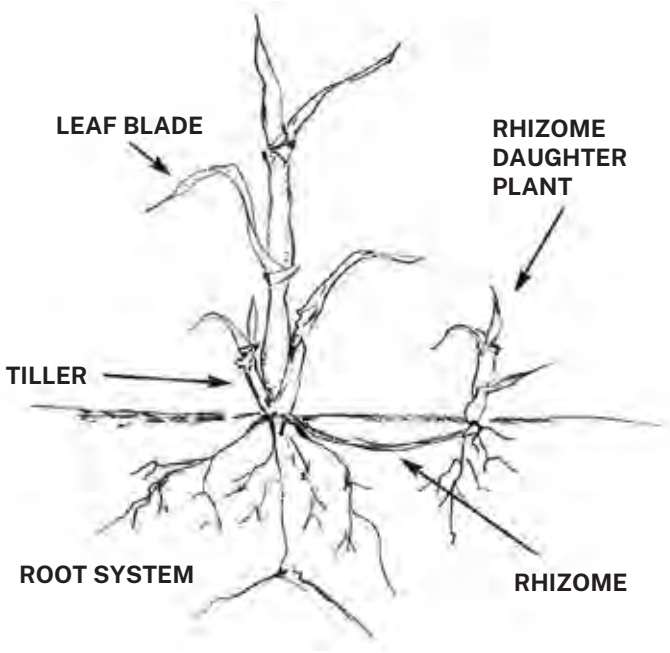

Figure 2. Anatomy of a grass plant. Drawing by Aubrey Stribling, University of Idaho.

It is difficult to dictate a one-size-fits-all lawn maintenance program, given Idaho's wide variety of microclimates and soil types. Basic practices are discussed in this chapter, but recommendations may need to be modified for your location. Talk with your local University of Idaho Extension educator for more information.

MOWING

Mowing is the most basic part of turfgrass maintenance since it influences a lawn's appearance and life span, as well as the need for other cultural operations. Mowing encourages lateral bud growth and **tillering** — the formation of aerial shoots from axillary buds located along the crown (Figure 2). As tillering increases, the grass becomes finer, the sod gets thicker, and the turf's overall appearance is optimized.

However, mowing reduces photosynthesis and hence carbohydrate production. In the short-term, it causes root growth to cease and increases water loss from cut leaf ends. Cut blades also create the potential for pathogen infection.

Some grasses are easier to cut cleanly than others. Perennial ryegrass and turf-type tall fescue, due to fibrous vascular bundles, are difficult to cut cleanly if the mower blade is not sharp. In contrast, Kentucky bluegrass has soft, succulent leaf blades that are easy to mow.

Table 4. Recommended mowing heights.

Species	Height (inches)[a]
Kentucky bluegrass	1.5–3
Perennial ryegrass	1–2
Fine fescue	2–3
Tall fescue	2–4

[a]In spring and fall, use the lower end of the range. Use the higher end of the range in summer.

Always leave an unmowed strip next to ponds, streams, and lakes to reduce surface-water pollution.

Mowing Frequency and Height

Frequent mowing (every 3–4 days during active growth) is recommended to avoid removing more than one-third of the grass blades at any one time. Limiting foliage removal reduces the loss of photosynthesizing tissue. When growth slows due to heat or drought, mowing may be needed only once a week or every 10 days. In shaded areas, photosynthesis is less active than in the sun. In these areas, grasses grow more slowly and can be mowed less frequently as well.

Proper mowing heights for cool-season grasses are listed in Table 4. During the heat of summer, raise the height of the mower blade by an inch. Longer grass blades trap moisture, shade the crowns, and promote a healthy, deep root system. Once temperatures cool, return to the lower recommended mowing height.

Scalping or mowing lower than the recommended height stresses grass and is not advisable at any time. A brown, scorched appearance often follows scalping, due to the removal of grass blades that otherwise would shade and protect the delicate crowns. Scalping ultimately results in decreased drought and heat tolerance, weed invasion, reduced photosynthesis, and shallow rooting.

Clipping Removal

Clipping removal is optional. Clippings quickly decompose and, contrary to popular belief, do not cause thatch.

Mowing frequently and allowing the clippings to filter into the grass benefit the turf. Clippings supply organic matter and recycled nutrients, especially nitrogen. Decomposition of the succulent leaf tissues by soil microorganisms results in a constant, even

supply of nutrients. Research indicates that as much as 20%–30% of a lawn's fertilizer requirement can be supplied by grass clippings, thus eliminating one fertilizer application per year.

A mulching mower makes it easy to recycle clippings in place. However, any mower will work if the one-third rule is followed. If you mow infrequently and generate a thick layer of clippings, remove them, as they may suffocate the turf.

THATCH MANAGEMENT

Thatch is the brown, fibrous, spongy layer located between the soil and green grass blades. Thatch is not caused by grass clippings. It is composed primarily of high-lignin materials such as roots and stems. As stems and roots grow, old tissues die and slough off, adding to the thatch layer. Soil microbes, earthworms, and other soil organisms decompose thatch.

Thatch accumulation is a natural process for rhizomatous grasses. Kentucky bluegrass is a prolific thatch former, while creeping red fescue is a medium thatch former. Bunchgrasses, such as perennial ryegrass, most turf-type tall fescue cultivars, and other fine fescues (chewings, sheep, and hard), do not develop thatch.

A thin layer of thatch (½ inch) is beneficial, as it reduces soil moisture evaporation and insulates the soil, thus moderating soil temperature. It also retains nutrients and protects roots from compaction by foot and equipment traffic.

Thatch that is more than ¾-inch thick is detrimental because it can restrict water, air, fertilizer, and pesticide movement into the grass and soil. During hot, dry weather, thatch can become dry and resistant to wetting (hydrophobic). Grass roots may grow into thick thatch instead of the soil, making the turf less heat-, drought-, and cold-tolerant. Many turf-eating insects and diseases find thick thatch a good place to call home. Finally, mowers tend to ride on top of deep thatch and do not cut the grass to the desired height.

Causes of Thatch Buildup

Thatch accumulates when conditions are good for organic matter accumulation and poor for its decomposition. Soil compaction contributes to thatch buildup because it affects soil oxygen levels and water movement.

Nitrogen fertilizer stimulates bacterial decomposition of thatch; consequently, insufficient fertilizing can cause thatch buildup. Conversely, overfertilizaton encourages thatch accumulation since it causes turf to grow (and die) faster than soil microorganisms can decompose the thatch. With excessive fertilization, soils also can become saline, which reduces populations of earthworms and soil microbes.

Overuse of some pesticides, excessively wet or dry conditions, and cool weather also contribute to thatch buildup because they affect the population and activity of decomposers.

Controlling Thatch Buildup

The best way to prevent thatch buildup is to follow proper turf management practices. Use the right amounts of fertilizer and water to create conditions needed for moderate growth.

Clippings left on the lawn add nutrients as they decompose, invigorating microbial activity and accelerating thatch decomposition. Routine core aeration can also help, especially when cores are left to break down on the lawn (see "Core Aeration").

Top-dressing is another way to reduce thatch buildup. Periodic top-dressing with a thin layer (¼–½ inch) of soil or humus encourages beneficial microbial populations. Top-dressing often follows core aeration if the cores are not left in place. A drop spreader is usually used to top-dress. After top-dressing, rake the material into the turf.

Dethatching

Measure thatch depth by removing a wedge of turf, leaving the underlying soil intact. When thatch is more than ½ inch deep, dethatching may be needed. It may be necessary to dethatch every year until thatch is reduced to ½ inch. If thatch buildup is extreme (1½–2 inches deep), it may be wiser to remove the lawn and reseed or resod the area (see "Turf Renovation").

Dethatchers (vertical mowers) use cutting blades or tines that spin vertically to slice into the turf and soil surface, ripping the thatch. Dethatchers are available at equipment rental centers. After dethatching in one direction, remove the debris. Then dethatch in a perpendicular direction and remove the remaining debris.

Dethatching makes a lawn look rough and ragged in the short-term. Top-dress after dethatching to level

depressions. Follow with fertilization and irrigation to stimulate regrowth. Damage caused by dethatching may require overseeding, so fall is the preferred time for dethatching.

IRRIGATION

The goal of irrigation is to keep a lawn healthy when rainfall is not dependable. The key is to moisten the top 12 inches of the root zone if possible. Kentucky bluegrass can develop a root system 6–12 inches deep and perennial ryegrass can root 18 inches deep. Fine fescues develop roots 2–3 feet deep and tall fescue roots can be 4–6 feet deep!

To irrigate properly, you must know your soil. Loamy soils are porous, yet retain moisture and are easy to irrigate. Clayey soils hold the most water, but can take a long time to absorb and release it.

When watered deeply, clayey soils can hold water for a week or more. If irrigation is too frequent, they can become waterlogged. Sandy soils, however, are porous; they wet and drain quickly. Thus, they may need to be irrigated twice weekly to maintain comparable turf health.

Benefits of Deep, Infrequent Irrigation

Watering deeply (10–12 inches) but infrequently (no more than once a week, twice on sandy soils) produces healthy turf. Light daily irrigations wet only the soil surface. Because roots grow where the soil is moist, shallow watering equals shallow-rooted turf. Shallow-rooted turf will not be able to withstand temperature extremes, pathogens, or insects, nor can it take advantage of nutrients deep in the soil. Deep watering also benefits landscape trees and shrubs, which suffer under a shallow watering regime.

Another advantage to deep watering is that it forces an exchange of soil atmosphere (in soil pores) with each irrigation. As water moves down the soil profile, oxygen is pulled into the soil. Improved soil aeration produces good root growth.

Watering infrequently also means more efficient water use because less moisture is lost to evaporation. Deep, infrequent irrigation can result in a water savings of approximately 45%–55% per year compared to daily irrigation.

Finally, infrequent watering reduces weed populations because the area is not constantly moist. Many shallow-rooted weeds die when drought stressed.

To determine how deep your irrigation water goes, use a soil probe or shovel to check soil moisture after irrigation. At 10–12 inches deep, the soil should feel like a slightly damp, well-wrung-out sponge — neither sopping wet nor bone dry. If the soil feels dry at the 10–12-inch depth, you are not watering long enough (see "Irrigation Challenges"). Monitor irrigation each month until you learn how long it takes your soil, under your watering regime, to wet to this depth. Soil moisture sensors can more accurately determine moisture at the desired depth and control when irrigation begins and ends. They can greatly improve irrigation efficiency and lawn health.

When to Irrigate

Learning to "read" your turf is an important skill. Watch for dry spots; they can indicate that the entire lawn needs water (see "Irrigation Challenges"). Failure of grass blades to spring back when walked on, a grayish turf color, or lack of overnight dew formation indicate a need for irrigation. However, it is best to irrigate before these signs appear.

How Long to Irrigate

Rules of thumb for lawn watering are often given in gardening books. Example: "Turf uses an average of 1–2 inches of water per week." Reading this, homeowners often set sprinkler clocks accordingly. Unfortunately, water use varies day to day, due to differences in temperature, wind, humidity, and solar radiation (whether it is sunny or cloudy), so averages do not necessarily reflect the amount of water needed at any given time.

The best approach is to determine when irrigation is needed and then water long enough for moisture to reach a soil depth of 10–12 inches. As weather conditions change, adjust the frequency and amount of irrigation.

If you plan to water weekly using the "1–2 inches" rule of thumb, the amount applied should vary with the weather. While 2 inches of water per week may be needed during hot, dry weather in midsummer, less than ¼ inch may be consumed during cooler weather and rainy periods.

You can check how much water you apply using the "can method." Use four or five flat-bottomed cans of the same diameter (such as soup cans). The reason for using several cans is that nozzles often do not apply equal amounts of water over the entire spray pattern.

Start within a foot or two of the sprinkler head and place cans in a line to the end of the spray pattern. Leave an equal distance between the cans. To determine the average amount of water applied over a specific period of time, add together the amount of water collected in all the cans. Then divide by the number of cans. For example:

Number of cans: 4

Watering time: 30 minutes

Total water collected in four cans: 2 inches

2 inches ÷ 4 cans = 0.5 inch of water applied over 30 minutes

How to Irrigate

Early morning (before sunrise) is the best time to water, since the turf will dry before evening. Night irrigation also uses water efficiently by reducing evaporation loss. However, it may increase disease problems if humidity and moisture remain high overnight. Daytime watering is not recommended, especially on hot or windy days, because of high evaporation rates and/or sprinkler drift. On hot summer days, as much as half of sprinkler output can be lost to evaporation.

Regardless of soil type, apply water slowly to achieve good infiltration and prevent runoff. On clayey soils, it may take hours to apply the desired amount of water. Slow application of water is especially important on slopes, thatchy turf, and sites with clay or compacted soils.

Overwatering Problems

If turf is squishy 12 hours after irrigating or if you observe standing water, either you are overwatering or there is a drainage problem (or both). Yellowish-green grass or a thinning lawn may also indicate excessive irrigation.

Overwatering can leach nutrients beyond the turf root zone. Also, oxygen levels are low in saturated soils. Because roots develop best where oxygen is adequate, saturated soils induce shallow rooting. Low oxygen levels also slow the activity of beneficial soil organisms and encourage root-rot pathogens that thrive under anaerobic conditions.

Water Stress

Turf can wilt during drought or when underwatered. Just before wilting, the turf will no longer spring back after being walked on. As turf wilts, the blades turn grayish. Turf can survive a little water stress, but it is best to irrigate before these symptoms develop. If you notice these symptoms, water immediately. During severe drought conditions, cool-season grasses protect themselves from dying by becoming dormant and drying to a tan color. Once moisture returns, the grass greens up again.

Irrigation Challenges

Sloped land and compacted soils present special challenges. On these areas, irrigation must be adjusted to reduce puddling and runoff. One solution is "cycle" watering. This method entails applying a portion of the water needed, just to the point before runoff. Irrigation is then switched to another area while water infiltrates the soil in the first area. Later the same day, the first area is watered a second or third time to reach the appropriate soil depth. To improve water infiltration on compacted soils, consider core aerating once or twice a year (see "Core Aeration") or amending the area.

Dry spots may indicate that it is time to water the entire lawn or they can indicate a problem with either the watering system or the soil. Check sprinkler spray patterns to make sure they overlap. Watch to see whether water is being blown off track. Look for bent or tilted sprinkler heads and foliage that might be blocking the spray. If necessary, move sprinklers or prune plants. In some cases, an additional sprinkler head may be needed to provide sufficient moisture.

Also check the soil in the dry spot with a shovel or probe to look for compaction and construction debris. If the problem is construction debris, remove it and relevel the area for seeding or sodding.

FERTILIZING

An adequate fertility program can produce dense, well-colored, manageable turf, while reducing weeds, moss, and some turf diseases. Underfertilized bluegrass or perennial ryegrass can exhibit poor color and turf thinning, which encourages weed invasion. However, fertilizer will not thicken up turf where compaction or other soil problems are present.

Conversely, overfertilizing increases the need for mowing and encourages thatch development. An overfertilized lawn also requires more water and pesticides, since fast-growing, succulent turf is more susceptible to diseases and insects.

CALCULATING FERTILIZER APPLICATION RATES

Table 5 gives fertilizer recommendations as pounds of nitrogen (N) per 1,000 square feet. Fertilizer package directions list rates to use as pounds of fertilizer per 1,000 square feet. Follow package directions or use the steps below to calculate how many applications are needed and how much to apply each time.

1. **Convert nitrogen rate to fertilizer rate.** Divide the amount of N needed (Table 5) by the percentage of N in the fertilizer, as indicated by the fertilizer analysis. For example, a 15-5-10 fertilizer contains 15% N. To apply 2 pounds of N using this fertilizer, you will need to apply 13 pounds of fertilizer (2 lb ÷ 0.15 = 13.3 lb). Leaving mowed clippings on the lawn may replace 20%–30% of the required N (see "Mowing").
2. **Split the total.** Excessive fertilization at one time can burn turf and contaminate surface and groundwater. The amount of fertilizer that can be safely applied at one time depends on the product's N percentage; higher N content reduces the maximum application rate. Package labels indicate how much fertilizer can be applied at one application. Split the total required fertilizer from step 1 into two to four applications in order to avoid exceeding the maximum. For example, if 13 pounds are needed, and the maximum application rate is 3 pounds, split the total into four applications (13 lb ÷ 3 lb = 4.3). If the amount needed is less than the maximum application rate, all of the fertilizer can be applied at one time.

Sandy and gravelly soils have limited ability to hold water and plant nutrients, making them prone to nitrate leaching and root burn. To avoid these problems, cut the rate in half and fertilize more frequently or use only organic or slow-release fertilizers.

See the sidebar, "How Much Do You Need?," to calculate how much fertilizer to purchase.

Nitrogen (N) is the most important nutrient for promoting good turf color and growth and N fertilizer usually is needed every year. Other nutrients may be needed, but determining which ones requires a soil test. Phosphorus (P) and potassium (K) are not always needed. A soil test every 3–5 years is very helpful.

Either organic or synthetic fertilizers can be used on turf. Organic fertilizers must be broken down into an inorganic form (cations and anions) by soil microbes before being utilized by plants. This breakdown, which releases nutrients slowly over the course of weeks or months, depends on the type of fertilizer, time of year, soil type, soil temperature, soil moisture, and microbial populations present in the soil. Thus, organic fertilizers can extend the supply of nutrients over time and reduce N loss to leaching. Using organic fertilizers takes advance planning to ensure that enough time is allowed for breakdown of materials so that nutrients are available when the grass needs them.

The most commonly deficient nutrient in lawns grown on alkaline soils is iron. Iron deficiency is treated using a chelated iron product or by altering soil pH prior to planting. A soil analysis can indicate whether a pH problem exists. See chapter 5 for more information.

Understanding Ratios and Analyses

The fertilizer analysis (the numbers on a fertilizer package) always reads in the order of N-P-K (nitrogen, phosphorus, potassium). The numbers indicate the percentage of each of the three nutrients in the package. For example, a 15-5-10 fertilizer contains 15% N, 5% P (expressed as P_2O_5), and 10% K (expressed as K_2O). See chapter 5 for more information.

On established turf, a fertilizer ratio of 3:1:2 or 3:1:1 is often recommended. A 3:1:2 ratio means the fertilizer contains three times as much N as P and twice as much K as P. An example of such a ratio is a fertilizer with an analysis of 15-5-10. A fertilizer analysis of 15-5-5 is an example of a 3:1:1 ratio.

How Much Fertilizer to Apply

Grass species differ in the amount of N they require (see Table 5). The sidebar "Calculating Fertilizer Application Rates" explains how to calculate the number of applications needed and how much to apply each time.

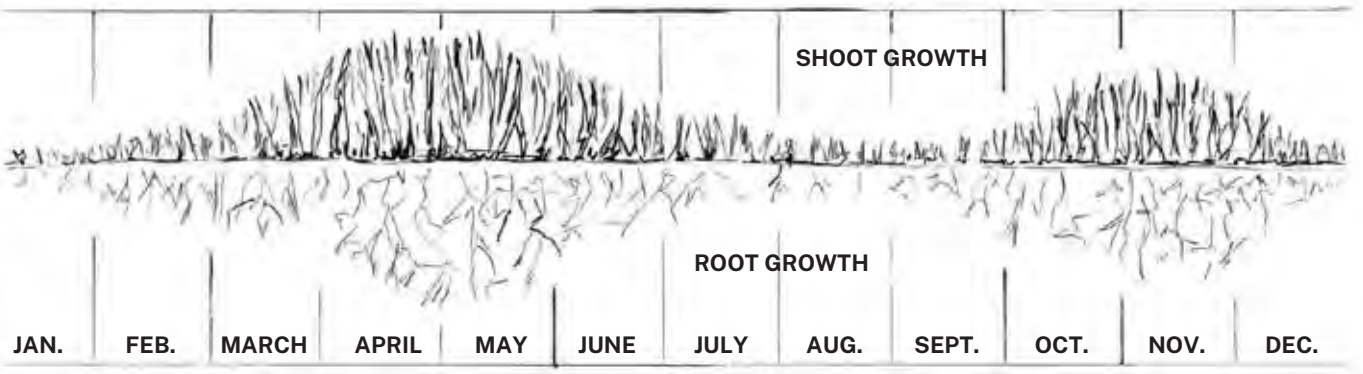

Figure 3. Cool-season grass growth cycle. Drawing by Aubrey Stribling, University of Idaho.

Timing Fertilizer Applications

The natural growth cycle of cool-season grasses influences the timing of fertilizer application (Figure 3). Two applications are recommended during the fall: in early September and mid-November. Fall fertilization coincides with the normal, vegetative growth phase of cool-season grasses and promotes turf vigor.

Benefits include the following: (1) increased storage of carbohydrate energy reserves, (2) stronger root systems, (3) increased shoot density, (4) greater stress tolerance, (5) better fall and winter color, and (6) earlier spring greenup. If a third or fourth application of fertilizer is needed, a late April or early May application time will suffice to prepare the turf for summer heat stress.

Avoid fertilizing cool-season grasses in the heat of summer — July and August — as this is when they tend to go semidormant. Fertilizing at this time stimulates growth when the turf needs to slow down or "rest." Over time, summer fertilization will cause turf thinning, invasion by weeds, and higher susceptibility to diseases and insects.

Table 5. Recommended annual N application for cool-season turfgrass.

Species	Actual N (lb/1,000 sq ft/year)[a]
Fine fescue	1–2
Tall fescue	2–4
Kentucky bluegrass	2–6
Perennial ryegrass	2–6

[a] Within the recommended range, the need for N is determined by cultural practices such as irrigation and clipping removal. If irrigation is limited, less fertilizer is needed. Leaving clippings on the lawn also reduces the need for fertilizer.

How to Fertilize

For even coverage, apply granular or pelleted fertilizer with a cyclone or drop spreader. Drop spreaders are more efficient and easier to use along driveways and walks, but remember to overlap the wheel areas to avoid leaving stripes. Set your spreader to apply the desired rate. Hand application is not recommended, except in small areas, because it leads to uneven coverage.

CORE AERATION

Coring (core aeration) involves removing finger-sized cores of turf and soil. It is accomplished using a core aeration machine with hollow tubes or tines (available from equipment rental centers).

Core aeration has several benefits. It increases oxygen and water infiltration in compacted soils, promotes fertilizer movement into the soil, and encourages root growth. Aeration can also reduce thatch development if done regularly. On tight, clayey soils or those exposed to heavy traffic, aeration might be needed once or twice a year.

Core aeration is usually done in the spring or fall, when exposed roots are less likely to dry out. Make sure soil is well moistened before aerating, as tines cannot penetrate to the needed depth in dry soil. Travel in one direction first; then switch to a perpendicular direction. Cores are usually left to disintegrate in place. Irrigation helps wash the soil from the cores. As this soil mixes with thatch, it hastens thatch decomposition. Depending on soil type, core disintegration may take a few days to several weeks.

If cores are removed from the lawn, top-dressing may follow aeration. Top-dressing with ¼–½ inch of humus or a 50:50 mixture of humus and sand places looser material into the holes, thus improving future air and water infiltration. Use only construction sand, not river-washed sand.

WEED CONTROL

Discouraging Weed Growth

Limiting the germination and growth of weeds can reduce the need for herbicides. Because competition reduces seed germination and survival, one of the best weed deterrents is a dense stand of turf. Thick turf can choke out most weeds, while a thin lawn exposes the soil to weed invasion. Follow good irrigation and maintenance practices to promote a healthy lawn.

Raising the mower blade slightly can allow grass to shade out germinating annual broadleaf weeds. In order to reduce future weed populations, mow the tops off weeds before they form seed.

Controlling Weeds

The first step to controlling weeds is to identify them. Weed life cycles and control measures vary. Annual weeds, for instance, are easier to control than perennial weeds, and small, immature weeds are more affected by herbicides than mature weeds.

Perennial weeds can be especially challenging. They are difficult to control without herbicides, due to their invasive and often extensive root systems. For instance, a single field bindweed plant can grow a 4-foot-deep × 20-foot-wide root system! Trying to dig out a perennial weed with a rhizomatous root system, such as bindweed, can be impossible, since cutting the rhizomes stimulates more shoot growth. Tough perennial weeds such as Canada thistle, field bindweed, and whitetop may require several herbicide treatments. Weekly hoeing to remove top growth reduces root vigor over time, but it can take years to eliminate established perennial weeds using this method.

Where possible, selective methods of control are recommended (e.g., hand pulling or herbicide application to individual weeds). Weed-and-feed formulations are not recommended for continued use near trees, shrubs, or other landscape ornamentals.

Make sure turf is well established and growing vigorously before herbicide treatment. To protect yourself, as well as your lawn and the environment, read and follow the herbicide label carefully. For more information on pesticides and pesticide safety, see chapter 9.

Herbicides will provide only temporary control if soil conditions and management factors that encourage weeds are not addressed. For example, soil compaction favors weeds and discourages turf growth. Common lawn weeds such as annual bluegrass, black medic, chickweed, clover, crabgrass, knotweed, prostrate spurge, and plantain thrive in compacted soils.

Timing Weed Control Measures

Annual grasses such as crabgrass are usually treated with a preemergent herbicide in mid-March (or when the forsythias bloom). Preemergent herbicides kill seeds before they have a chance to germinate. Early April is a good time to treat summer annual weeds with a postemergent herbicide, while winter annuals are often treated in late summer or fall.

Fall is the best time to treat perennial weeds. It is difficult to kill established perennial plants in the spring; these plants move nutrients from the roots to aboveground parts in spring, so herbicides may not move down to the roots. In the fall, however, perennial plants translocate carbohydrates from their aerial portions to their roots, so a fall-applied herbicide will be carried to the root system, where it will work all winter to kill plant tissues.

For more information on weeds and their control, see chapter 14.

TURF RENOVATION

Renovation is needed if a lawn becomes thin or too poor to save. Renovation is also useful for extremely weedy lawns or those with extreme thatch accumulation. On lawns with underlying problems, such as poor drainage or extreme compaction, renovation eliminates the frustration and cost of trying to keep sickly turf alive and provides an opportunity to correct the problem and start afresh.

To renovate turf, kill the grass with a nonselective herbicide and remove it with a sod cutter. Add soil amendments, if needed, and then plow or rototill. Grading, smoothing, and seeding or sodding (as described earlier in this chapter) are the final steps.

Turf Problems

Turf problems often go unrecognized until considerable damage has occurred. To effectively solve problems, you first must identify the cause. Some have their beginnings in improper maintenance practices.

COMMON PROBLEMS

- **Improper watering** (too much or too little) is the single most important cause of poor turf. Follow irrigation recommendations.
- **Poor soil drainage** is seen on clayey or compacted soils. It may show up as standing water or as muddy or damp areas with sparse turf and moss. Cycled irrigation may help. If you choose to renovate the lawn, correct underlying problems at that time.
- **Summer dry spots** are common, especially in southern Idaho. Check for compaction, buried debris, and bent or blocked sprinkler heads. On steep slopes with recurring dry spots, consider terracing or replacing turf with a ground cover or meadow grass.
- **Mowing too low** (scalping) can stress turf and cause it to scorch and turn brown. Mow at the correct height for your grass species.
- **A dull, brown cast** on the surface of the grass blades could indicate a dull mower blade. If cut ends look shredded, it's time to sharpen the blade.
- **Yellowing turf** may indicate excess water, lack of N, or iron deficiency caused by high soil pH. Follow irrigation recommendations and obtain a soil test to check pH and soil nutrient levels.
- **Turf that grows too fast** between mowings usually indicates overfertilization. Follow fertilizer recommendations and fertilize during the proper times for cool-season grasses. Avoid fertilizing in July and August.
- **Thin turf** may result from shading or improper fertilizing and watering. Fertilizing cool-season grasses during the heat of summer can cause turf to thin over time. If shade is the culprit, reseed with a shade-tolerant mix or plant a ground cover.
- **Thatch buildup** is indicated by turf that feels spongy when walked on. Thatch should not be thicker than ½ inch. Dethatch if needed. Follow maintenance recommendations to minimize thatch buildup.
- **Crabgrass and other weeds**, when found persistently next to a driveway or sidewalk, usually indicate that the turf is stressed by heat radiated from the paved area. An accepted xeriscape solution is to replace turf in these areas with a 2–3-foot-wide bed of shrubs and herbaceous perennials.

INSECTS

Insects can occur on even the best-kept lawns. Many lawn insects are not harmful. Where there is a history of insect pest problems, however, control may become necessary. Begin by identifying the insect. If needed, use an insecticide registered for the specific pest. Always read and follow pesticide labels.

Three common turf insects in Idaho are sod webworms, white grubs, and billbugs.

Sod Webworms

This insect is the most common aboveground insect in Idaho lawns. Sod webworm larvae are ¼–¾-inch-long smooth caterpillars. They are green, gray, or light brown, with rows of regularly spaced darker spots.

Adults are white, tan, or brownish nocturnal moths that fly up from the turf when disturbed (as by mowing). They have a snout-like projection on the head and a very narrow body profile. (They fold their wings around their bodies instead of fanning them outward.) Eggs are laid in June and August and larvae overwinter.

Sod webworm larvae feed at night on grass leaves and stems above the crown. Initially, damage appears as small, brown patches of grass that look scalped. As damage progresses, patches can merge into larger, irregular shapes. During the day, the caterpillars hide in silk-lined tunnels located in the soil near grass roots — hence the name "web" worm. Because sod webworms are surface feeders, they are easy to kill with insecticides.

White Grubs

White grubs are larvae of several species of June beetles (June bugs) and chafers. The C-shaped, plump grubs are large (up to 1½ inches long and ½ inch wide), with six legs close to the head end. They are creamy white with brown heads.

Larvae feed on grass roots and the resulting damage causes grass to succumb to drought stress. Grub-damaged grass dries out and is easily pulled out or rolled back like a carpet. A deep thatch layer can protect grubs. Digging by birds, skunks, and raccoons often indicates that grubs are present. If white grub damage is suspected, check for grubs in the top 2–3 inches of soil. Adult beetles do not feed on grass.

One application of insecticide often gives season-long control.

Billbugs

Adult billbugs are slow-moving, black weevils (¼–½ inch long) with a long, curved snout — hence the name "bill" bug. The C-shaped larvae are tiny (⅛–¼ inch long) and creamy white with brown heads. They look similar to white grubs, but are much smaller and lack legs.

Adults feed on grass blades and stems, while larvae feed on roots. Billbug damage often occurs in turf that is stressed by heat and drought (e.g., turf that abuts cement or is growing on a slope). Damage appears as spotty patches of yellow or dead grass. Damaged grass breaks away at the crown as you pull on it or can be rolled back like a carpet. A sawdust-like material (frass) may be evident.

Begin checking for adult weevils in late April to mid-May. Adults are slow moving and nocturnal, so check at night with a flashlight. They often can be found crawling on pavement near lawns. Digging may reveal billbug larvae; after mid-July, larvae move deep into the soil and are harder to detect.

The key to billbug control is to kill the adults before egg laying begins in May by using an appropriate insecticide.

DISEASES

Turf disease problems are uncommon in Idaho's arid and semiarid climates. Fairy ring fungus is one frequently seen disease. At high elevations or where snow accumulates for long periods, snow mold may be a problem. See Table 6 for a list of lawn diseases, descriptions, and solutions.

For long-term disease control, you may need to adjust cultural practices to discourage pathogens. Sometimes, a single change (such as irrigating less frequently, reducing fertilizer rates, or mowing at the correct height) is sufficient to keep turf disease free.

In recent years, major advances have been made in the development of effective fungicides and bactericides for turfgrass disease control. When necessary, carefully select and use these products and always read and follow the pesticide label.

Further Reading and Resources

BOOKS

Christians, N., A. Ritchie, and D. Mellor. 2007. *Lawns: Your Guide to a Beautiful Yard*. Des Moines, IA: Meredith.

Turgeon, A. J. 2011. *Turfgrass Management*. 9th ed. New York: Prentice-Hall.

WEBSITES

University of Idaho Extension
https://www.uidaho.edu/extension.

Colorado State University, CSU Turfgrass Program
http://csuturf.colostate.edu.

Oregon State University, Department of Horticulture
https://horticulture.oregonstate.edu/.

Utah State University Extension, Lawn Care
http://extension.usu.edu/yardandgarden/htm/lawns.

Washington State University, Turf Management
http://turf.wsu.edu.

Table 6. Lawn diseases.

Disease/Symptom	Conditions Favoring Development	Management
Brown patch (*Rhizoctonia solani*) Brown, irregularly shaped or circular patches.	Moist, warm (above 80°F)	Avoid excessive, frequent irrigation and high N fertility.
Fairy ring (*Marasmius oreades*) Rings of dark green grass or arches of dead grass, with or without small, tan mushrooms (mushrooms appear mostly in spring and fall).	Mild, moist. Fungus grows on decomposing organic matter in the soil.	Core aerate or, for small areas, use a potato fork to poke holes in rings. Soak rings with water daily for 1 month to reduce hydrophobic patches. Keep turf well fertilized.
Fusarium patch (*Microdochium nivale*) Browning and thinning of turf in large, irregular spots (1–8 inches).	Cool, wet. Worse in spring and fall.	Promote soil aeration and drainage by amending the soil and following irrigation recommendations. Avoid excessive N.
Helminthosporium diseases (*Helminthosporium bipolaris*, *H. drechslera*, and *H. exserohilum*) Root and crown rot; yellowing and thinning of turf; tan to purple spots on leaves.	Moist. Common on bluegrass and perennial ryegrass.	Water in morning. Pick up clippings. Do not let grass get matted. Avoid excess N.
Necrotic ring spot (*Leptosphaeria korrae*) Dead circles, arches, and eventually patches; starts small but can spread to cover large areas.	Found on seeded and sodded bluegrass. Most common on 2–5-year-old sodded bluegrass.	Choose a resistant cultivar. Promote deep-rooted turf with proper fertilization, irrigation, and mowing.
Rust (*Puccinia* spp.) Leaves turn yellow; yellow, orange, or reddish-brown powdery growth on leaves.	Variable. Most common on certain cultivars of bluegrass and perennial ryegrass.	Increase N. Water during dry periods. Mow frequently.
Snow mold, gray (*Typhula* spp.) Irregular dead, bleached areas (2–24 inches) with gray mold, usually under or near melting snow.	Cold, wet. Worse under prolonged snow cover.	Avoid heavy late N fertilization.
Snow mold, pink (*Microdochium nivale*, *Fusarium nivale*) Circular, light-brown patches (2–12 inches); grass blades are faded and covered with pink fungus.	Cold, wet. Worse under prolonged snow cover.	Avoid heavy late N fertilization.
Yellow patch (*Rhizoctonia cerealis*) Light brown to yellow patches or rings.	Prolonged moisture at 40°F–60°F	Ensure deep rooting. Avoid excessive irrigation and fertilization.

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CHAPTER **SIXTEEN**

LANDSCAPING

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Learning Objectives

- Understand the principles of landscape design
- Understand how to conduct a site analysis
- Understand use areas in a landscape
- Understand the elements of landscape design
- Understand plant selection for a landscape design
- Understand the steps of installing or renovating a landscape
- Understand the maintenance and irrigation of a landscape

Introduction

Horticulture is an art and a science — especially when it comes to landscaping. Imagine the landscape as a canvas with the greenscape (plants) and hardscape (sidewalks, edging, and patios) the colors, shapes, and patterns of a living portrait. Landscape architects even use the term "plant palette" when referring to plant lists. The science that fleshes out these visions demands even more skills — the ability to match the proper plant to the proper environment and to identify and correctly apply the cultural inputs that guarantee the survival of plants in a given landscape.

The benefits of a well-planned, well-designed landscape are twofold. In addition to being more attractive and easier to maintain, designed landscapes can generate economic savings (reduced inputs of water, fertilizer, and pesticides), enhanced real estate values, and personal satisfaction and peace of mind.

To help you create an attractive and functional landscape, we will discuss some basic principles of landscaping including planning and design, plant selection, and installation and maintenance. Although the following principles are primarily for homeowners, you also can apply them to larger properties or landscapes.

Definitions

landscape. An arrangement of outdoor space for a specific purpose or goal. Goals may be as general as increasing the attractiveness of a landscape to more specific things such as reducing the amount of water, maintenance, and chemical inputs into the landscape.

landscape architect. A professional who creates landscape designs.

landscape contractor. Someone who installs and sometimes maintains landscapes. This individual also may be the landscape manager who is responsible for meeting the landscape plan's objectives.

landscape design. A blueprint or drawing of the landscape that the designer creates to fulfill the property owner's goals and objectives for the landscape.

landscape maintenance. The specific activities (weeding, spraying, watering, fertilizing, etc.) needed to meet the goals and objectives of the landscape plan.

landscape management. Coordinating the maintenance procedures to meet the landscape plan's objectives.

landscape plan. Describes how you are going to meet the goals and expectations of the landscape design.

landscaping. Includes all of the concepts from design to maintenance.

Creating a Plan

Plan before you plant. Whether you are developing a landscape plan for a new home or renovating an older landscape, it is important to have a plan before you do anything. In the long run, not having one may create maintenance problems, thus reducing a design's overall quality. The following steps will help you develop a plan for a landscape that is both functional and aesthetically pleasing.

DEFINE YOUR GOALS AND OBJECTIVES

This is the most important step of the landscape process. Establishing clear goals and objectives at the beginning will help you achieve the benefits you hope to receive from your landscape plan.

Decide what type of plan best fits the needs of your household, while working within the economic, social, environmental, and physical constraints that will affect your final landscape plan. Specific goals and constraints might include the following:

Goals

- Low maintenance, low input (includes reduced watering, pesticide and fertilizer applications, and less mowing).
- More privacy.
- More recreation area.
- More color.
- More wildlife habitat (includes forage and cover for birds and desirable insects).

Constraints

- Environmental conditions (includes climate, soil, and precipitation).
- Physical barriers or obstacles on the landscape.
- Social (includes public ordinances restricting water use or plant selection).
- Economic.
- Physical handicaps.

DO A THOROUGH SITE ANALYSIS

Gather as much information as possible about your site and the area where you live. Make a preliminary map of your property, drawn to scale, that includes the locations of your house, buildings, sidewalks, and driveway. Indicate on the map, or on a separate sheet of paper, the following information:

Macroclimate

This refers to major weather patterns (temperature and precipitation) that affect large areas. In Idaho, cold hardiness is a critical factor for determining plant survival. Idaho covers five United States Department of Agriculture USDA hardiness zones, 2–6 (-50°F to -10°F), with temperatures affected by elevation and latitude (Figure 1). Temperature and precipitation can vary considerably within a hardiness zone. Always consult local or regional weather services or Extension publications for specific weather information for your area.

Microclimates

These are the weather patterns that the landscape in your immediate area affects. When conducting a site analysis, look for potential problem areas such as hot spots, frost pockets, wet spots, or shaded areas. Mark these microclimates on your preliminary map for future reference.

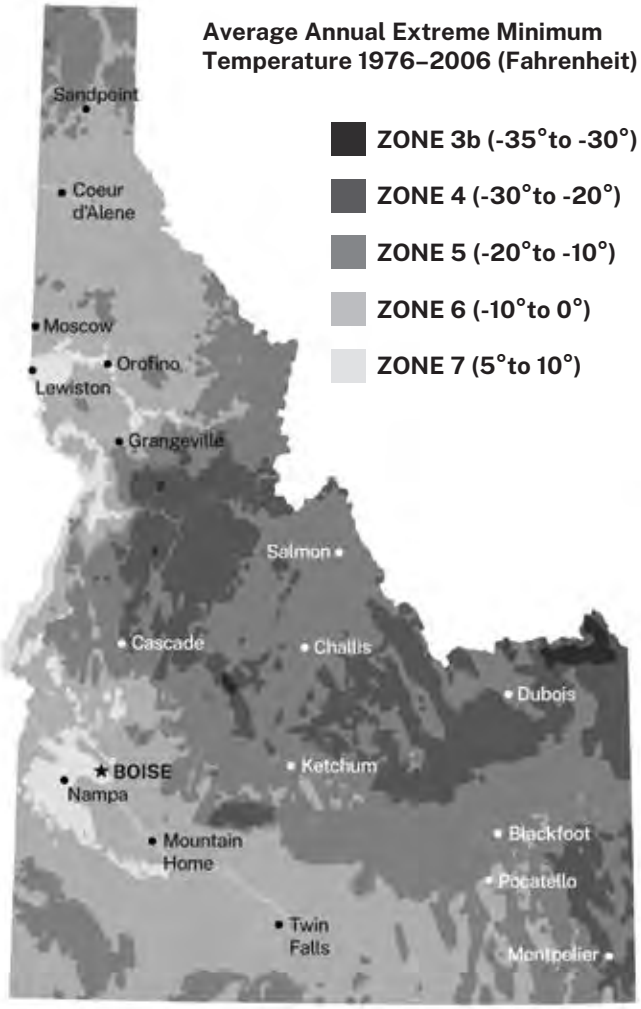

Figure 1. USDA plant hardiness zones for Idaho.

Soils

See chapter 5 for more information about soils. In regard to urban or residential landscapes, consider the following:

- Most urban or residential soils are disturbed soils and probably won't resemble the less disturbed, native soils of the surrounding region.
- Proper soil conditions are as important to plant growth and survival as ideal climate conditions. Drainage, pH, structure, organic matter, and mineral composition are factors to consider in relation to plant growth.
- Because you are working with a small area, it is easier to improve the soil using various soil amendments.

Topography

Besides altering the microclimate, topography can affect drainage and make some areas difficult to plant and maintain.

NOTE

If the soil in your site has a lot of variability, indicate the different areas on your preliminary map and plan accordingly. See the University of Idaho (UI) Extension Bulletin 704, *Soil Sampling*, for information about taking soil samples on your site.

Aspect

Note the exposure of the site relative to the sun. This is more critical in mountainous areas or areas with steep hills. Generally, plants growing on the warmer, south-facing side of a slope will break dormancy faster than plants growing on the north-facing side. This provides a longer growing season, but it also can make plants more susceptible to late frosts and other freezing-related injuries.

Existing Plant Materials and Structures

Show existing plant materials, sidewalks, driveways, patios, and other structures in your preliminary plan.

Access

Besides driveways and sidewalks, plot "traffic" areas around the landscape. Consider ways to improve access to your home or other parts of the landscape.

Easements

Draw these on your map to prevent planting any permanent plant materials in these areas.

Overhead Utility Lines, Sewer Lines, Underground Cables, and Transformers

Note these on your preliminary site plan and plan accordingly. Some basic rules for planting in these areas include the following:

- Plant trees and shrubs away from utilities
- Plant taller or broad-spreading trees away from overhead lines and use shorter, slower growing trees for closer planting if you must plant near overhead utilities
- Don't plant species near utilities that prevent access or cause maintenance problems
- Avoid planting species such as poplars, willows, and cottonwood with dense, fibrous roots near sewer lines or septic systems

NOTE

See the UI Extension CIS 991, *Landscaping and Utilities: Problems, Prevention, and Plant Selection*, for more information.

Views

Indicate your views looking out from your house and those that develop when approaching it. What do you want to see? What don't you want to see? What do you want others to see or not see?

Available Water

Show the location of your water sources. If your property has areas that are difficult to water, you may want to modify your plan to meet the needs of these areas by using drought-tolerant plants or hardscape (nonliving) materials.

Local Ordinances

Consult state and local authorities for specific regulations about planting trees and shrubs along streets, sidewalks, and rights of way.

DEFINE USE AREAS

You can divide use areas into three major categories:

Public Areas

This usually describes the front of your landscape. The primary function of this area is aesthetics (to "welcome" visitors to your home).

NOTE

There are no distinct boundaries on these areas and they will frequently overlap in terms of function and appearance. Within these major use areas, you should designate specific use areas (e.g., recreation, perennial flower beds, vegetable garden, and patio) for the various activities that you are planning for your landscape.

Private Areas

These are the areas used for recreation, family activities, and entertaining.

Service Areas

These areas are reserved for the vegetable garden, composting, pet and livestock areas, storage shed, woodpiles, and other utilitarian purposes. They can include areas that are difficult to maintain, have limited access to water, or have poor soil.

DEFINE PLANTING AREAS

Plot planting zones based on water needs or the plants' maintenance requirements and to meet the landscape plan's objectives.

Hydrozone or group plants with similar water needs in the same areas. For example, consider planting willows, dogwoods, or birches that usually thrive under moister conditions near annual flower beds (high water users). To conserve water, do not mix plants that have low water requirements with plants that have high water requirements.

Reduce maintenance activities by grouping plants with similar maintenance requirements together.

- Perennials generally require less frequent maintenance than annuals. In Idaho, most of the maintenance of perennials occurs in the spring and fall.
- Plant trees or shrubs with messy leaves, fruits, or seeds away from flower beds especially if these plants reproduce easily from seed. It is easier to rake this material up or remove the new seedlings from a lawn than from your planting beds.
- Group shrubs with similar flowering periods together so it's easier to remember which plants you need to prune in early summer and which ones in the fall or early spring. Grouping also will help you focus maintenance activities on specific areas of your landscape.

Design planting areas to meet the objectives of your landscape plan. If your objective is privacy, design planting areas to maximize privacy. However, if you are concerned about security, you may want to leave large areas of open space with reduced opportunities for concealment. Perhaps you would like to encourage more wildlife on your landscape? Then plan for more areas that provide both food and shelter. Plan and plot your objectives before starting to plant.

PRINCIPLES OF DESIGN

The house is the focal point of a design. The landscape should complement, not clash, with the house. The landscape is an extension of the living space. Just like the appearance and arrangement of your house affects your personal living space, so does the appearance and arrangement of your landscape. It affects you aesthetically based upon your inward and outward views and from a functional perspective.

Balance

You can achieve balance on the landscape in two ways:

1. **Symmetrically**. Place equal numbers of plants, plants of equal size, or structures or planting beds of equal size opposite each other on the landscape. For example, plant two shrubs of the same size and species on opposite sides of an entryway or plant two flower beds of equal size, dimension, and species composition on opposite sides of a sidewalk.
2. **Asymmetrically**. Balance plants and structures in terms of volume of space occupied on the landscape. One example might be to plant a large red oak on one side of the yard to counterbalance a mass planting of ornamental shrubs on the opposite side. Also, you could counterbalance a deck with a perennial bed.

Movement

You can create a sense of vertical and horizontal movement on the landscape. For example:

- Tall, columnar trees or shrubs draw your eyes upward, whereas a low, flat bed of colorful annuals pulls your eyes downward.
- Lines, especially curved lines of walkways or planting beds, create a sense of motion that encourages you to move visually and physically through the landscape.

Harmony

The proper use of space, color, texture, and plant materials on the landscape creates harmony.

Use plants and structures that are in scale with the house.

Enhance the overall landscape design with plants and plantings that complement each other.

ELEMENTS OF DESIGN

Space

Use space effectively by considering the following principles:

- Select a mixture of plants that provide an effective transition from the vertical plane (air) to the horizontal plane (earth) to create a better sense of harmony and balance.
- Plant trees that provide filtered shade (e.g., honey locusts) rather than trees that provide heavy shade (e.g., maples) for a more subtle influence on vertical space.
- Select different species of plants based upon their form and structure as well as their color or flowering habits.
- Use curved lines to create a more natural, informal appearance. Straight lines are less natural and more formal.

Color

Color affects the landscape design in various ways.

- It gives the landscape movement, accent, shade, and depth. For example, bright colors such as reds and yellows are good for accent, variety, and for attracting attention to specific areas. Use blues and dark colors to create shade and depth.
- Color affects mood. Reds are exciting colors that generate energy; pinks and greens are soothing colors; and light blues create a cool feeling.

NOTE

A color wheel will help you make effective color choices. They are available at crafts, art, paint, or office supply stores.

Texture

Texture is the "visual feel" of the landscape or of landscape plants. Some plants have a coarse texture because of their foliage, branching patterns, or bark. For example, a horse chestnut tree with its large, serrated, compound leaves will have a coarser texture than a weeping willow.

Plant Arrangement

The individual attributes of the plantings and overall effectiveness of the landscape plan is affected by plant arrangement.

Specimen plants draw attention to themselves because of their color, shape, or size. Plant them by themselves or enhance beds with mass plantings. Large shade trees (oaks, maples, and conifers) or small trees and shrubs (ornamental crabapples, hawthorns, burning bushes, and viburnums) make effective specimen plants.

Mass plantings enhance the appearance of plants that may not be as attractive or effective individually. Annuals, perennials, small shrubs, and ground covers are generally more effective as mass

plantings. Also, on more naturalized landscapes, it is best to plant shrubs in odd numbered clusters for a more natural appearance.

PLANT SELECTION

Select plants that meet your design objectives. These might include the following:

- Functional.
- Aesthetically pleasing.
- Cold hardy. Check if the plant is adapted to the minimum temperature zone for your area.
- Low maintenance. Select species that require a minimum amount of pruning, watering, and raking. Cut the frequency of maintenance time for woody plants by reducing the variety of early and late-flowering species.
- Low input. Select plants that require less water and chemical inputs.
- Nonpoisonous and safe. This is especially important in areas that children will use. Try to reduce the number of plants that may have poisonous fruits, flowers, or foliage or that have thorns or spines that can cause injuries.

NOTE

Contact your local Extension educator or the Poison Control Center if you have any questions.

- Appropriate selections for planting near utilities.
- Economical. What we want is not always what we can afford. Your budget will determine your choice and size of the plant materials that you can purchase.
- Native or nonnative species. Some people recommend planting native (indigenous) species over nonnative (nonindigenous) species because, theoretically, they are better adapted to an area. This is not necessarily true since most residential landscapes are disturbed sites and unnatural environments that probably will have more inputs (irrigation, fertilizing, and pest control) than the preexisting natural environment. Native plants are not always more drought tolerant than nonnative species either.
- Nonnoxious. Noxious weeds are a serious problem in agricultural areas. If you plan to purchase or introduce plants from out of state, contact your local Extension educator for information or the County Weed Control supervisor about noxious weeds in Idaho.

NOTE

The bottom line is to choose the best plant that is adapted to the area you are going to plant it in and that meets your desires for your landscape.

OTHER CONSIDERATIONS WHEN BUYING PLANTS

Some other important things to consider when you are **buying** plants:

- To ensure greater adaptability to your area, purchase plants that local seed sources have produced. This is especially important for woody and herbaceous perennials.
- Before purchasing plants via mail order, check local nurseries. You may save money and you will be able to inspect the plants for pests and diseases. Also, you are more certain of getting a live plant.

Installation and Renovation

Follow these steps when installing a new landscape or renovating an older one. The sequence depends upon your needs and abilities.

- Primary hardscape. Install sidewalks, driveways, walls, terraces, decks, patios, and ponds. These will define your use areas and will prevent future damage to your landscape if done at the beginning.
- Install planting beds. Amend soils, if necessary, and install weed barriers, if desired.
- Plant or move trees and shrubs. Plant and transplant shrubs early in the spring or late fall when plants are dormant and the soil is workable. Do not transplant large trees and shrubs when they are actively growing.
- Install an automatic irrigation system.
- Plant lawn or ground covers. Add soil amendments if you have poor soils — especially soils low in organic matter — or plant some type of an annual cover crop to improve the soil before planting.

Maintenance and Irrigation

MAINTENANCE

Review the maintenance requirements of your landscape plan before actually installing the landscape. This will save you a lot of frustration and expense in the long run. Refer to other *Master Gardener Handbook* chapters for more information about the following maintenance activities:

- Proper pruning. Timing and technique is important.
- Staking and wrapping trees or shrubs.
- Mulching. Includes organic, inert, and synthetic mulches. Organic mulches should not be deeper than 2–4 inches. Incorporate fine mulches such as sawdust into the soil. Plastic, nonporous mulches are not recommended for landscape use.
- Pest control. Includes disease, insect, and weed control.
- Proper turf management. Mow grass to proper heights. Leave trimmings as a mulch to improve soil and water retention, fertilizing, and top-dressing. Proper watering is also important to maintain a healthy lawn and to avoid waste, runoff, and water pollution. (See chapter 15 for more information and publications about establishing and maintaining a lawn.)

WATER MANAGEMENT

Match the irrigation program to the plants' moisture requirements, the time of the year, and soil types. Important components of a good water management program include:

- Proper timing and duration of watering. Deep and infrequent waterings are better than shallow frequent waterings. Deeply water evergreen trees and shrubs before the ground freezes in the winter.
- Match sprinklers and irrigation scheduling to plants and planting areas. Trees and shrubs require less frequent watering than turf and herbaceous ornamentals.
- Monitor and maintain the irrigation system frequently to prevent runoff, waste, and pollution.

Further Reading

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BOOKLETS AND PAMPHLETS

University of Idaho Extension

BUL 644 *How to Prune Coniferous Evergreen Trees*

BUL 915 *Soil Testing to Guide Fertilizer Management*

CIS 991 *Landscaping and Utilities: Problems, Prevention, and Plant Selection*

CIS 1054 *Low Input Landscaping*

PNW 496 *Propagation of Plants by Grafting and Budding*

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CHAPTER **SEVENTEEN**

LANDSCAPE PLANTS

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17 LANDSCAPE PLANTS

Learning Objectives

- Understand what an ornamental plant is
- Understand soil and water considerations for ornamental plants
- Understand how to prepare a site and to plant ornamental plants
- Understand the different types of problems associated with ornamentals

Why Ornamental Plants?

Landscape plants are placed as they are for various purposes: to create shade, to define space, to enhance architecture, to provide food (e.g., fruit trees), and to further general aesthetics. These plants should be installed according to a plan, so that they are correctly selected and placed to create the desired design effect. Plantings should be in tune with the environmental situation and take into account such things as exposure, amount of light, pH, water availability, and soil type.

Trees and shrubs will last in the landscape for many years. However, when a stress is imposed on a plant, that plant becomes much more susceptible to other problems, including insects and disease. A large percentage of landscape plant problems can be related directly to improper selection of plant material and improper cultural practices that lead to plant stress. In some cases, the effects of improper cultural practices may not be seen for years.

Soils and Water Considerations

SOIL COMPOSITION

Soils are roughly 50% solid material and 50% pore space. (Pores are holes in the soil that are either filled with air or water.)

Pore Space

Pore space, ideally, should be 50% air and 50% water.

Air is necessary for root respiration and normal metabolism, including the uptake of water.

Water is used in transpiration within the plant and for the transport of dissolved mineral nutrients from the soil to roots and on up the plant through the xylem.

Solid Material

The solid material is composed of organic matter, decomposed rock, and various biological life.

WATER STATUS DEFINITIONS

capillary or **available water**. Held less tightly to soil particles; available for plant usage.

gravitational water. Moves with the force of gravity; drains away. This water is not available to the plant.

hygroscopic water. Tightly bound to the soil particles; not available for plant growth.

saturated conditions. Tend to exclude air; detrimental to most plants (with the exception of aquatic species).

WATER MOVEMENT

The thicker the film of water, the greater the ease of movement in the soil. The thinner the film of water, the harder it is to move through the soil, therefore, becoming less readily available to plants.

Water movement is always from wetter areas in the soil mass to drier areas. When water is lost from the soil surface (through evaporation), more water is drawn up from lower levels. When a plant draws water in through the roots, more water moves into the area.

Roots **do not** seek water; roots grow where water is.

SOIL STRUCTURE (AGGREGATE SIZE)

Soil particles may be made up of many small particles clumped together.

Spaces (**macropores**) between large particles contain air for root respiration.

Spaces between smaller particles and within very large particles contain capillary (available) water. Water also is found on the surface of larger particles.

Increase aggregate size by

- Adding calcium (usually gypsum): only works with clay soils.
- Adding organic matter: Water and air are found **in** and **between** the organic matter particles. Organic matter loosens a clay soil for better air and water movement. In sandy soils, organic matter helps hold water and nutrients.

DRAINAGE PROBLEMS

Hard, Compacted Soil

Air space squeezed out; low infiltration, little air space, and slow drainage.

Impenetrable Layers

Clay layers, hardpan, and plowpans, etc.; may not allow water or roots through.

Fine-Textured Soil

Preferable over a coarse-textured soil or gravel.

At the **interface**, water cannot move rapidly into coarse soil; consequently, moisture is limited or not continuous.

MASTER GARDENER TIP

The interface is where one soil type stops and another begins.

Water movement downward is impeded across the interface and much of the finer soil's pore space may fill with water.

Coarse-Textured Soils Over or Contained within a Fine-Textured Soil

Drainage through coarse soils is rapid.

Infiltration into fine soils is slow, causing macropores in the coarse soil to fill with water.

Roots lack oxygen and root rots may ensue.

Add organic matter to the coarse soil to slow water penetration.

OVERCOMING DRAINAGE PROBLEMS

1. Till by adding 3–4 inches of organic matter.
2. Raise plant slightly above grade and create a bed with good soil or a raised bed.

3. Add tile to create good drainage.
4. Contour slope away from the plants so that water runs off.
5. Break through hardpan layers.

Planting and Site Preparation

TYPES OF PLANT MATERIALS

Bareroot (B.R.)

Dug without a ball of soil; little or no soil around the roots. Examples: dormant deciduous shrubs, roses, deciduous trees, and small evergreens.

Balled and Burlapped (B and B)

Dug with soil that is enclosed in burlap or some sort of synthetic material. The root system has been cut for easier handling and transport.

Field-Potted

Dug with or without soil and potted into a container.

Container

Plant grown for a time in a container.

PLANTING

Bareroot (B.R.)

1. Cut back damaged or broken roots.
2. Dig hole twice as large as the root system.
3. Put the plant in the hole at the same level it grew originally. Build a cone or mound of soil at the bottom of the hole under the plant for support and to aid in spreading the roots. Be sure the roots are spread.
4. Backfill with native, **not amended**, soil.
5. Water thoroughly.
6. Fertilize with a high phosphate fertilizer (5-10-10) or a balanced slow-release fertilizer (10-10-10). Fertilizers may be added to a backfill material. Fertilizer may also be added to the soil surface after watering. Always follow label directions as to amount.

Balled and Burlapped

1. Dig hole twice as wide as the ball of soil.
2. Remove **all** of the rope, twine, or string on the ball after setting it in position in the hole. The burlap can be sliced on the sides and the top burlap should be laid back so that no burlap is exposed aboveground. Burlap exposed aboveground will wick moisture away from the root ball. Synthetic or plastic burlaps should be removed totally. Unless B and B trees have been kept in burlap for a long time, don't worry about girdling roots or cutting damaged roots.
3. Backfill with native, **not amended**, soil.
4. Water thoroughly.
5. Fertilize with a high phosphate fertilizer (5-10-10) or a balanced slow-release fertilizer (10-10-10). Fertilizers may be added to a backfill material. Fertilizer may also be added to the soil surface after watering. Always follow label directions as to amount.

Container Plant

1. Dig hole twice as wide for root-system spread.
2. **Remove** container, no matter what type.
3. Roots:
   - If the roots are not circling (potbound), carefully spread the exterior roots outward, away from the soil ball.
   - If the roots are circling, make three to four vertical cuts into the sides of the root ball (¼–½ inch into the ball). If the roots are woody and cannot be cut with a knife, lay the ball on its side. Using a sharpened spade or shovel slice through the lower half of the root ball. This is called "butterflying." Spread out the two flaps of roots and place in planting hole so the top of the root system is level with, or slightly higher, than the surrounding soil. When butterflying, be sure not to damage the crown by splitting too close to the trunk. Make sure the split area is filled with soil so that no air spaces are left.
4. Backfill with native, **not amended**, soil.
5. Water thoroughly.
6. Fertilize with a high phosphate fertilizer (5-10-10) or a balanced slow-release fertilizer (10-10-10). Fertilizers may be added to a backfill material. Fertilizer may also be added to the soil surface after watering. Always follow label directions as to amount.

PRUNING AFTER PLANTING

1. Leave as much of the crown intact as possible, and remove only dead, injured, and diseased branches.

2. Remove interfering, rubbing, or poorly placed branches.
3. Remove a branch from narrow "V" crotches or multiple leaders.
4. Prune to shape, if necessary.

STAKING

Avoid staking unless wind is a problem. Stake as low on the stem as possible and remove the stake after one year.

Reasons for staking:

- To anchor plant until it can root into the soil.
- To protect the tree from slanting with the wind.
- To straighten a crooked trunk.

Staking is used mostly for B.R. and B and B plants. There are one-stake and two-stake methods.

Plant Problems

Problems associated with plant roots may show up in other plant parts, especially the leaves.

CIRCLING ROOTS/POTBOUND

Symptoms

A general decline of plant vigor over a period of time.

Causes

Plant remaining in container too long at some stage of development, not necessarily the last stage of production.

Remedies

"Butterfly" the root ball or cut and spread the roots before planting.

GIRDLING ROOTS

Symptoms

Girdling roots limit water and nutrient transport causing deterioration of the plant. Top growth diminishes; plant is stressed.

Causes

An impenetrable planting hole; twisting the plant after setting into hole; bending roots to fit into a hole that is too small; and planting potbound or rootbound container stock.

Remedies

Chop off girdling root; spread roots when planting; remove debris or rocks in planting area.

KINKED ROOTS/ONE-SIDED ROOT SYSTEM

Symptoms

A general decline of plant vigor over a period of time.

Causes

Improper production methods (such as dragging with a mechanical planter, causing "J"-hooked roots, or jamming the plant in the pot or the planting hole).

Remedies

Cut off kinked roots when planting; carefully spread and straighten the roots.

ROOT ROTS

Symptoms

Soft, brown, partially to totally decayed roots, resulting in wilting or death of the plant.

Causes

Cause varies with susceptibility of the plant. There might not have been enough soil aeration; the water table might be high; the backfill might have been amended with fresh manures when planting; or the soil might be waterlogged.

Remedies

Improve downward and lateral drainage; tile, if necessary; and plant in raised beds. Select a water-loving species of plant and amend the soil to improve drainage.

CHANGING SOIL GRADES

Symptoms

No buttressing or flaring roots at tree base; general decline of tree; leaves and branches die from top down; collar rots are evident. The decline may take several years to occur or to complete. Susceptibility varies with species.

Causes

Filling with soil or pavement on top of an established root system results in a decreased air supply to the plant, changing drainage and water patterns.

Remedies

Cover roots with a thick layer of gravel, then with soil. Provide drainage, and in some cases, **welling** the trunk will help.

MASTER GARDENER TIP

Welling is the building of a "well" or wall around the tree several feet out to keep soil away from the trunk.

TRENCHING/CUTTING ROOTS

Symptoms

Cutting roots reduces water and nutrient uptake. The decline may take several years to occur or complete. Cuts can become infected with root rot, leading to the decline of plant growth. The result is often the death of a tree from the top downward. Sometimes the decline is limited to that half of the tree with the cut or damaged roots.

Causes

Removing top layers of soil to change a grade or damaging roots by cutting.

Remedies

Avoid cutting large roots; fertilize and water the rest of the root system; use a high-phosphorus fertilizer to encourage new root development.

COMPACTION

Symptoms

Decline of the tree from the top down.

Cause

Soil compaction after the plant is in the ground.

Remedies

Direct foot traffic and machinery away from the dripline of trees. Aerate soil using a core aerator or cushion the soil with a thick mulch.

Stem Problems

Stem maladies usually arise from improper cultural practices and stresses to the plant.

HEART ROT

Symptoms

Decay of heartwood.

Causes

Improper pruning, topping, breakage, or wounding of the stem or the large branches.

Remedies

Prune properly and avoid wounding. Remove decayed branch wood; if rot is in an advanced stage, remove the tree.

STEM WOUNDS

Symptoms

Cankers, girdling, holes, splits, and oozing.

Causes

Various, including hitting the tree with lawn mowers and string weeders; leaving support wires or B and B string around stem; diseases, borers, and sunscald.

Remedies

Keep equipment away from plant stems and trunks. Remove all lawn grass to at least 1 foot from the trunk. Keep all mulch 2–3 inches from plant stems. Identify and treat insects or disease. Remove labels and ties when planting. Painting or spraying with tree wound compound does **not** improve healing, but it may prevent insect entry.

SUNSCALD OR SOUTHWEST DISEASE

Symptoms

Bark tends to be blistered, burnt, dead, or split on the southern or southwestern sides of the trunk. Young, newly transplanted trees are the most susceptible.

Causes

Alternating freezing and thawing of bark on sunny side of tree during winter. Intense heat during summer.

Remedies

Shade southern and southwestern sides of trunk; wrap the trunk with tree wrap or paint with white, water-based (latex) paint. If there is an advanced stage of damage, carefully remove any dead bark, apply tree wound dressing, and wrap to keep insects out of heartwood.

BRANCH ROTS AND INFECTIONS

Symptoms

Oozing, cankers, holes, and splits.

Causes

Improper pruning. Branch stubs or flush cuts leave a tree open to disease and insects.

Remedies

Prune correctly; cut back only to the branch collar; do not top trees. Treat insects and diseases when first noticed.

DAMAGE TO CROTCH AREAS

Symptoms

Splits, oozing at crotch.

Causes

Narrow “V” crotches, borers, water gathering in crotch.

Remedies

Prune out all but one of the leaders if the tree is young and has multiple leaders. Narrow branch angles can be spread when the tree is young; cable or brace narrow crotches if the tree is older to prevent breakage.

FREEZE DAMAGE

Symptoms

Blackened tissue; dead twigs or buds; death of plant. Stem dieback. Usually younger stems die, but older wood also can be damaged during severe winters. There is generally a partial to total necrosis of the young leaves. Older leaves may become distorted later. New growth might have been frozen by late spring frost when plant was in the soft-growth stage.

Causes

Lethal winter temperatures and early or late frosts.

Remedies

Use frost-prevention methods; select trees and shrubs specified for your zone; do not fertilize trees and shrubs after July 1.

GRAFT INCOMPATIBILITY

Symptoms

Large overgrowths above and below union; earlier than normal fall coloration; a stem that breaks off at graft.

Cause

Incompatibility between scion and stock.

Remedy

Purchase plants rooted from cuttings or use a reliable source of grafted stock.

Leaf Problems

Problems with stems and roots often will show up in the leaves. If a plant is wilted, the leaves are either not getting enough water or are losing water faster than it is being supplied by the roots. Determine the cause of wilting. There also are many insects and diseases that affect leaves.

DROUGHT

Symptoms

Wilting, drying of soft growth, and blotchy necrosis.

Causes

Extended periods of dryness. High heat/bright sunlight on shade-loving plants could cause leaf scorch, early leaf drop, or marginal and interveinal chlorosis or necrosis.

Remedies

Water plant; provide better soil preparation by adding organic matter to increase water-holding capacity; mulch to reduce surface evaporation. Select drought-tolerant plants. Shade plant; mist periodically for temporary cooling.

FROST DAMAGE

Symptoms

Partial to total necrosis of young leaves or buds. Older leaves may become distorted if buds were injured.

Causes

New growth frozen by late spring frost when the plant is in the soft-growth stage.

ROOT INJURY

Symptoms

Wilting, early leaf drop, leaf chlorosis, root damage, necrosis, and plant death.

Causes

Root damage due to trenching, insects (such as root weevils), or disease. Overwatering limits oxygen uptake by roots and encourages root rot.

Remedies

Determine the cause, then take appropriate action. If the cause is not a root rot, then proper watering of the remaining root system will help. Fertilization with a high phosphorus fertilizer may help rejuvenate the root system. If overwatering is the problem, increase drainage and cut back on water. If a high water table or poor drainage exists, choose water-loving plants (such as a willow).

VASCULAR SYSTEM INJURY

Symptoms

Wilting or drying of a portion of the plant.

Causes

Disease, such as Verticillium wilt, can plug the xylem vessels.

Remedies

Determine the cause and take appropriate action. Remove the infected portion; treat for Verticillium.

SALT DAMAGE

Symptoms

Marginal to interveinal chlorosis/necrosis; rootlets are brown instead of white.

Causes

Salts from excessive use of commercial fertilizers, manures, and deicing salts. The latter may be more prevalent next to sidewalks and driveways.

Remedies

Leach with water, if possible; limit the use of offending materials. Alternate organic fertilizers with commercial fertilizers to reduce salt buildup.

LEAF CHLOROSIS AND NUTRIENT DEFICIENCIES

Nitrogen Deficiency

Symptoms. Overall yellowing of older leaves first. Stunted growth of plant. Pale green color on rest of plant.

Cause. Nitrogen deficiency.

Remedy. Fertilize with a nitrogen fertilizer.

High pH (Over 7.5)

Symptoms. Interveinal chlorosis, light green to white in color (with zinc, older leaves affected; with iron, new leaves affected first). The margins of leaves may become necrotic, but the veins remain green. With zinc deficiency, leaves may be small, narrow, and thickened. Foliage loss may be early and leaves at tips of branches may be bushy with few or none along the branch. Manganese deficiency is similar to iron deficiency, but chlorosis is not so dominant on young leaves. Also there is severe browning and dropping of leaves with maturity.

Cause. Iron, zinc, or manganese deficiencies because of the soil pH.

Remedies. A long-term solution is to decrease soil pH. A temporary solution is to apply the deficient nutrient. You may need to make annual spring or fall applications.

Other Causes of Leaf Chlorosis

- Wrong soil pH for acid-loving plants
  Example: azaleas
- Herbicides (see subsection “Herbicide Damage” of this section and Table 1)
- Drought (see section “Leaf Problems,” subsection “Drought”)
- Natural leaf maturity and abscission in autumn
- Natural variegation

HERBICIDE DAMAGE

Herbicides are formulated to be toxic to specific weeds, but they also may cause damage to desirable plants.

Symptoms

Some herbicides act hormonally and produce a twisted, cupped, puckered, or distorted growth. Other herbicides inhibit photosynthesis and chlorophyll formation, causing a peculiar coloration or characteristic chlorosis depending on the material used (see Table 1 on next page). In general, if many plants in one area are affected with unusual twisting, puckering, or with strange colorations and drying leaves, chemical or herbicide misuse may be the culprits. If only part of the conifer root system is affected by a herbicide, the damage may create a spiral pattern on the stem of the plant.

Table 1. Common herbicides.

Herbicide	Damage Symptoms
Dichlobenil (Casoron)	Broadleaf plants: Tip, marginal to interveinal chlorosis/necrosis. Sometimes more severe on leaves oriented toward the afternoon sun. Conifers: Needle tip chlorosis to necrosis.
Phenoxy compounds (2,4-D, MCPP, MCPA)	Broadleaf plants: Twisted, distorted leaves and stems. Blistering of bark on London plane tree. Conifers: Misshapen, hooked needles.
Dicamba (Banvel)	Broadleaf plants: Twisted, cupped, distorted new growth, chlorosis, necrosis, death of stem tissue. Conifers: Distorted, twisted needles, needle necrosis from the base to the tip; club-shaped growth, needle distortion on pines.
Glyphosate (Roundup)	Broadleaf plants: Yellowing and necrosis of part or entire plant. New leaves do not develop correctly; they are skinny, strap-shaped, yellow.
Triazines (Atrazine)	Broadleaf plants: Marginal chlorosis.
Simazine (Princep)	Conifers: Tip chlorosis.
Chemical sterilants (many kinds)	Severe chlorosis; necrosis; death if applied near the root system of desirable plants.

Causes

Most people do not know where the root zones of desirable plants are; consequently, they overspray, and translocation of the herbicide into a desirable plant occurs.

Remedies

Almost all problems arise from misapplication and misuse. Few problems arise when label directions are followed closely and the broadcasted material is kept 5–10 feet away from the dripline of desirable plants. Spot treat weeds rather than broadcast when possible.

INSECTICIDE INJURY

Symptoms

Dormant oil will remove the waxy bloom that gives the blue cast to Colorado Blue Spruce. Oils used on deciduous plants that have started to show green will burn exposed green tissue. Some insecticides, such as malathion, will burn leaves when applied during high temperatures.

Causes

When used for insect and mite control on needled evergreens, dormant oil may cause burns, especially if the concentration is too high, if the oil is applied during freezing weather, or if the plant has started to grow.

Further Reading

BOOKS

Harris, R. W. 1983. *Arboriculture: Care of Trees, Shrubs and Vines in the Landscape*. Hoboken, NJ: Prentice Hall.

Partyka, R. E. et al. 1980. *Woody Ornamentals: Plants and Problems*. Columbus, OH: ChemLawn.

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CHAPTER **EIGHTEEN**

WOODY LANDSCAPE PLANTS

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18 WOODY LANDSCAPE PLANTS

Learning Objectives

- Learn what woody landscape plants are and how they are used in a landscape
- Learn how to select woody plants based on function, growth characteristics, ornamental characteristics, genetic adaptability, and site consideration
- Learn how to purchase, plant, and care for woody plants
- Learn how to properly maintain woody plants, focusing on irrigation, mulching, fertilizing, and pruning
- Learn how to protect woody plant material during construction projects
- Learn which woody landscape plants are suitable for use in Idaho landscapes

Introduction

Woody landscape plants are perennials with stiff, woody stems. These plants are loosely classified as trees, shrubs, or vines. Trees usually have a single trunk and can grow to impressive heights. The tallest trees are the Coast redwoods (*Sequoia sempervirens*), which grow to 350 feet or more.

Trees can develop — or be pruned to grow — several trunks. If a mature single-or multitrunk woody plant is less than about 20 feet tall, it is considered a large shrub rather than a tree.

Shrubs are less than 20 feet tall at maturity and usually have multiple trunks. Standards, which are shrubs trained to grow with a single trunk, may serve as small trees in the landscape. Because they had to be trained (pruned) to grow this way, however, they are still considered to be shrubs. Woody shrubs may spread by stolons (horizontal stems), rhizomes, or underground roots. Very short woody shrubs make good ground covers.

Vines may climb, trail, creep, or even remain erect with some support for their stems. Woody vines may root at various places along their stems, wherever they come in good contact with the ground and have proper growing conditions. Climbing vines, such as English ivy, may attach to supports with small aerial roots. Grapes can climb by winding slender stems called tendrils around objects.

Some plants will perplex the expert horticulturist and the Master Gardener by defying classification with the above system. Crabapples are a good example. Some insist on growing with multiple stems, yet grow taller than 15 feet at maturity. Others are natural, single-stemmed beauties, reaching only 5 feet at maturity. Some weeping forms, if grown on their own rootstocks, would creep across the ground. So, crabapples can be large shrubs, tiny trees, or even vines! Thus, use the tree, shrub, or vine classification only in a general sense.

The Art of Designing Landscapes with Woody Plants

Woody plants form much of the structure in landscape design and contribute to a pleasing composition. They define the skyline and become the structural element dividing space. Landscapers must carefully consider choices and placement. Established trees and shrubs cannot be moved easily. Within the principles of landscape design (see chapter 16), woody plants serve the following purposes:

Balance. Tree and shrub placement, whether symmetrical or asymmetrical, creates equilibrium in the landscape. Trees and shrubs provide the coordinating composition for other elements, such as annuals, perennials, and garden features like fences and decks.

Movement. Repeating or alternating shrubs and trees can carry the eye throughout a landscape. The rhythm created is an underlying theme of landscape. Taller shrubs and trees draw the eye skyward.

Harmony. Trees and shrubs serve as a dominant feature or accent in a landscape, thus contributing to the harmony of the design. Repetition of structural elements, such as woody plants, helps to tie the landscape together. The interconnectedness of a low woody ground cover under trees or of a line of shrubs or trees provides continuity that creates harmony in the landscape.

WHICH WOODY PLANTS TO INSTALL AND WHERE

Plant selection is extremely important if the landscape design is to be successful. Of the many factors to consider when choosing plants, two are most important — size and site suitability. During most of its life, a plant must be of a size suitable for a location. Site suitability means that a plant adapts its growth based on where it is planted.

Function, color, texture, shape, bloom date, rate of growth, and how well the plant relates to other elements of the design are additional important considerations. In recent years, special uses (e.g., theme gardens or patios) or adaptations (e.g., native plants or xeriscape) have become more popular. See the listing on the next page for a summary of plant uses and characteristics, as well as site considerations. See chapter 16 for landscape-planning guidelines.

The following landscape considerations apply specifically to woody plants:

Function

Choose woody plants with a specific function in mind, which may be as simple as providing shade. Some functions include the following:

Firewise landscapes. Landscaping for fire prevention (firescaping) is particularly important for suburban and rural locations in dry areas near hillsides or in narrow canyons surrounded by thick stands of trees and brushy open spaces. For a firewise landscape, clear brush from within 30–400 feet that resist fire or have low levels of oil or resin. Plants should have foliage with a high moisture content or low brush and litter potential. Avoid designs that place plants of different heights in the form of a **fire ladder**. Fire ladders provide a continuous fuel supply from the ground up to the plant canopy.

Screening and barriers. Windbreaks, shelterbelts, woody plant borders, and screens are all made up of rows of woody plants of various shapes and sizes. Besides providing beauty, they reduce wind velocity, capture snow, stop erosion, and shelter wildlife. They also provide protection from unsightly views, disturbing sounds, dust, and, to some extent, atmospheric pollutants. The right sequence of woody shrubs and trees reduces high winds around the home, farmstead, park, or recreation area, while permitting breezes to enter.

PLANT AND SITE CHARACTERISTICS TO CONSIDER WHEN SELECTING WOODY LANDSCAPE PLANTS

Plant Uses

- Attract birds or other wildlife
- Attract butterflies or hummingbirds
- Bonsai
- Borders
- Container or patio plants
- Edible parts or fruits
- Espalier
- Fast growth
- Foundation plantings
- Ground cover
- Native plants
- Rock gardens
- Screen or windbreak
- Shade
- Variety of specimens
- Vines for fences or trellises
- Vines to cling to stone or brick
- Understory for woodland setting
- Weeping form

Plant Characteristics

- Colored summer foliage
- Columnar, pyramidal, or globe shape
- Decorative fruits and berries
- Decorative or interesting bark
- Fragrant flowers
- Good fall color
- Multiple trunks
- Ornamental seedpods
- Showy flowers

Site Characteristics

- Acidic soil
- Alkaline soil
- Arid sites
- Dry or sandy soil
- Heavy clay soil
- Saline soil
- Shady areas
- Low-maintenance areas
- Wet sites
- Windy areas

Plant screens and barriers consist of one to eight rows of trees and shrubs. Where space permits, several rows of shrubs and trees of various sizes and habits, both deciduous and evergreen, can be used. To serve as a windbreak, the planting should be at a right angle to prevailing winds. Where drifting snow is a problem, the last row of the planting should be at least 60 feet from the home. Careful attention to the design of site entries and exits will prevent snow or soil from drifting onto access routes. Windbreaks must be carefully maintained to be effective and must be kept weeded, mulched, or cultivated.

Energy efficiency. Trees can reduce utility bills and improve the comfort of your home. In summer, trees on the southern and western sides of structures can block hot sunlight, thereby reducing the need for air conditioning. In winter, these same trees — if they are **deciduous** (lack leaves in winter) — allow the sun's rays through to warm your house. Blocking cold winter winds with shelterbelts can also reduce heating expenses, especially in homes with poor insulation or air leaks.

Xeriscape. In a xeriscape, drought-tolerant plants are chosen in order to conserve water. With this approach, all of the plants in a given area must have the same water-use requirements to obtain maximum irrigation efficiency.

Native plants. Plants naturally growing in our region are becoming increasingly popular in Idaho landscapes. Native plants are adapted to existing climatic conditions and bring a rich diversity of texture and color to home gardens. They often have lower water demands, fewer pest problems, and lower fertilizer needs than non-native landscape plants. For naturalized plantings, native species often are the best selection and they should be the first choice for conservation plantings and ecosystem restoration.

Keep in mind that even native plants need adequate water, especially right after being planted. After plants are established, you can reduce water to those that thrive in the wild with little moisture. The goal is to duplicate the growing conditions of the plant's natural habitat.

When using native plants, purchase them from a reputable nursery rather than collecting them from the wild. Wild collection puts pressure on wild plant

communities and introduces diseases and insects found in the wild to your yard. The one exception to this rule is rescuing or salvaging plants that are facing destruction by construction.

To have well-adapted native plants, use plants propagated from those growing as close to your landscape as possible. This step will also help prevent degradation of the gene pool of local native plant populations.

Growth Characteristics

Growth characteristics of woody plants influence their ability to fulfill a specific function in the landscape.

Exposure. Select woody plants according to their preferred exposure in the landscape. Plants may be labeled (1) full sun/partial shade, (2) partial sun/full shade, or (3) shade. Check the plant species in several references to learn the range of exposures suitable for a plant. Some species can grow under many conditions, but specific cultivars may tolerate only one type of exposure.

Growth rate. Woody plants are designated as slow, medium, or fast growers. The rate of growth refers to vertical increase unless specified differently.

Growth habit. Woody plants can grow prostrate, horizontal, or upright. They can be dwarf or standard in size. Growth shapes include round, globe, vase-shape, pyramidal, and columnar (Figure 1). Some cultivars are selected for weeping or contorted forms. Plant propagators select these growth habits and plant shapes for artistic, space-saving, or landscape purposes.

Foliage density. Most coniferous evergreens and some deciduous trees and shrubs have very dense foliage; thus, their shadows form dense shade, affecting growing conditions beneath the tree. Trees with dense foliage are very effective at blocking unpleasant views. Most deciduous trees create filtered shade and distant views can be glimpsed through their foliage.

Crown size and height. Knowing the approximate size of trees, shrubs, and ground covers at maturity allows the landscaper to plant them where they can develop to their full extent. Plant descriptions state general height and spread (width) of a plant, based on average growing conditions. However, mature height and spread are greatly influenced by the

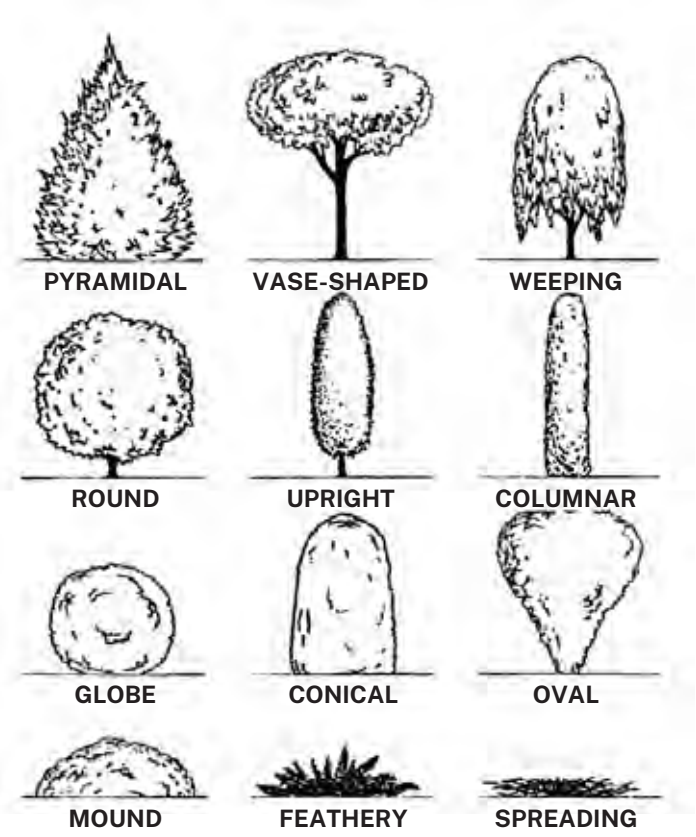

Figure 1. Plant growth habits and their resulting shapes.

length of the growing season, temperature, light, water, soil type, fertility, and other factors. Variation in these factors makes predicting the exact mature size of a plant very difficult. Be sure to compare the mature height listed on the retail sales tag or in reference books with the actual height of plants growing in your area.

Trees, shrubs, and ground covers can be categorized by height into the following groups: large trees (50 feet and over), medium trees (25–50 feet), small trees (under 25 feet), large shrubs (8 feet and over), medium shrubs (5–8 feet), small shrubs (3–5 feet), very small shrubs (under 3 feet), tall ground covers (under 2 feet), and short ground covers (under 1 foot).

Longevity. Short-lived trees and shrubs often grow quickly and provide height and bulk in a short period of time. They may be susceptible to pests and weather-related problems, however. Long-lived species have strong trunks and sturdy, wide angles of branch attachment. They tend to tolerate winter storms, pests, and human damage.

Hardiness zones. Select plants adapted to your climatic zone. Several types of hardiness zone maps can be found in references and on the internet.

The most common is the map developed by the United States Department of Agriculture (USDA) (see Figure 1, chapter 16 for Idaho USDA hardiness zones). The USDA hardiness zone map is revised from time to time. The latest revision was completed in early 2012. Other maps include the Arnold Arboretum Hardiness Zones, the Sunset Western Garden Book Climate Zones, and the heat zone map of the American Horticultural Society.

Whichever map you use, the zone concept is a useful tool that can provide an idea of how well adapted a plant is to your climate. When choosing woody plants that will be long-lived, dominant features of your landscape, choose plants that tolerate extreme climatic events. To be safe, choose only woody plants adapted to one zone colder than your zone.

Salt tolerance. Salt accumulation plays an important role in woody plant growth and survival. Too much salt in the soil interferes with a plant's ability to take up water, causing leaf burn and decline. Even salt-tolerant plants will fail to grow where salt levels are high. Plants native to a region have adapted to existing salt conditions in the local soil.

Several sources are responsible for contributing salts to the soil. In arid regions, soluble salts accumulate at the depth to which soil moisture soaks each season. These salts can be brought to the surface with irrigation. Also, if water sources contain high levels of salt, woody plants can be injured. Salt used for winter ice removal on roads can also cause problems.

Ornamental Characteristics

Ornamental characteristics of a plant, such as flowering, fragrance, foliage color, foliage texture, etc., must be considered by gardeners and landscapers during the selection process (see listing page 3). Although these characteristics are important, plants must first be selected based on their adaptation to a site. A plant that is growing poorly due to its inability to adapt to a site will most likely have poor flowers, poor foliage color, etc.

The style of the garden needs to be considered as well. Whether the garden is cottage, Mediterranean, tropical, oriental, formal, artistic, avant-garde, rustic, naturalized, or native plays a key role in the types of woody plants selected. Finally, how the garden will be used and maintained should also guide design and plant decisions.

Plants that accent, define boundaries, and/or are a special feature in the landscape must be selected with specific goals in mind. Numerous landscaping books, computer programs, and publications can assist in the plant selection process (see Further Reading and Resources at the end of this chapter). More on arranging the form, shape, and space of woody plants is covered in chapters 16 and 17.

Genetic Adaptability

Plant hardiness is genetically determined. The genetic makeup of plants enables them to grow and thrive under certain environmental conditions and completely fail in others. Therefore, **plant provenance**, the area where plants were collected before propagation, influences their ability to adapt to new locations and climates.

Many plants are adapted across several climatic areas or hardiness zones. However, for native plants that are propagated from seeds, plants from more southern seed sources are generally less hardy than those propagated from northern seed sources. For example, red maple, *Acer rubrum*, is a native tree that grows from Florida to Canada. Trees grown from a southern seed source will be less hardy than those grown from a northern source. The same might be said for plants grown on the East Coast and then planted in the West. Plant adaptability is often called **plasticity** among professional horticulturists and should be considered when selecting woody landscape plants.

Site Considerations

Complete a landscape site analysis. This analysis should include climate, soil type, water availability, hardscapes (nonplant elements such as sidewalks, patios, decks, pools, etc.), utility locations, **aspect** (direction the landscape site faces), access, etc. Landscape site analysis is covered in chapter 16.

When choosing plants, various types of insect and disease pests (bronze birch borer, Dutch elm disease, etc.) must also be considered. In order to minimize maintenance and the need for pest control, selecting the right plant for the existing conditions is essential. Even features such as dropped fruit, seedpods, or resulting seedlings must be considered.

If your soil is poorly drained, select plants adapted to wet soil conditions. Improve surface drainage by changing the grade or trenching. Root-zone aeration

can help prevent puddle formation and runoff. If simple **aeration** (poking holes at regular intervals) fails to improve soil drainage, drill holes 6–18 inches deep before planting and backfill them with sand or pea gravel. This procedure is called **vertical mulching**. In extreme cases, install drain tiles to carry excess water away from the site.

Getting Started With Woody Plants

As discussed above, the planning stage should include finding woody plant species that will grow in your area and will serve your landscape needs. Make a scale drawing of your site to provide a basic plan that you can use and update. Since trees and shrubs are essential elements of this plan, choose and buy them wisely and then plant them properly so you can have years of pleasure.

PURCHASING WOODY PLANTS

Plants can be purchased from local garden centers, retail outlets that seasonally bring in wholesale nursery stock for resale, mail-order companies, farmers markets, nursery cooperatives, or at special plant sales sponsored by service or gardening organizations. Select only vigorously growing plants that have a healthy appearance and are correctly labeled. Inspect all plants for insects, diseases, or poor growth structure before you purchase them or right after they arrive (if mail ordered). If a plant is grafted, check the graft union. Purchasing healthy, pest-free plants will allow you to avoid having to treat your plants or quarantine them before planting them into your landscape. The goal is to avoid introducing new pests or problems into your landscape.

Beware of "good deals" at the end of the summer, for these plants may be stressed or root-bound. If gardening friends offer you plants that fail to fit your landscape plan, are in poor health, or might become invasive, have the courage to decline their offer.

Local retail garden center personnel know the planting dates for your area and have experience with species and cultivars suited to local needs, as well as with common problems in your area. They have selected plants that are adapted to your climatic conditions and soils. In many cases, local garden stores are willing to special-order plants. In addition, they often guarantee the plants they sell. If you personally select your plants, have your plan and plant list in hand when you visit the garden center. Be open to new ideas and plants suggested by plant professionals.

Plants can also be purchased from discount, hardware, drug, convenience, grocery, or produce stores. However, plants at these stores may not be appropriate for your landscape. Prices are often lower due to volume discounts, but the species may not be adapted to your area, and the plants' condition may be poor due to a lack of proper maintenance.

Mail order is another alternative for purchasing plants. Check catalogs carefully to make sure the plants meet all the criteria in your landscape plan. Mail-order plants will be bare-root or container-grown. They may be small, but if shipped correctly and planted promptly, these plants generally survive and grow well. When ordering over the phone or by mail order, ask about returning plants if their quality is low. Many mail-order nurseries guarantee the plants they sell.

Service organizations, garden clubs, schools, and public agencies occasionally hold special plant sales. These sales provide great opportunities to obtain rare or prized woody plant species from local sources.

PLANTING WOODY SHRUBS AND TREES

The techniques required for successful transplanting of woody plants depend on the kind of plant; its age and size; whether it is dormant or growing; its nutritional status; whether it is nursery-grown, growing around the home, or a native plant; whether it is adapted to the selected site; and the site conditions and climate of the area. For more information, see chapter 17.

Newly transplanted trees may be staked if necessary. The main reasons to stake a tree are to hold its canopy upright if the trunk is weak or to prevent the root system from moving and breaking roots.

The goal for staking a tree is to allow the trunk to flex while the roots are held in place. Trunks grow strengthening "reaction wood" when they move back and forth in the wind; thus, be sure the trunk is free to move in the wind but held securely enough to prevent the root system from moving. Secure the tree to two or three stakes placed at least 12–18 inches from the trunk (Figure 2). Use broad, smooth

Figure 2. Proper staking of a tree involves attaching two or three stakes as low as possible on the trunk. The objective is to hold the tree roots in place yet allow the trunk to flex in the wind. Notice the broad strap material connecting the trunk to the stakes. Photo by Kaitlin Moroney.

material, such as nylon straps, to attach the tree to the stakes, since this type of material will not damage the trunk. Tie the trunk as low as possible to hold the tree upright on a calm day. Remove staking materials as soon as possible and no later than 1 year after planting.

FIRST-YEAR CARE

The first year in a new site is critical for transplanted woody plants. Survival is determined by care and conditions and a good start helps a landscape planting fill in quickly.

Water new plants to a depth of at least 2 feet during each irrigation. Light, shallow watering fails to provide enough water to develop a wide, deep root system, and it may promote accumulations of harmful salts. The amount of water needed to fill the soil to a depth of 2 feet depends on the soil type; sandy soil holds less water than clay soil.

Soil type and drainage determine the frequency of irrigation, but, generally, watering is required every 5–7 days. Soil should drain and dry between irrigation cycles to maintain adequate oxygen levels in the root zone and to reduce the possibility of development

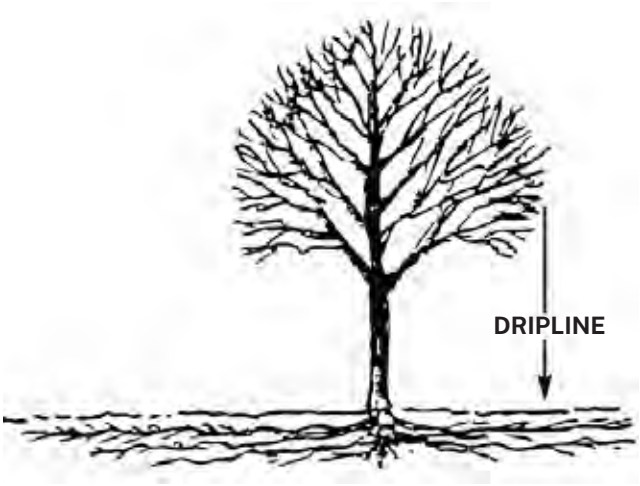

Figure 3. Dripline on a deciduous tree.

of root rot diseases. New plants will wilt in saturated soil due to a lack of oxygen around the roots.

Fertilizing woody plants during the first growing season may be unnecessary and can be harmful. Excess fertilizer salts in the root zone damages the limited root system of a newly installed plant. Plants generally need a season to establish a vigorous root system before fertilizer promotes more foliage growth.

In general, plants with fibrous roots and root hairs (container-grown and balled-and-burlapped plants) could benefit from a light fertilizer application, as their root hairs can absorb the minerals and avoid wasting nutrients. Plants that lack root hairs at planting time (bare-root plants) may be unable to absorb nutrients from fertilizer applied to the soil. Nutrients may remain in the root zone or **leach** (wash) away, wasting minerals and money. Therefore, use fertilizers carefully at planting time. If using a fertilizer, be sure the product is labeled for use on newly transplanted shrubs or trees.

You can protect newly planted shrubs and trees from the wind by erecting a barrier of burlap or other material. Wrapping plants with narrow, upright branches, such as arborvitae, in winter can prevent damage caused by snow accumulation. Avoid using plastic for wrapping because temperatures get too hot under the film.

For species sensitive to cold temperatures, bury small or horizontal plants in leaves or loose, unfinished compost after the first frost. Keep in mind, however, that burying small, tender plants can

encourage disease development or rodent activity. Therefore, periodically check buried plants during the winter. If you see problems, take appropriate actions to eliminate them.

Maintenance of Woody Landscape Plants

IRRIGATION

Proper watering of woody landscape plants is probably the most important factor to promote plant growth, beauty, and health. For more information on water management, see chapter 7. The amount of water used by a woody plant is determined by species, size, air temperature, relative humidity, wind, and light intensity. A hot, sunny, dry, windy day can cause a lot of water to be transpired by a large tree. Many sites in Idaho have just such conditions.

The water-absorbing roots of trees (feeder roots) grow mostly in the top 12–18 inches of soil. Their distribution extends well beyond the dripline (Figure 3). Apply water over the entire absorbing zone. If practical, expand water-holding basins around the base of plants on a yearly basis to accommodate the previous year's growth.

Irrigate to wet the soil to a depth of at least 2 feet. The amount of water needed to fill this soil depth depends on the soil type; sandy soil holds less water than clay soil.

As with newly planted trees, avoid keeping the root zone saturated in order to allow proper root aeration. Avoid shallow, frequent irrigations because this practice encourages shallow and limited root development.

Irrigation Methods

Flood irrigation provides an infrequent, deep soaking. You can achieve the same result on a small scale by flooding the basin around the base of a tree or shrub using a bubbler hose attachment. This type of watering is the most efficient method of irrigation for isolated plants.

Sprinklers are the most common method of irrigation. Be sure to apply enough water to soak the root zone of trees and shrubs. *The amount of water needed for the shallow roots of a lawn will not be enough for trees and shrubs.* Sprinkling the foliage of trees and shrubs can increase the potential for some diseases. Minimize this risk by watering early in the morning (by 10 a.m.) so the plant can dry during the day. Early morning watering also improves watering efficiency.

Drip irrigation systems are extremely efficient and provide a slow source of water. They work better with heavy soil than with sandy soil. Apply water away from the trunk and in the area of water-absorbing roots. As the plants grow, update drip systems by adding more lines or emitters to provide enough water for the larger plant and root system.

Winter Water Management

Where winters are cold and the ground freezes, take special care to make sure woody plants enter the winter completely dormant and with an ample supply of subsurface water to get through the winter. Gradually withhold water after mid-September by applying less water or irrigating less frequently for 4–6 weeks. Withholding water slows plant growth and helps the plant enter a dormant state.

Sometime just before the first hard freeze (often October 15–November 1), irrigate the soil thoroughly. Add enough water to wet the root zone down to about 18 inches. Most of this moisture will be available to the plant roots beneath the frozen layer of soil during the winter. Fall watering is particularly important for evergreens, due to the amount of water that needles and leaves can lose on a sunny winter day.

MULCHING

The benefits of a mulched area around trees and shrubs are five-fold: (1) elimination of competition from weeds and grasses, (2) conservation of soil moisture, (3) moderation of soil temperature, (4) protection of plants from lawn mower and string trimmer damage, and (5) growth of a more extensive root system.

Good mulches include coarse compost, bark chips, rocks, or gravel. Use of very fine or less permeable mulches, such as sawdust, may encourage shallow rooting.

The mulch layer should be 2–3 inches deep and can extend to the dripline of the tree. Keep mulch away from the plant's trunk or stems to reduce the possibility of crown rot or animal burrowing. Installing permeable landscaping fabric beneath the mulch will help control weeds. Avoid using nonperforated plastic since it reduces water and air infiltration in the root zone.

SYMBIOTIC RELATIONSHIPS

Roots of many trees and shrubs form symbiotic relationships with fungi or bacteria. Symbiotic relationships are those in which both parties benefit. For example, mycorrhizal fungi live around and sometimes in plant roots, obtaining carbohydrates, vitamins, and other organic compounds from the plant. The soil in the root zone area, known as the **rhizosphere**, is more hospitable to nutrient absorption by plant roots because of the fungi's presence. Mycorrhizal fungi may enhance a plant's tolerance of environmental extremes and its resistance to or tolerance for pathogens. Many of the "mushrooms" seen in the landscape at some distance from trees are fruiting bodies of mycorrhizal fungi.

Commercial products containing a mixture of mycorrhizal fungi can be mixed with the soil when planting trees and shrubs. Although mycorrhizal spores are found in most soils, preliminary studies indicated that commercial products may speed the establishment of a symbiotic relationship. Be aware, however, that most research has shown that these products have had limited success inoculating roots of woody plants in landscape situations. More research is needed to prove the value of mycorrhizal fungi inoculations.

On some woody plants (typically species in the legume family), specific bacteria induce formation of nitrogen-fixing root nodules. Black locust, alder, ceanothus, and Russian olive, for example, are able to transform atmospheric nitrogen into a form that is usable for their own growth and for that of nearby plants. This capability enables these species to grow on nitrogen-poor sites.

FERTILIZING

Woody plants require essential elements to function. However, too much nitrogen can promote excess growth that requires more pruning and water and increases pest problems. On coniferous evergreens, a "spurt" of growth in reaction to fertilizer can create whorls of branches farther apart at the top of shrubs or trees and on the branch tips, detracting from the symmetry of the plant. If a woody plant is healthy, lacks nutrient deficiency symptoms, and grows at a satisfactory rate, it probably needs little, if any, fertilizer.

Pruning

THE BASICS

In the home landscape, trees and shrubs usually have ample light and space, so they produce many branches and grow to a maximum size. Proper pruning shapes or directs growth of plants into appropriate and beautiful forms, while maintaining and augmenting plant health and function.

REASONS FOR PRUNING

Plants are pruned for a number of specific reasons. Training young trees and shrubs (in other words, directing plant growth) to create attractive shapes and a strong structure is a good reason to prune. Prune mature plants to remove dead, diseased, hazardous, or unsightly branches. Pruning to maintain a central leader on a tree is sometimes necessary, as is removal of branches that interfere with activities and structures. Pruning can enhance flowering and fruiting. It can also open up a tree or shrub for less wind resistance and better light penetration. Shrubs may need pruning to create a fuller look or to maintain a special shape or form, such as for hedges.

Pruning plants to limit their size (height and width) is a legitimate reason to prune, but only minor amounts of pruning should be used for this purpose. A woody plant too large for its growing space cannot be made small by pruning! Drastic pruning — removing large amounts of branches or severely reducing the heights of tall trunks — results only in temporary size reduction, can be expensive, and is damaging to the plant.

Figure 4. Tools used to prune woody plants include (a) bypass hand shears, (b) bypass loppers, and (c) handsaws. Photo by Robert Tripepi.

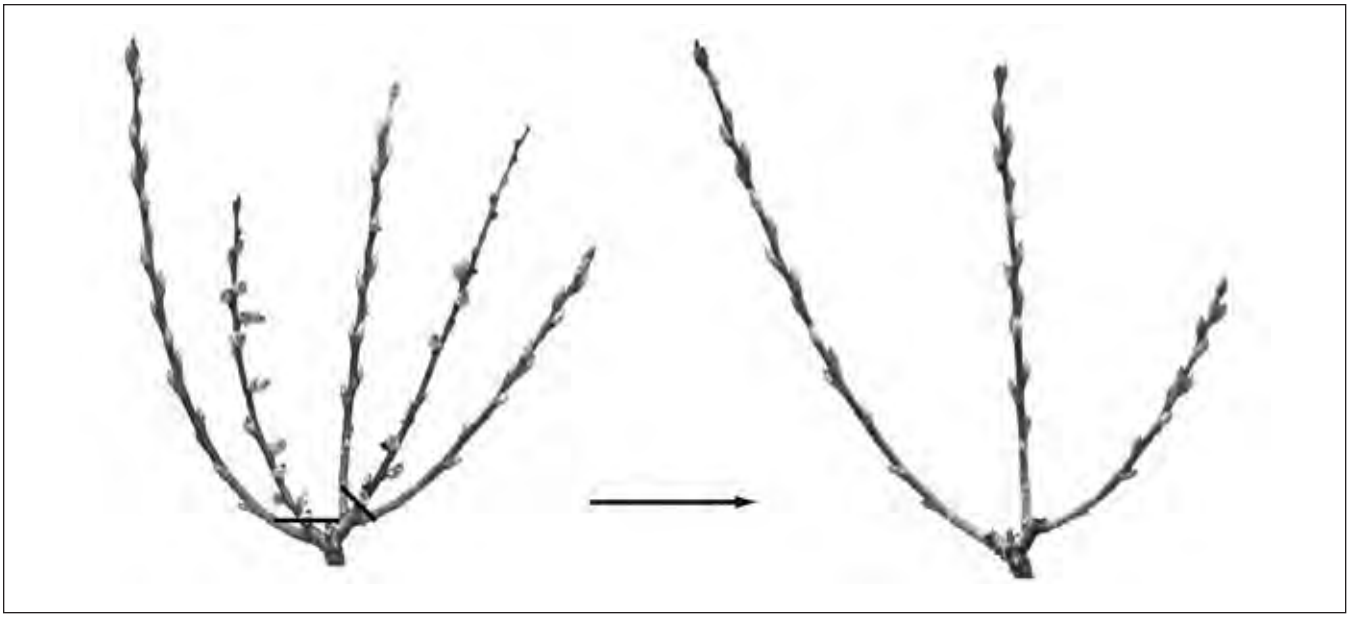

Figure 5. Thinning cuts on willow. Note that the stems are cut at their point of origin on a larger stem. Photo by Robert Tripepi.

Plants pruned severely to reduce their size will be badly misshapen when they regrow and new branches may be weakly attached and break during wind stress or under snow loads. The best solution is to remove the oversized plant and replace it with one whose mature size is more suited to the growing space.

Pruning Tools

Proper tools are essential for satisfactory pruning (Figure 4). If possible, test a tool before you buy it to ensure it suits your specific needs. As with most things, higher-quality tools often cost more than cheap tools.

The choice of which tool to use depends largely on the size of the branches to be pruned and the amount of pruning to be completed. Hand pruners (pruning shears) are usually used to cut branches one-half inch or less in diameter. Loppers can be used to cut branches from one-half inch to 1 inch in diameter. A pruning saw is used to cut branches 1 inch or larger in diameter.

If cutting a branch with hand shears is difficult, avoid twisting or bending the branch or tool; instead, use a larger tool, such as loppers. Some loppers have a ratchet mechanism, enabling branches larger than 1 inch in diameter to be cut easily. However, even though the branch cuts easily, these loppers often crush branch tissues in the cut area. Therefore, using a pruning saw on branches larger than 1 inch in diameter often results in a better cut and less damage to the plant tissues.

Figure 6. Heading cut made close to a bud on a branch. Note the close-up view of the angled cut above the bud (far right). Photo by Robert Tripepi.

Types of Pruning Cuts

Two types of basic pruning cuts are thinning cuts and heading cuts (Figures 5 and 6). Keep in mind, however, that several types of heading cuts (for example, shearing or stubbing) can be made, and two types of thinning cuts can be used.

Thinning cuts. Thinning cuts are often the preferred type of pruning cut for landscape trees and shrubs. One type of thinning cut removes a branch or stem at its point of origin. This type of cut opens up a shrub or tree and reduces the weight of limbs. These

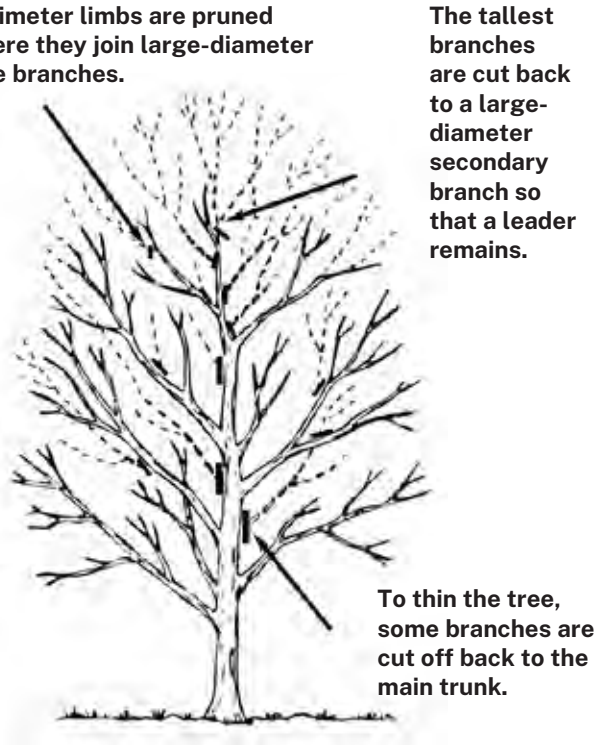

Figure 7. Drop-crotch pruning reduces the size of a tree without inducing vigorous new growth. Source: Colt, W.M., R.R. Tripepi, R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. University of Idaho Extension Bulletin 819.

cuts avoid stimulating new growth and help retain the natural shape of the plant. They are made at a location on the stem where wounds can be grown over quickly, thus preventing decay fungi from spreading in the wound.

The second type of thinning cut is called drop-crotch pruning, which reduces the overall height of a plant or length of a limb (Figure 7). This type of pruning removes a branch back to a lateral branch large enough to assume the terminal role.

This means that the remaining lateral branch can exert apical dominance, i.e., it can suppress growth below the cut, thus preventing latent buds from growing farther back on the branch. The lateral branch should be at least one-third the size of the branch removed. In other words, to remove a branch 6 inches in diameter, cut it back to a branch that is at least 2 inches in diameter.

Heading cuts. A heading cut removes a branch to a stub, a small bud, or a lateral branch not large enough to assume the terminal role. This type of cut usually induces branching and bushiness (increased branch density) below the cut. Heading cuts are commonly used for fruit trees, but often are inappropriate for woody landscape specimens, especially trees. Numerous vigorous upright shoots can arise below the cut, especially on larger branches, altering the tree's natural form.

Topping. Topping is a type of heading cut that involves cutting all major vertical trunks or branches back with heading cuts. This practice forms large stubs at the ends of the trunks. Topping a tree is an unacceptable pruning practice. It results in an ugly, deformed tree with many branches that often are weakly attached. These trees often become infected with decay organisms and are highly susceptible to insects and diseases. Within a few years, a topped tree often grows back to its original height because of bushy, invigorated growth, but it will be poorly shaped, as well as hazardous, due to its many weakly attached branches. The only instance in which topping is acceptable is for a storm-damaged tree.

Topping a coniferous tree results in multiple leaders or a flat top — in any case, the natural shape of the tree is destroyed. The older the tree is at topping, the less likely a lateral branch near the pruning cut will become a new leader. Although the tree may look healthy, research has shown that serious decay often develops at the wound site. This decay moves down the trunk, creating a hazardous tree.

Timing of Pruning

The timing for pruning woody plants is important and depends on the type of plant and the purpose of pruning. You can do light pruning (removing small numbers or sizes of branches) or remove deadwood at any time of the year.

Except for pines, pruning coniferous evergreens during the dormant season can stimulate regrowth. To stimulate vigorous spring growth on fir, Douglas fir, and spruce, prune these plants in late winter, when the plants are dormant. Pruning cuts will be covered by new growth later in spring, making the plant look more natural.

On these species, you can also prune off part of the new growth while it is still growing. Pruning at this time of the year will reduce the length of new growth and encourage branching. However, it usually stunts plant growth. Pruning after the annual flush of spring growth will maintain size and preserve atypical (clipped) forms. On these species, you can also make heading cuts back to visible buds or light thinning cuts at any time.

EXAMPLES OF FLOWERING SHRUBS THAT BLOOM IN SPRING (ON OLD WOOD) OR SUMMER/FALL (ON NEW WOOD)

Spring-Flowering Shrubs

- Azaleas, deciduous and evergreen (*Rhododendron* spp.)
- Barberry, deciduous and evergreen (*Berberis* spp.)
- Beauty bush (*Kolkwitzia amabilis*)
- Brooms (*Cytisus, Genista* spp.)
- Cherry laurel (*Prunus laurocerasus*)
- Chokeberry (*Aronia arbutifolia*)
- *Cotoneaster* spp.
- *Euonymus* spp.
- *Daphne* spp.
- Dogwood, shrubby (*Cornus* spp.)
- Flowering almond (*Prunus triloba*)
- Flowering plum (*Prunus cistena*)
- Flowering quince (*Chaenomeles* spp.)
- *Forsythia* spp.
- Heather (*Erica* spp.)
- Holly (*Ilex* spp.)
- Honeysuckle (*Lonicera* spp.)
- *Kerria* spp.
- Lilac (*Syringa* spp.)
- Magnolia (*Magnolia* spp.)
- Mock orange (*Philadelphus* spp.)
- Mountain laurel (*Kalmia latifolia*)
- Oregon grape (*Mahonia aquifolium*)
- *Pieris* spp.
- Privet (*Ligustrum* spp.)
- Pussy willow (*Salix* spp.)
- *Pyracantha* spp.
- Serviceberry (*Amelanchier* spp.)
- Siberian pea shrub (*Caragana arborescens*)
- *Spiraea* spp. (white-flowering species)
- *Viburnum* spp.
- *Weigela* spp.
- Witch hazel (*Hamamelis virginiana*)

Summer/Fall-Flowering Shrubs

- Butterfly bush (*Buddleia davidii*)
- Heather (*Calluna* spp.)
- Heavenly bamboo (*Nandina domestica*)

CONTINUED

- *Hydrangea* spp.
- *Potentilla fruticosa*
- Roses, shrubby (*Rosa* spp.)
- Rose of Sharon (*Hibiscus syriacus*)
- *Spiraea* spp. (pink-flowering types)
- Saint-John's-wort (*Hypericum* spp.)
- *Tamarix* spp.

Carefully observe when flowers bloom for nonlisted species.

Pine species are pruned at a specific time of the year. Pines form buds only at the tips of branches. If new growth (candle) is pruned after the growth flush is completed and the terminal bud is well formed at the end of the branch, new buds will fail to form and regrowth is impossible. Prune or pinch candles when their new needles have expanded to about half the length of the mature needles on the previous year's branches. Pruning candles at this time allows buds to form near the cut-branch surface for the following year and allows the new growth to be more compact.

Some plants, such as maples, walnuts, birches, and grapes, may bleed when pruned just before or during sap flow. Although unsightly, this does no harm to the plant and will stop as the season progresses.

Some plants, such as *Potentilla* sp., bloom on the current season's growth (new wood). Prune these species during the dormant period, usually in late winter or early spring. Wait until the coldest part of the winter has passed, but prune before buds swell.

Other plants, such as lilac and forsythia, bloom on the previous year's wood. To avoid reducing the number of flowers on these plants, prune these species in early summer, within about two months after the flowers fade. On these species, flower buds form in late summer and early fall. Thus, winter pruning decreases the number of flowers the following spring by removing branches containing flower buds.

The listing on this page indicates the bloom time of some flowering shrubs. For other species, check reference books. If you are unable to find a reference for your plant, use flowering date of the plant as a rough estimate. For most areas of Idaho, plants that

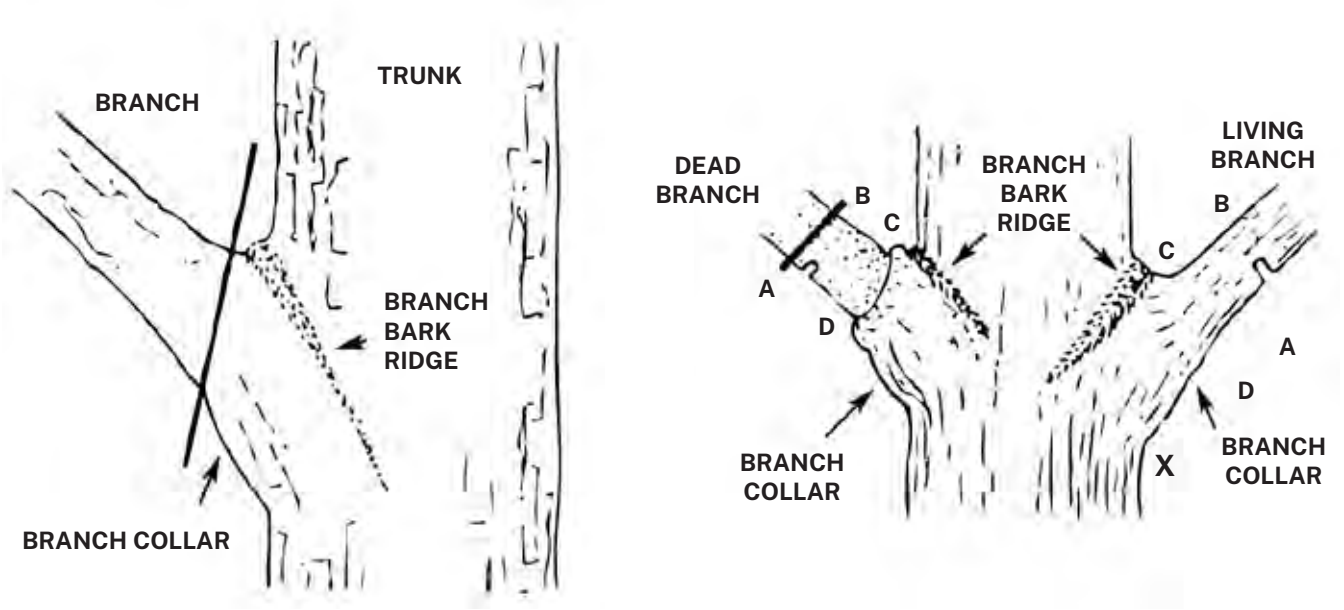

Figure 8. Proper location for thinning cuts. Source: Colt, W.M., R.R. Tripepi, and R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. University of Idaho Extension Bulletin 819.

bloom before June 1 formed flowers the previous year on old wood. Those that bloom after June 1 form flowers on new growth. Keep in mind that this is only a rough guideline.

Also keep in mind that on any plant, pruning after flowering will remove fruits that would have formed.

Summer pruning, completed after spring growth has stopped, slows the development of a plant or branch. Plant growth is slowed because of reduced photosynthetic capacity (fewer leaves). Reduced photosynthesis means that less food is manufactured and sent to the roots for their development and for next year's growth. Prune in the summer cautiously, as summer pruning can weaken the tree or shrub, perhaps severely.

Avoid pruning in late summer. Any new growth stimulated by late-summer pruning can be susceptible to frost damage if it fails to harden before cold temperatures affect the plant tissues. Pruning can be completed in fall after plants are well on their way to becoming dormant — late September at the earliest.

The threat of introducing diseases into pruning wounds is higher in the fall than in winter since more fungal spores are in the air in the fall. Pruning in late fall (late November) reduces the potential for fungal spores, particularly those of wood-rotting fungi, to contact pruning cuts. Avoid pruning frozen branches or stems (woody tissues) since the wood may crack, making the wound larger than desired.

Where to Make Pruning Cuts

The location of a pruning cut depends on whether it is a heading cut or a thinning cut. Make heading cuts about one-quarter inch above a bud or small lateral branch and slant the cut away from the bud or branch (Figure 6). Heading cuts made to the middle of a branch and not to a node will often induce a latent bud to grow from a node below the pruning cut. However, these cuts leave a stub on the branch. Avoid this practice, since these stubs are unsightly and may serve as an entry point for pests.

The base of a branch contains important tissues that help a plant grow over a pruning wound and prevent decay-causing microorganisms from spreading to the interior tissues of the stem or trunk. These important tissues are located between the bark ridge and the branch collar, collectively known as the **branch shoulder**. The **bark ridge** is usually a rough patch of bark on the stem or trunk located just above the lateral branch that is being removed. On some shrubs or trees, however, the bark ridge may be thin and barely discernible. The **branch collar** is a slightly swollen area on the lower side of the lateral branch near its point of attachment.

When removing a branch at its point of origin (thinning cut), avoid wounding tissues in the branch shoulder area. Whether pruning live or dead branches, make pruning cuts outside the branch shoulder area (Figure 8). For both types of branches,

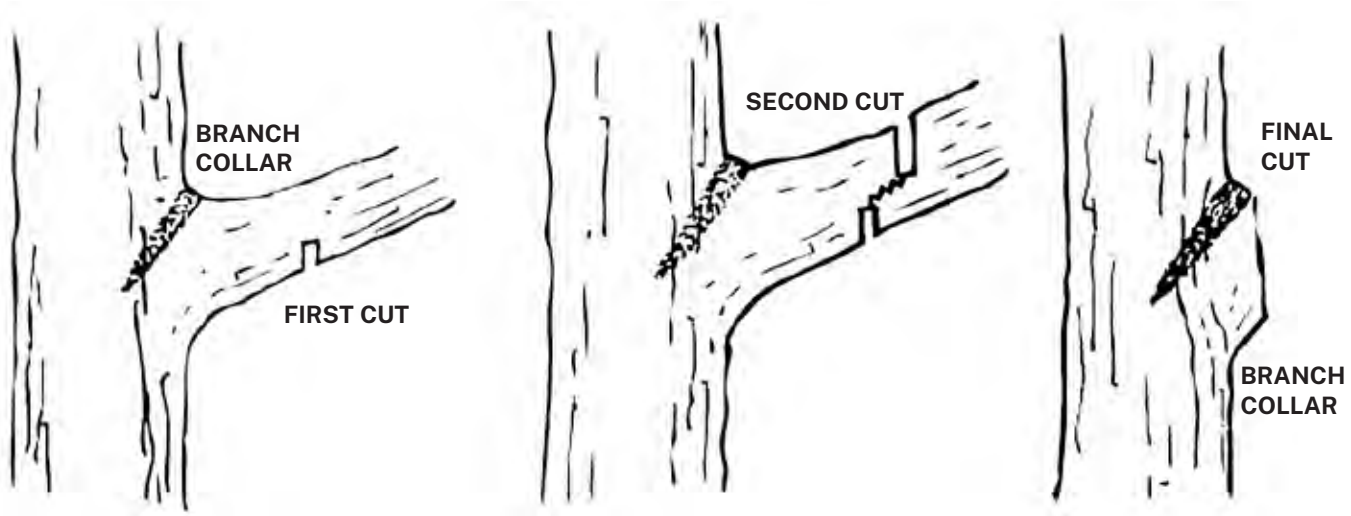

Figure 9. Three cuts are necessary to remove large branches or limbs that are difficult to hold by hand. Source: Colt, W.M., R.R. Tripepi, and R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. University of Idaho Extension Bulletin 819.

the final cut should be from point C to point D (Figure 8), since cutting in this location is outside the bark ridge and branch collar. Avoid cutting from point C to point X. This type of cut is considered a **flush cut**, which can allow decay-causing microorganisms to enter the interior tissues of the stem or trunk. Also, pruning wounds are covered by new growth more slowly when flush cuts are made. Be sure to hold the branch while cutting to prevent lower stem tissue from tearing. Tearing of stem or branch tissue causes a large wound that is covered slowly by new growth.

Branches larger than 2 inches in diameter may be too heavy to hold. Even when a smaller branch is pruned, its location may make holding the branch impossible while making the pruning cut. The likely result would be bark stripping. In these situations, use a three-cut method to remove the branches (Figure 9). Make the first cut on the underside of the branch about 6–12 inches from the branch crotch. An **undercut** is used to prevent the bark from stripping or tearing due to lack of support when the cut is made. Cut about one-quarter of the way through the limb or until just before the saw binds due to the limb weight. If the saw blade becomes bound by a heavy limb, you most likely will be unable to lift the limb enough to free the saw blade.

Make the second cut on the top side of the branch, 2–5 inches farther out on the limb from the undercut (Figure 9). Cut down until the branch drops off. Be careful to avoid being hit by the branch. It may move sideways as the limb cracks under its own weight until the crack reaches the initial undercut.

Make the third cut just outside the bark ridge/branch collar area. This final cut removes the stub and allows new tissue to grow quickly over the wound. Be sure to support the remaining stub while making the third cut; otherwise, the bark may tear, making the wound larger. Wound dressings and pruning paints are cosmetic only. Research has shown that pruning paint or wound dressing usually fails to keep insects or diseases out of the pruning wound. They also fail to promote new tissue growth over the cut. In fact, some research indicates that these treatments may inhibit the wound-covering process. Therefore, they generally are considered unneeded and a waste of money.

Special Care When Pruning Coniferous Plants

A latent bud is an inactive bud that will grow following a shock, such as pruning. Latent buds are distributed differently on conifer branches than on deciduous trees, limiting the amount and type of pruning that conifer species can tolerate without being permanently misshapen. See page 19 for information on pruning conifers correctly.

EARLY TRAINING OF TREES AND SHRUBS

Early Training of Deciduous Trees

Trees with good form have a longer life and less structural problems than trees that were allowed to develop a poor framework (scaffolding). By establishing a good framework early, a deciduous

tree, such as a maple, will grow to fill its allotted space and should require minimal annual pruning.

This early pruning is known as training. Training involves directing tree growth into a desired shape and form. It should begin during the tree's second year. Train to create a tree that has a pleasing shape, with branches growing in the right direction for its space. Respect the natural growth habit of the tree when establishing an initial framework of branches.

The mature shape (round, columnar, pyramidal, etc.) should be evident, even in a tree with only five or six branches.

Train the young tree to develop a central leader; strong branch attachment angles; a straight, strong trunk; and a good form. The central leader should be taller than any other branch. When a single leader (trunk) is obvious, remove some of the other branches (by using thinning cuts) to maintain the dominance of this branch.

Sometimes, however, a tree has many laterals that are of similar length. In this case, choose the trunk with the best placement to be the leader and shorten the other lateral branches into a pleasing and appropriate form. When cutting out branches, maintain at least two-thirds of the plant as a live crown, since removing too many branches can damage or severely weaken a tree.

On a mature deciduous tree, scaffold branches, branches that form the permanent structure of a tree, should be 12–18 inches apart. Choose branches that come off in different directions around the tree to create a balanced form and decrease competition for space and light. First remove any crossing and inward-growing branches. Then thin out (remove) selected lateral branches that compete for space and light. In other words, remove one branch if two adjacent branches arise from a trunk directly over one another. Next, eliminate any branches that grow in opposition to the natural form of the tree.

Finally, thin any codominant branches (those that grow out from a single point, forming a Y) to a single branch, keeping the one that is most upright and has the fewest defects in its canopy. Think about what the tree will look like when all of these branches get longer and larger in diameter, particularly branches with the potential to cause problems (rubbing branches, branches with limbs growing toward the center of the plant, etc.). Branches should be directed to grow to an area where they can develop to maturity without pruning. Remember that branches do not move upward as a tree grows in height. If you are hitting your head on a 1-inch diameter branch now, in a few years you will still be hitting your head, but the branch may be 6 inches in diameter! Prune out problem limbs early.

A strong, well-tapered trunk can be developed by keeping some branches (called temporary branches) below the lowest permanent branch on your young tree. They will protect the young bark from sun injury and their foliage will produce carbohydrates that add taper and strength to the trunk. Leave temporary branches in place for 3 or 4 years. Prune them to prevent them from becoming large and vigorous. After 3 or 4 years, remove them a few at a time over the next 2 or 3 years, beginning with the largest ones.

Branches should be strongly attached to the limb from which they arise. Strong branch attachment will allow limbs to tolerate ice, snow, and wind loads better than weakly attached branches and will help prevent the need for expensive pruning corrections later. The best branch angle attachment to the trunk is wide — ideally between 45° and 90° (Figure 10).

When crotch angles are very narrow, bark can become "trapped" or embedded between the two branches as they grow. This situation is known as a

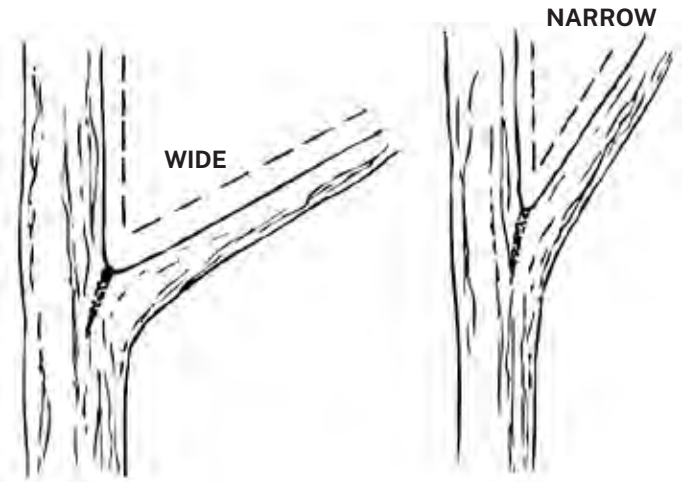

Figure 10. The angle of branch attachment should be wide, ideally between 45° and 90°. Branches with narrow angles of attachment often develop "included" bark, making the branch attachment weak. Source: Colt, W.M., R.R. Tripepi, and R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. University of Idaho Extension Bulletin 819.

bark inclusion. Where the bark is trapped, structural attachment is absent between xylem tissues in the two branches. As both branches become larger, the area of structural integrity (connected xylem tissues) becomes proportionally smaller, making the attachment between the two branches weak.

Encourage a critically placed small branch with a narrow crotch angle to grow to a better angle by placing a stick or narrow board between the branch and the trunk to brace it open. Leave this brace in place until, when removed, the branch stays at the wider angle (Figure 11). Several species of deciduous trees have narrow crotch angles and develop bark inclusions more often than coniferous trees. Avoid planting these species in areas with heavy ice, snow, or wind loads.

As young trees grow, prune to correct structural weaknesses and to remove dead, pest-infested, or broken branches. Remove rubbing branches since they result in wounds, decay, and notches. When choosing between rubbing branches, remove the most damaged branch with the narrowest crotch angle.

Other branches to remove include water sprouts and suckers. Water sprouts are rapidly growing, weakly attached shoots that form on trunks or limbs above the ground or graft union. Suckers are rapidly growing branches that form on roots (belowground) or below the graft union. Both should be removed as soon as possible. Rubbing them off (rather than cutting) is possible when they are very young and helps to keep them from resprouting. If water sprouts or suckers have grown several inches, cut them off as close to the trunk or root as possible. The best way to prevent suckers from sprouting from the cut sucker is to dig into the soil and cut off the sucker where it arises from the root.

Figure 11. Brace narrow-angle branches, bending them to a wider angle from the main trunk, and leave the support in place for at least six months. Photo by Kaitlin Moroney.

Early Training of Coniferous Trees

Training conifers such as spruce, pine, and juniper takes special consideration. Many coniferous trees have pyramidal forms, regular whorls of growth, and tall, straight trunks. Conifers can develop multiple leaders, so maintaining a single central leader is important for developing a properly shaped mature tree. Remove all but one leader by using thinning cuts. Randomly branching conifers should be trained when the plants are young so they will develop attractively to fill their allotted space. Otherwise, coniferous plants need little training — unless the goal is to make a hedge or pruned shape (a topiary plant). See section on pruning coniferous trees and shrubs for more information.

Early Training of Large Shrubs

Some deciduous and broadleaf evergreen shrubs grow to a large size and have permanent scaffold branches. Examples are viburnum and magnolia species. Most coniferous shrubs, such as junipers, have permanent trunks and branches.

Essentially, these plants can be treated like small trees with multiple trunks, so establish their framework as described earlier. Train shrubs when they are young to direct plant growth so that the shrubs are appealing and have good branch structure. Begin pruning as the plant approaches its desired size, rather than after it is oversized.

Early Training of Hedges

A hedge is a row of closely spaced shrubs or trees, usually consisting of one species. Hedges can be grown informally as a row of natural-looking plants or formally with a lot of training and shearing. In both cases, minimize pruning right after planting and during the first year of growth. Training of the hedge will begin the second year after planting.

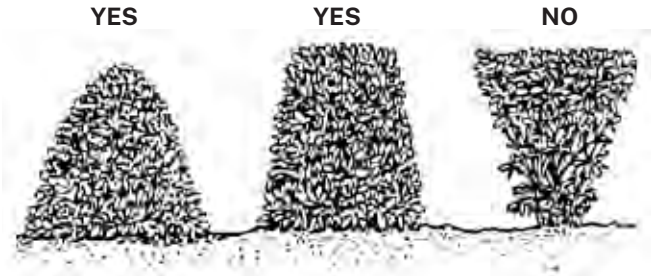

Figure 12. Trim hedges to be wider at the bottom to prevent lower branches from becoming weak and losing foliage.

To produce an informal hedge, during the second year after planting train and prune as with individual plants, striving to keep the plants similar in shape, density, and height. Pay special attention to keeping the foliage dense from the ground up. Train hedges to be wider at the base than at the top to prevent dieback of lower foliage due to inadequate light (Figure 12).

With newly planted deciduous and broadleaf evergreen hedges, induce low, dense branching by heading back the entire plant by as much as half its height the second year after planting (in late winter or early spring). Use the same technique for yew and hemlock plants.

With other new conifer hedges, including spruce, juniper, arborvitae, and false cypress, increase branching by pruning the tips of the new growth as, or just after, it elongates during the second year. Keep in mind that pines are an exception; prune new growth on pine species after the needles on the candles expand to half the length of the mature needles on the plant.

For formal hedges, prune the same as for informal hedges during the second year. In the third year, shear new shoots by one-half to two-thirds of their length every time they grow 6–12 inches. With the exception of pine species, shear conifers whenever growth elongates (it probably will be less than 6 inches long). Avoid pruning after midsummer.

Continue shearing one-half to two-thirds of the new growth during successive years until the hedge reaches the desired width. Then allow the hedge to grow more in height than width until it reaches the desired height. Do this by shearing new growth on the sides shorter (and less frequently) than the shoots on the top.

Early Training of Vines

Train vines according to their growth habit. Vines that are natural clingers support themselves by aerial roots (e.g., English ivy). Boston ivy has small, branched tendrils tipped with adhesive disks to help it attach to a wall or structure. These vines grow on walls and other supports. Twining vines, such as honeysuckle, clematis, Virginia creeper, and wisteria, climb by curling or twining their leaf tendrils, leaf stalks, or stems on some kind of support system. Scramblers and floppers, such as roses, need to be tied to a support system.

Any required support should be in place when planting a vine. Direct (place) or train the branches of the vine in the desired directions.

PRUNING MATURE TREES AND SHRUBS

As woody plants grow, age, and mature, they require maintenance training and pruning.

Mature Deciduous and Broadleaf Evergreen Trees

Inspect mature trees yearly and follow with maintenance pruning if needed. On a tree neglected for many years, never remove more than one-third of the total canopy at one time. Excessive pruning can cause formation of numerous water sprouts. Water sprouts on large branches or trunks are usually weakly attached and can break off. Excessive pruning can also weaken a tree's ability to develop structural strength and good form.

Mature trees are usually large and require specific pruning knowledge and physical skills to complete the various pruning operations. For this reason, hiring a professional tree-pruning company that is insured and bonded may be the best and safest way to be sure mature trees are pruned correctly.

Names for pruning operations on mature trees can vary, but the reasons for pruning remain the same as for any tree. Four typical pruning operations for mature trees are described below.

Cleaning out. This procedure primarily involves removing broken, diseased, dying, or dead branches, as well as those that cross, are weakly attached (including water sprouts and suckers), or of low vigor. These types of branches are removed from trees neglected for years. After these branches

are removed, examine the tree for problems that negatively affect its growth (radial spacing of limbs) or structural strength (angle of branch attachment as well as vertical and radial spacing of limbs).

Raising the crown. This procedure involves removing lower branches from the trunk or lower parts of a tree. As a tree grows, the branch weight increases, causing limbs to bend downward. When training young trees, plan the height of the lowest scaffold branch so that removing large branches will be unnecessary, as such pruning can cause large pruning wounds. If you must remove many lower branches, do so over several years. Leave at least two-thirds of the total canopy volume on the tree.

Crown thinning. This operation involves opening up the tree canopy to permit air movement and deeper light penetration. This procedure will benefit inner leaves and branches. The first branches removed are those described in "Cleaning out" (below left). For scaffold branches too closely spaced vertically or radially, remove the entire branch at its point of attachment to the main trunk.

Make cuts for crown thinning at the top and around the edges of the canopy. In most cases, choose branches 1–2 inches in diameter for removal and make thinning cuts at the point of origin or to a vigorous smaller branch that is at least one-third the size of the branch being removed (drop-crotch pruning). These two types of thinning cuts should avoid inducing the growth of numerous water sprouts, as long as less than one-third of the total canopy volume is removed.

Crown reduction. This procedure is used to reduce the overall size of a tree canopy when it becomes larger than is desirable or safe. Although pruning can roughly control tree size, crown reduction will need to be a regular maintenance task if the tree grows too large for its allotted space. For better effectiveness of crown reduction pruning, prune the tree just as it attains its acceptable size. Delaying pruning until the tree reaches its maximum height makes maintaining an acceptable canopy size more difficult, creates larger pruning wounds, and can induce weakly attached shoots to form.

Crown reduction involves drop-crotch pruning (described above and on page 10; also see Figure 7). Properly used, drop-crotch pruning should prevent water sprouts from forming near the pruning cuts. Drop-crotch pruning can reduce tree height by one-fourth to one-third of its original size. Using thinning cuts during crown reduction will cause the plant to grow back to a critical height more slowly than topping a tree. Thinning cuts also help the tree retain its natural shape and minimize decay problems. Since this pruning procedure involves cutting some of the most distant branches on a tree, use of a tree pruning professional should be strongly considered.

FLOWERING LOCATIONS FOR SELECTED SHRUBS

Plants Flowering on Midportions of Stems

- Barberry (*Berberis* spp.)
- Beauty bush (*Kolkwitzia amabilis*)
- Brooms (*Cytisus, Genista* spp.)
- *Cotoneaster* spp.
- Flowering quince (*Chaenomeles* spp.)
- *Forsythia* spp.
- Holly (*Ilex* spp.)
- Honeysuckle (*Lonicera* spp.)
- *Kerria japonica*
- Mock orange (*Philadelphus* spp.)

Plants Flowering on Terminal Tips

- Azaleas, evergreen (*Rhododendron* spp.)
- Dogwoods, shrubby (*Cornus* spp.)
- *Hydrangea* spp.
- Lilac (*Syringa* spp.)
- *Magnolia* spp., shrubby
- Oregon grape (*Mahonia* spp., also known as *Berberis* spp.)
- *Photinia* spp.
- *Potentilla fruticosa*
- Privet (*Ligustrum* spp.)
- *Rhododendron* spp. (and deciduous azaleas)
- Serviceberry (*Amelanchier* spp.)
- *Spiraea* x *bumalda* cultivars
- *Viburnum* spp.

Carefully observe where flowers are produced on species not listed.

Mature Deciduous and Broadleaf Evergreen Shrubs

The unique characteristics of each type of shrub determine the pruning technique(s) used. Shrubs that produce little, if any, new growth (sprouts) from their bases, such as large viburnums and magnolias, are pruned as if they were small trees (i.e., they are trained to have scaffold branches).

When growing shrubs for flowers or fruit, plants should be pruned to encourage or enhance flower production, which should also increase fruit production. Keep in mind that removing flowers will decrease fruit production. These large shrubs (like trees) produce flowers and fruit at the tips of their branches.

With any shrub, as with trees, keep the natural form in mind and prune to develop this form by removing stems and branches that detract from the desired shape of the plant. The growth habit of the plant should be enhanced by the pruning.

Observe where the flowers are produced on a shrub in order to know how to prune it. See the listing at right for flowering locations on selected shrubs. These shrubs also produce new wood (sprouts) from stems at or near the ground level throughout their lives (continuous basal growth). These plants and similar species should be pruned as follows:

- Prune plants that flower on the midportions of their stems to maximize production of 2–5-year-old wood. Do this by removing one-fourth to one-sixth of the oldest stems at or near the ground each year. Make thinning and heading cuts on the remaining stems as necessary.
- Prune plants that flower at the tips of their stems to maximize production of terminal tips. Do this by removing a few older canes and spindly new canes at or near ground level. Head back vigorous canes to force branching and growth of new tips where desired, and thin other stems as needed.
- Thinning cuts on deciduous and broadleaf evergreen shrubs preserve the shrub's natural form. Direct growth by thinning out (removing) stems back to a vigorous side branch that points in the desired direction. Use thinning cuts to remove selected inner branches to open up a dense shrub and to maintain the size (width and height) of the shrub.
- Heading cuts on deciduous and broadleaf evergreen shrubs stimulate the development of shoots right below the cut, resulting in denser growth. Make cuts where you want branching. Use heading cuts sparingly unless you are shearing a formal hedge, topiary, or other atypical shape. Heading cuts may result in an undesirable bushy or topped look.
- See page 12 for information on when to prune flowering shrubs.

Mature Coniferous Trees and Shrubs

Mature conifers need little pruning if they have been cared for over time. Selected branches may be growing out of place. If so, use thinning cuts to remove them. Like deciduous trees, coniferous trees should not be topped.

The type of pruning cut to use depends on the pruning objectives. If a plant is too tall or has branches that are blocking a view or use of a structure (for example, a sidewalk), use thinning cuts to remove branches at their point of origin. Thinning cuts are often less noticeable and create an open, natural-looking plant.

On fir, spruce, and Douglas fir, dormant buds are found mainly on branches that are one year old. Prune these species only into one-year-old branches or to where you can see buds on the branch (Figure 13). Pruning stems back into branch tissues that are more than one year old will leave permanent stubs, as the pruned branches will not produce new growth. Likewise, prune arborvitae and false cypress back only to where green foliage is seen on the plants; avoid pruning back to bare branches on these species.

Conifers with latent buds, such as yew and hemlock, can be pruned severely because latent buds will grow after pruning. They will respond to heading cuts on older branches or trunks by producing strong, new foliage growth. **Shearing** is a type of heading cut that consists of cutting off small branches to produce an even shape. Shearing shapes plants and increases branch density. However, shearing without some thinning can cause the center of a coniferous plant to die from lack of light, thereby increasing dead zones, or areas that lack foliage.

On many conifers such as pines and junipers, latent buds are usually absent from the branches, including

the current season's growth. Avoid cutting branches more than one year old on these species. Heading cuts that remove large amounts of foliage will result in dead zones and stubs. Pines have buds only at the tips of branches. Therefore, new growth on pines can be pruned only as the new candles expand (Figure 14). This pruning will induce new buds to form at the cut surface of the stem (at the base of the needle bundles) and will make the plant more dense and shorten its height. The amount of candle to prune off depends on how much new growth is desired. If only light pruning is needed on the new growth, remove only about 1 inch of the candle. In contrast, if little new growth is desired (to keep the plant dense), remove about two-thirds of the new candle.

Figure 13. Buds (arrows) present on the newest (one-year-old) branches on a spruce tree. Photo by Robert Tripepi.

Figure 14. New growth on a pine candle (the expanding pine branch) should be pruned when new needles on the candle are about one-half the length of mature needles to induce new buds to form at the base of the needle bundles near the cut. Arrows show the buds that were induced to form. Photo by Robert Tripepi.

Damaged Trees

Over time, plants may become damaged or parts of a plant may become diseased. Physical damage often requires corrective pruning. On some species, such as oak, branches die of natural causes and may remain attached high above the ground. Remove broken or dead branches, typically with a thinning cut, observing all of the pruning techniques outlined earlier. Sometimes, to maintain good symmetry, you can also thin or remove limbs opposite the broken ones.

After removing a broken branch that tears the bark on the branch or trunk from which it arose, carefully use a wood chisel to remove any torn or stripped bark and remove ragged edges of dead or dying bark (Figure 15). Remove loose or dead bark back to where it attaches to the tree. Keep the wound as narrow as possible to hasten wound closure.

If a pyramidal conifer loses the top of its main leader (trunk), help a branch near the wounded area to become the new leader. Select the best limb, which could be the longest one, and carefully bend it upright. Tie this branch to an upright pole or stake and fasten the stake securely to the trunk (Figure 16). Check ties frequently to make sure they do not cut or wound the bark, and remove the pole in two or three years.

A plant struck by lightning may not be damaged severely; remove broken branches, but do nothing else for 6–12 months. This length of time may be needed for damage to become visible. If damaged, the tree will decline due to an injured root system, vascular system, or cambium layer.

A hazard shrub or tree has a structural defect that may cause the plant or a portion of the plant to fall on someone or something. Hazardous conditions on plants need immediate attention in order to protect lives and property. Be sure to call a certified professional arborist if you suspect you are dealing with a hazard tree.

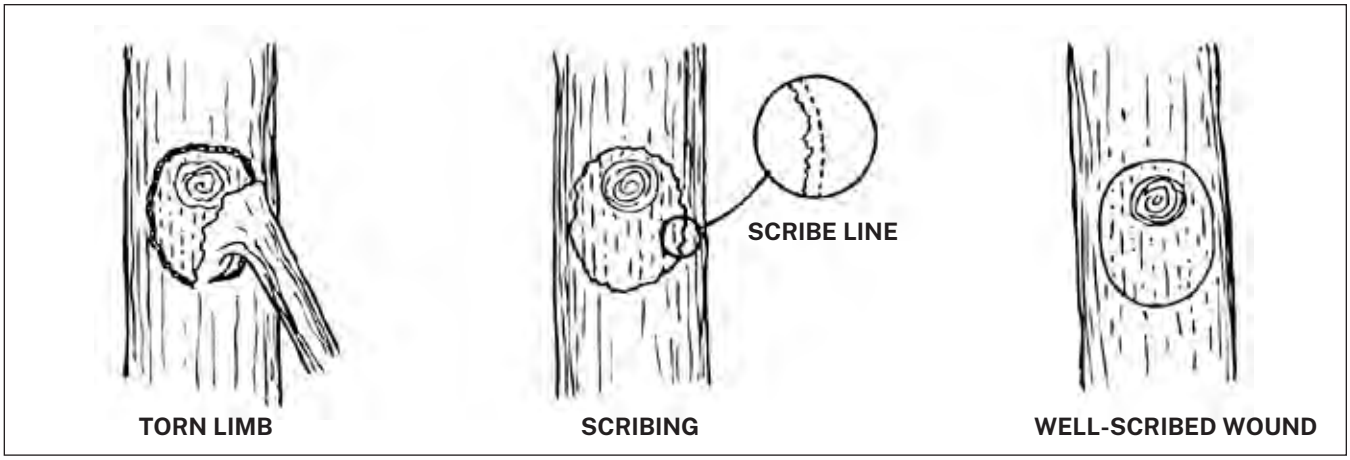

Figure 15. Remove the ragged edges of damaged tissue on broken or torn limbs. Use a chisel or sharp knife to remove the dead or dying plant tissues. Source: Colt, W.M., R.R. Tripepi, and R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees.* University of Idaho Extension Bulletin 819.

Figure 16. Select a new leader on a top-damaged conifer and tie it to a vertically secured stake (left). In the photo on the right, a new leader (indicated by the arrow) formed without being staked. Note the bow in the new leader. Photo by Marla Schwartz.

Careful inspection and a rational assessment of problems determine what corrective measure to take. If the entire tree is dead or dying, remove it. All dead branches are accidents waiting to happen. Remove them. Prune off weak or wounded spots on branches caused by rubbing. Forked (or codominant) trunks may indicate a weak-structured tree. A sudden lean in the entire tree is cause for action. Sudden dieback of top limbs may indicate root problems. Check for signs of internal decay by examining the plant for fruiting bodies of fungi (conks) or disfiguration (cankers). Conks at the base of the tree can indicate root and trunk decay.

A tree that has been topped has an increased risk of internal decay due to the large, open wounds that may have failed to be covered by new growth before wood-rotting microorganisms entered the wounds. Examine these cut areas carefully, possibly using an increment borer or an electric drill equipped with a ⅛-inch bit, to test for soundness of branches and trunks. Keep in mind, however, that drilling or boring into a trunk causes a wound that could be detrimental to a weakened tree. If you have inherited an older tree with poor shape or structure or one previously topped, do remedial pruning following the guidelines on page 17.

Hedges

After the second year, and in established hedges, make judicious heading cuts interspersed with a few well-located thinning cuts to create the desired

shape and size. Thinning cuts are typically used on informal hedges, whereas shearing is used to provide a formal shape. Thinning cuts and/or heading cuts are usually made on relatively small limbs.

Complete maintenance pruning from late winter to early spring for maximum growth. To stunt plant growth, prune in summer after the plants have completed their growth flush. Remove an occasional branch at any time.

Prune all established, full-grown formal hedges once a year after the season's growth ends, typically mid- to late summer. If you want a very formal effect, you will need to shear more often during the growing season. For a looser, less formal effect, shear only once in midsummer.

At each shearing, remove new growth to within ½ inch of the previous shearing, leaving only one to three new leaves and buds. Keep in mind that this amount of shearing will most likely result in thick, densely packed branches.

Vines

Treat vines the same as shrubs. Determine how to prune them by when (and thereby where) the flowers are produced (see listings on page 33). Besides encouraging flowering, fruiting, and new growth, prune vines to remove weak or diseased branches. Prune any vine with a permanent framework as you would a tree.

Woody Ground Covers

Low-growing woody shrubs and vines often serve as ground covers. Prune these plants as though they were flowering or nonflowering deciduous, broadleaf evergreen, or coniferous evergreen shrubs.

RENOVATION AND REJUVENATION PRUNING

Removal of large numbers of branches may be needed on older woody plants that have become too large, have grown into obstructions, were pruned incorrectly, have little flowering wood, lack vigor, or are unattractive. Renovation may also be necessary for plants that have died back from winterkill or other damage. Remember to remove any plant that is too large for its growing space when correctly trained. Replace it with a plant of a more appropriate mature size.

If a tree was poorly placed and is now growing into an obstruction, such as overhead power lines, consider removing it and replacing it with a properly placed or smaller tree. Trees properly pruned under or beside obstructions can continue to grow. Selectively remove branches to direct growth away from wires or other obstructions. This type of pruning is called directional pruning and can result in a V-shaped or one-sided tree (Figure 17). However, directional pruning is a better alternative than topping trees, since topped trees will eventually grow back into the obstruction.

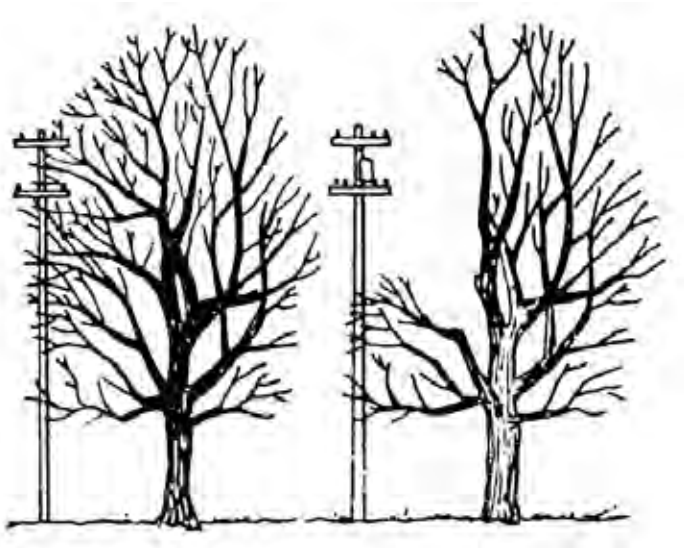

Figure 17. Side pruning was used to change the direction of this tree's growth. Source: Colt, W.M., R.R. Tripepi, and R.L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. University of Idaho Extension Bulletin 819.

Because of the danger of electrocution, if pruning will be done near a power line, be sure to contact your power company or hire a professional arborist. Only a person certified to prune near power lines can legally prune any branches growing within 10 feet (about 3 meters) of an energized conductor or transmission line.

Deciduous and Broadleaf Evergreen Trees and Shrubs

If a tree has never been pruned and is seriously tangled and perhaps damaged, approach pruning from the standpoint of "better late than never." In addition to the information in this section, follow the guidelines for pruning deciduous and broadleaf evergreen trees on page 17.

First, remove all dead and damaged branches, rubbing branches, branches growing inward on the tree, and branches growing outside the natural shape

of the tree. Often pruning these types of branches first clears out the canopy and is all that is necessary. Once this unwanted growth is removed, you can determine whether additional pruning is needed. The next set of branches to remove could include those with weak angles of attachment and those with inadequate vertical and radial spacing, particularly for scaffold branches. The age and condition of the tree may eliminate some pruning possibilities; for example, establishing a central leader or eliminating codominant branches may be quite difficult without severely weakening the tree.

You can use drop-crotch pruning (see page 11) to reduce the size of a tree without weakening its structure or creating an eyesore. This type of cut retains a lateral branch large enough to become the new leader. Its presence reduces latent bud sprouting and the bushy growth typical of heading cuts or topping. This method is often used by utility companies when trees grow into power lines.

Trees that have been topped or otherwise incorrectly pruned to a new height can sometimes be reshaped using thinning cuts and recommended training techniques. To correct problems from topping, remove some of the competing new branches near the pruning cut to reduce their density. Remove the tree if substantial amounts of wood rot are found, if the tree is in poor health, or if it is impossible to reconstruct a decent shape. Replace it with a recommended species for the site and space.

Deciduous and broadleaf evergreen shrubs that continuously produce basal growth can be rejuvenated by heading back all stems to 3–5-inch stubs. Use this technique only on shrubs that contain many latent buds. Boxwood, American holly, and almost all rhododendrons have good buds back to 3–5-year-old wood. Prune these severely. Cut back to 2–3-year-old wood on other species. This severe heading should be completed in late winter or early spring.

Once new, vigorous stems have grown about a foot long, selectively thin to remove weak or poorly placed stems and excessive growth. This step is very important for producing an attractive, healthy shrub. For shrubs with permanent scaffold branches, rejuvenate by thinning and heading back to the basic framework of the shrub.

Coniferous Trees and Shrubs

Rejuvenating misshapen, broken, or diseased coniferous shrubs is possible only if the plant has good latent buds on older wood. Severe heading cuts into old branches will produce vigorous growth and much smaller shrubs only if latent buds are present. Later, be sure to thin new growth to create a desirable open form (unless the plant is a sheared hedge or topiary). Complete this type of pruning in late winter or early spring before new growth begins.

Avoid rejuvenation pruning for most species of coniferous shrubs since most lack latent buds on older branches. Growing points on most species of juniper, arborvitae, and false cypress are found only in green foliage on young twigs. Severe heading cuts to stems of these species usually results in branch stubs without new foliage or needles. Some exceptions exist; for instance, one species of arborvitae has latent buds on older stems and at least one species of juniper has a few latent buds. The bottom line, however, is that rejuvenation pruning is not practical for most species of pine, spruce, fir, juniper, arborvitae, false cypress, and other conifers that lack latent buds on older stems and trunks. To correct damage or remove dead branches on most conifer species, make the necessary corrective thinning cuts and then prune new, young growth to increase foliage density.

Protecting Trees and Shrubs During Construction

Older trees contribute to the diversity of the landscape and should be preserved during construction if at all possible. Remove trees that are in poor health, those unable to withstand the necessary changes in their environment (such as shade lovers suddenly exposed to full sun), those leaning over an existing or proposed structure, and those that will be 5 feet or closer to a constructed building or utility line.

Good preconstruction planning often can ensure the survival of desirable trees. For instance, installing a flagstone walk or permeable pavers over a root system, rather than concrete or asphalt, allows aeration and water penetration to tree roots. Work with contractors to designate areas for driving, parking, and materials storage. Stake out exact

locations of trenches. If plants cannot remain where they are currently growing, consider transplanting any that are small enough or that can be dug with a tree spade.

Soil compaction seriously limits aeration and water penetration to root systems. The best solution is to keep all heavy equipment and foot traffic off root zones. First, surround trees with a barrier that extends beyond the dripline. This barrier will keep heavy equipment from driving over the majority of the plants' roots and from causing collision. The barrier will also keep chemical spills away from the root system.

If equipment or people must travel over a tree's root system, spread about 6 inches of wood chips or bark mulch (the larger the chip size the better). To provide even more protection, cover root areas with steel bridges, mesh matting, exterior plywood, or planks on top of the mulch. Use of mulch or wood chips and metal or plywood sheets will reduce compaction by spreading out the weight of heavy equipment or foot traffic.

Severing roots can be very damaging to trees, reducing their water- and nutrient-absorbing capacities and sometimes affecting their stability in the soil. Careful selection of routes for underground utilities — detouring around root systems when possible — can reduce root damage. If rerouting trenches for utility lines is impossible, tunneling, rather than trenching, is a good solution. To reduce damage to trees close to structures, substitute posts and pillars for footers and walls that require a trench.

Changes in grade can be extremely destructive to shrub and tree root systems, since cutting (removing soil) severs roots, whereas filling (adding soil) usually buries them, causing them to die due to lack of oxygen. Avoid grade changes by using retaining walls to maintain the original soil level over the majority of the root zone. Also, tree wells or tree islands can help maintain the original grade and minimize cutting of roots. Make wells or islands as large as possible. When a grade is changed more than 6 inches, vertical mulching (see page 6) may help modify the effect of extra soil.

Woody Landscape Plants for Idaho

Given the hundreds of plant species, botanical varieties, and cultivars that can be grown in the Intermountain West, selecting the right trees, shrubs, vines, and ground covers for your landscape can be an enormous challenge.

A limited selection of woody plants suitable for Idaho is provided in this chapter (see Table 1); however, many other plant species and cultivars are available. Table 1 provides categories that can be used in selecting plants for different purposes and growing conditions. Consult the internet, resource books, local garden centers, landscape architects, your Extension educator, and "Further Reading and Resources" in this chapter.

Use plant descriptions and photos to visualize what will best meet your own and your site's needs and preferences. Then, make a list and seek quality plants from the best sources. Be open to using alternative plants.

In southern Idaho, summer temperatures and light intensity are high and humidity is low. Northern Idaho has higher humidity and frequent cloud cover. Summer temperatures in southern Idaho can exceed 100°F, while northern Idaho experiences cooler temperatures (80°F–90°F). During the winter, dormant conditions, elevation, local microclimates, and temperature determine plant survival.

Plants listed in garden publications from the eastern United States and lower coastal elevations often do poorly in Idaho for several reasons: early or late frosts, different soil characteristics, the dry summer climate, etc. For these reasons, plants native to Idaho and the Intermountain West often grow best in many regions of the state. More and more native plants are becoming available at retail garden stores. Look online or consult with local garden stores to learn about native plants that will thrive in your area.

Table 1 lists some of the top woody landscape plants for Idaho. These plants have grown well or are deemed worthwhile for trial in Idaho. Selections were made based on Idaho research and recommendations from Idaho horticultural professionals, arborist

associations, tree committees, urban foresters, and the Idaho nursery industry. This list provides selected plants from a large number of woody species, varieties, and cultivars.

The following attributes are listed for the plants:

- **Common name**. The most widely accepted common name is given.
- **Scientific name**. Since several plants may share the same common name, the scientific name is included for precise identification.
- **Desirable cultivars** (cultivated varieties) are listed.
- **Height**. Mature height varies, depending on the region of the state, microclimate, fertilizer practices, light source and intensity, and soil conditions. A range of heights is given for most woody landscape plants listed.
- **Bloom time**. Approximate time of flowering.
- **Color**. Refers to foliage color. Color for listed cultivars may vary.
- **Light**. Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial sun is filtered sunlight through tree leaves or a minimum of 6–8 hours of sunlight per day; full shade indicates filtered sunlight through a dense foliage canopy or less than 6 hours of sunlight each day.
- **Use in landscape**. Lists potential planting locations as well as functions; for example, street tree, xeriscape, windbreak, or native. This category also indicates whether irrigation is critical.
- **United States Department of Agriculture (USDA) zone**. These ratings are based on the USDA plant hardiness zones for Idaho (see Figure 1, chapter 16) and upon reported preferences by region by Idaho plant professionals. Keep in mind that factors other than low temperatures affect plant survival in a specific area and USDA zones should be used only as a guideline.
- **Idaho zone**. Indicates in which part of Idaho this plant will grow best.
- **Growth habit**. Provides a mental picture of the mature form or outline of the plant.
- **Rate of growth**. Refers to the vertical increase in growth unless specified differently. The designation “slow” means the plant grows 12 inches or less per year, “medium” indicates 13–24 inches of growth per year, and “fast” is 25 inches or more of new growth annually. Rate is influenced by numerous variables such as soil, drainage, water, light, and exposure.
- **Wildlife rating**. Provides a guideline of the likelihood that the plant will attract and be damaged by wildlife.
- **Utility rating**. When available, this rating indicates whether this plant may be planted under power lines.
- **Source**. The reference that lists this plant.

Table 1. Woody plants for Idaho landscapes.

The following key is used in this table:

Height: At maturity with a range for most plants (spread for vines)

Bloom: Season of flowering
- Sp = spring
- Su = summer
- F = fall

Color: Predominant foliage color
- Grn = green
- Pur = purple
- Yell = yellow
- Gry = gray
- Blu = blue
- Wht = white

Light:
- F = full sun
- P = part sun
- S = shade

Use in landscape:
- B = border
- S = specimen
- W = windbreak
- St = street tree
- X = xeriscape
- I = irrigation
- N = native

USDA zone: Idaho's USDA plant hardiness zones are 3-6.

Idaho zone:
- 1 = northern Idaho
- 2 = southwestern Idaho
- 3 = eastern Idaho
- All = whole state

Growth habit:
- P = pyramidal
- V = vase shaped
- W = weeping
- R = round
- U = upright
- C = columnar
- G = globe
- O = oval
- M = mound
- F = feathery
- S = spreading

Rate:
- F = fast growth
- M = medium growth
- S = slow growth

Wildlife rating:
- 1 = Protective — Rare damage
- 2 = Protective — Slight damage
- 3 = Beneficial — Some damage
- 4 = Attractive — Severe damage

Utility rating:
- — = Recommended for planting under power lines
- ? = Questionable for planting under power lines
- Ø = Not recommended under power lines
- $ = Extreme expense; NOT recommended under power lines.
- * = Not a concern under power lines

Source: The referenced sources that list these plants as growing in our region.

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large Deciduous Trees — over 50 feet													
Ash, green	*Fraxinus pennsylvanica* 'Bergeson' 'Marshall' 'Patmore' 'Urbanite'	50'–60'	—	Grn	F	S,W,X	3–6	All	U,S	M	1	Ø	1,2,6
Ash, Raymond	*Fraxinus oxycarpa* 'Raywood'	40'–50'	—	Grn	F	S	5–6	1,2	O,U	M	1	Ø	2
Ash, white	*Fraxinus americana* 'Autumn Applause' 'Autumn Purple' 'Rosehill' 'Skyline'	50'–60'	—	Grn	F	St	4–6	All	O,U	M	1	Ø	1,2
Aspen, quaking	*Populus tremuloides*	30'–50'	—	Grn/Gry	F,P	S,I	3	All	S,U	F	2	Ø	1
Bald cypress	*Taxodium distichum*	50'–80'	—	Grn	F	S,I	5–6	1,2	P	M	1	$	2,4
Beech, European	*Fagus sylvatica* 'Pendula' 'Riversii' 'Roseo-Marginata'	50'–70'	Sp	Grn/Pur	F,P	S	5–6	1,2	O,U	S	2	Ø	2,6
Birch, river	*Betula nigra* 'Heritage'	40'–60'	—	Grn	P,S	S,N	4–6	All	O,U	M	2	Ø	2
Catalpa, northern	*Catalpa speciosa*	50'–70'	Su	Grn	F,P	S,X	5–6	All	S,U	F	3	Ø	1
Coffee tree, Kentucky	*Gymnocladus dioicus* 'Espresso'	50'–75'	Sp	Grn	F	S	4–6	1–3	U,O	S	4	Ø	2

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large Deciduous Trees — over 50 feet cont.													
Cork tree, amur	*Phellodendron amurense* 'Macho'	35'–45'	—	Grn	F	S	4–6	All	U,V	M	2	Ø	2
Filbert, Turkish	*Corylus colurna*	40'–50'	—	Grn	F	S,X	5–6	1,2	P	M	2	Ø	2
Hackberry, common	*Celtis occidentalis*	40'–60'	—	Grn	F	S,W,X	4–6	All	U,O	S	3	Ø	1,2
Honey locust	*Gleditsia triacanthos* var. *inermis* 'Imperial' 'Moraine' 'Shademaster' 'Skyline'	30'–60'	Sp	Yell/ Grn	F	S,W,X	5–6	All	S,U	M	3	Ø	1,2,5
Hornbeam, European	*Carpinus betulus* 'Fastigiata'	40'–50'	—	Grn	F,P	S,St	5–6	1,2	P,O	S	2	Ø	2
Horse chestnut	*Aesculus hippocastanum* 'Baumannii'	40'–60'	Sp	Grn	F,P	S	4	All	U,O	M	3	Ø	1,2
Larch, European	*Larix decidua*	50'–70'	—	Grn	F	S,W,B	3–6	All	P	M	2	$	2,4
Linden, American	*Tilia americana* 'Legend' 'Redmond'	40'–60'	Su	Grn	F,P	S,I	3–6	All	P,O	M	1	Ø	2
Linden, littleleaf	*Tilia cordata* 'Chancellor' 'Corinthian' 'Glenleven' 'Greenspire'	40'–60'	Su	Grn	F	S	4–6	All	P,O	S	2	Ø	1
Linden, silver	*Tilia tomentosa* 'Green Mountain' 'Sterling'	40'–60'	Su	Grn/ Wht	F	S	5–6	1,2	O,P	M	3	Ø	2
Locust, black	*Robinia pseudoacacia*	40'–50'	Su	Grn	F	B,W,X	3	All	S,U	F	4	$	1
Magnolia, cucumber tree	*Magnolia acuminata*	40'–60'	Sp	Grn	F,P	S,I	4–6	1,2	O	M	1	Ø	2
Maidenhair tree	*Ginkgo biloba* 'Autumn Gold' 'Magyar' 'Princeton Sentry'	40'–60'	—	Grn	F	S	4–6	1,2	P,S	S	3	Ø	1,2
Maple, Freeman	*Acer X freemanii* 'Autumn Blaze'	50'–60'	Sp	Grn	F,P	S	4–8	All	O	M	2	Ø	
Maple, Norway	*Acer platanoides* 'Columnare' 'Crimson King' 'Deborah' 'Emerald Queen' 'Royal Red' 'Schwedler'	40'–50'	Sp	Grn	F,P	S	4–6	All	U,O	M	2	Ø	1,2

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large Deciduous Trees — over 50 feet cont.													
Maple, sugar	*Acer saccharum* 'Green Mountain' 'Legacy'	50'–70'	—	Grn	P,S	S	4–6	1,2	O,U	S	3	Ø	2,4
Oak, bur	*Quercus macrocarpa*	70'–80'	—	Grn	F	S,W,X	3–6	All	O,U	S	4	Ø	2
Oak, English	*Quercus robur* 'Fastigiata'	50'–70'	—	Grn	F	S	5–6	All	U,O,C	M	4	Ø	1,2,4
Oak, northern red	*Quercus rubra*	50'–75'	—	Grn	F,P	S	5–6	1,2	U,O,C	S	4	Ø	1
Oak, swamp white	*Quercus bicolor*	50'–70'	—	Grn	F,P	S	4–6	All	O,U	M	4	$	2
Oak, white	*Quercus alba*	50'–80'	—	Grn/Gry	F,P	S	4–6	All	U,O	S	4	Ø	1
Pagoda tree, Japanese	*Sophora japonica*	40'–60'	Su	Grn	F	S	5–6	1,2	O,U	M	1	Ø	2
Persimmon, common	*Diospyros virginiana*	30'–50'	Sp	Grn	F	S	5–6	1,2	O	S	3	Ø	2
Planetree, London	*Platanus x acerifolia* Note: the scientific name is sometimes listed as *Platanus x hybrida* 'Bloodgood'	50'–100'	—	Grn	F,P	S	4–6	1,2	O	M	3	$	1
Poplar, black	*Populus trichocarpa*	75'–100'	—	Grn	F	S,N,I	4–6	All	V	F	1	$	2
Poplar, white	*Populus alba* 'Bolleana'	45'–90'	—	Grn/Wht	F,P	S,B	3–6	All	U,S	F	1	$	1
Poplars	*Populus* spp.	50'–80'	—	Grn/Gry	F,P	W,N,I	3	All	O,U,S	F	1	$	1
Sweet gum	*Liquidambar styraciflua*	50'–60'	—	Grn	F	S,I	5–6	1,2	P,O	M	2	Ø	1,2
Tree of Heaven	*Ailanthus altissima*	30'–45'	—	Grn	F	S	4	All	U,S	F	4	Ø	1
Tulip tree	*Liriodendron tulipifera*	65'–90'	Sp	Grn	F	S,I	5–6	1,2	U,O	M	3	$	1
Walnut, black	*Juglans nigra*	40'–50'	—	Grn/Yell	F	S,W	4	All	U,D	M	3	$	1
Willow	*Salix* spp. 'Tristis' golden weeping 'Tortusa' corkscrew	40'–80'	—	Grn/Yell	F,P	S,I,N	3	All	U,S,O	F	4	$	1
Yellowwood	*Cladrastis kentukea*	30'–50'	Sp	Grn	F,P	S,I	5–6	1,2	O	M	1	Ø	
Large Evergreen Trees — over 50 feet													
Arborvitae, eastern	*Thuja occidentalis* 'Pyramidalis'	30'–50'	—	Grn	F	B,S	3–6	All	P	M	2	$	2,4
Douglas fir	*Pseudotsuga menziesii*	40'–60'	—	Grn	F,P	S,N	4–6	All	P	M	1	$	2,4
Fir, subalpine	*Abies lasiocarpa*	40'–50'	—	Blu/Grn	P	S,I,N	3–6	All	U,C,P	S	2	$	1
Fir, white	*Abies concolor*	50'–70'	—	Gry/Grn	F,P	S,N	4–6	All	P,U	M	2	$	2,4
Pine, Austrian	*Pinus nigra* var. *nigra*	50'–60'	—	Grn	F	S,W	4–6	All	U,P	M	3	$	1,2

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large Evergreen Trees — over 50 feet cont.													
Pine, ponderosa	*Pinus ponderosa*	50'–100'	—	Grn	F	S,W, N,B	4–6	All	U,P	M	2	$	1,2,4,5
Pine, Scots	*Pinus sylvestris*	50'–80'	—	Grn	F	S,W, B,St	3–6	All	U,P	M	1	$	1,2,4
Pine, Swiss stone	*Pinus cembra*	30'–40'	—	Grn	F	S	4–6	All	P,C	S	2	Ø	3,4
Spruce, Colorado	*Picea pungens*	45'–80'	—	Grn/Gry	F	S,W	3–6	All	U,P	S	2	$	1,2,4
Spruce, Engelmann	*Picea engelmannii*	80'–100'	—	Grn	F	S,B	3	All	U,P	S	1	$	1,2,4
Spruce, Norway	*Picea abies*	50'–60'	—	Grn	F	S,B	4–6	All	U,P	M/F	2	$	1,2,4
Spruce, Serbian	*Picea omorika*	50'–60'	—	Grn/Gry	F,P	S,B	4–6	All	P,C	S	2	$	2,4
Spruce, white	*Picea glauca*	40'–50'	—	Grn	F,P	S,W	3–6	All	P	M	2	$	2,4
Large Deciduous Trees — 25–50 feet													
Alder, mountain	*Alnus tenuifolia*	20'–40'	Sp	Grn	F,P	S,N,I	3–6	All	O	M	2	Ø	2
Apricot	*Prunus armeniaca*	15'–25'	Sp	Grn	F	B	4	All	S,O	M	4	?	1
Cherry plum	*Prunus cerasifera* 'Atropurpurea' 'Newport' 'Thundercloud'	15'–25'	Sp	Pur	F	S,B,St	4–6	1,2	U,O	M	3	—	1
Cherry, Japanese flowering	*Prunus serrulata* 'Kwanzan' 'Mount Fuji'	20'–25'	Sp	Grn	F	S,St,I	5–6	1,2	S,C,V	F	3	—	2,3
Chokecherry	*Prunus virginiana* 'Shubert'	15'–30'	Sp	Grn	F	B,W	2–6	All	S,O	M	3	—	
Crab apple	*Malus* spp. 'Adirondack' 'Donald Wyman' 'Indian Summer' 'Prairifire' 'Purple Prince' 'Red Jewel' 'Spring Snow' 'Strawberry Parfait'	15'–40'	Sp	Grn/ Red	F,P	St	3–6	All	S,U, C,O	F	4	?	1–4
Dogwood, Cornelian cherry	*Cornus mas*	20'–25'	Sp	Grn	F	B,S,St	4–6	All	O	M	3	?	3
Dogwood, flowering	*Cornus florida*	20'–25'	Sp	Grn	P	B,S	5–6	1,2	R,U	S	2	?	2,3
Dogwood, Kousa	*Cornus kousa*	15'–25'	Sp	Grn	P	B,S	5–6	1,2	R,U	S	2	?	2
Eastern redbud	*Cercis canadensis*	20'–30'	Sp	Red/ Grn	F,P	S,I	5–6	1,2	O	M	2	?	2,3
Filbert, purple giant	*Corylus maxima* var. *purpurea*	15'–20'	Sp	Pur	P	B	5–6	1,2	R,P	S	3	?	3,4

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Medium Deciduous Trees — 25 to 50 feet cont.													
Golden rain tree	*Koelreuteria paniculata*	30'–40'	Su	Grn	F	S,X	5–6	1,2	O	F	1	Ø	2
Hawthorn, English	*Crataegus laevigata*	15'–24'	Sp	Grn	F,P	St	3–6	All	S,U, C,O	M	3	?	1,2
Hawthorn, green	*Crataegus viridis*	25'–35'	Sp	Grn	F	St,S,B	5–6	1,2	O	M	3	?	2,3
Hawthorn, Lavalle	*Crataegus x lavallei*	15'–30'	Sp	Grn	F	B	4–6	1,2	O	M	2	?	1,2,4
Hawthorn, Washington	*Crataegus phaenopyrum*	20'–30'	Sp	Grn	F	St,S,B	3–6	All	O	M	3	?	1–3
Hornbeam, columnar	*Carpinus betulus* 'Columnaris'	20'–40'	—	Grn	F	B,S,St	4–6	All	U,P	M	2	Ø	3
Lilac, Japanese tree	*Syringa reticulata*	20'–30'	Sp	Grn	F	S,St	4–6	1,2	O	M	1	?	2
Magnolia, saucer	*Magnolia* x *soulangiana*	20'–30'	Sp	Grn	F,P	S,I	5–6	1,2	P,O	M	1	?	2
Maple, amur	*Acer ginnala*	15'–20'	Sp	Grn	F,P	B,W,B,S	3–6	All	U.S	M	2	—	1-3
Maple, hedge	*Acer campestre*	25'–35'	—	Grn	F,P	St,S	5–6	1,2	O	S	2	?	2
Mountain ash, American	*Sorbus americana*	10'–30'	Sp	Grn	F	B,S	3–6	All	R,U,S	F	3	Ø	4
Mountain ash, European	*Sorbus aucuparia*	25'–50'	Sp	Grn	P	S	4–6	All	R,U,S	M	3	Ø	1
Olive, Russian	*Elaegnus angustifolia*	20'–45'	Sp	Gry	F	S,W,X	4	All	U,S,O	M	4	$	1,5
Pear, Callery	*Pyrus calleryana* 'Aristocrat' 'Redspire'	25'–35'	Sp	Grn	F	St,S	5–6	1,2	O,P	M	1	?	2
Plum, Blireiana	*Prunus* x *blireiana*	15'–25'	Sp	Red/Pur	F	S	5–6	1,2	O	M	3	?	2
Serviceberry	*Amelanchier* x *grandiflora*	20'–25'	Sp	Grn	F	B	4–6	All	U,O	M	4	—	3
Walnut, Persian	*Juglans regia*	40'–50'	Sp	Grn	F	S	5–6	All	U,O	S	4	Ø	1
Medium Evergreen Trees — 25–50 feet													
Juniper, Rocky Mountain	*Juniperus scopulorum*	20'–40'	—	Gry/Grn	F	B,W,B,N	3–6	All	P,O	S	2	?	1–3
Juniper, Utah	*Juniperus osteosperma*	20'–40'	—	Gry/Grn	F	B,W,B,N	3	All	S,U	S	2	?	—
Pine, limber	*Pinus flexilis*	20'–50'	—	Grn	P	S,N	3–6	All	P	S	1	Ø	1,2,4
Red cedar, eastern	*Juniperus virginiana*	20'–40'	—	Grn/Red	F	B	4	1,2	G,U	S	2	?	1–3
Small Deciduous Trees — under 25 feet													
Fringe tree, Chinese	*Chionanthus retusus*	8'–20'	Sp	Grn	F,P	S,B,St	5–6	1,2	O	M	2	—	3,4
Gamble oak	*Quercus gambelii*	5'–15'	—	Grn	F,P	S	4–6	All	S,U	S	4	—	5
Golden chain tree	*Laburnum* x *watereri*	12'–15'	Sp	Grn	F,P	B,S,St	5–7	1,2	O,R	M	2	?	3,4
Magnolia, star	*Magnolia stellata*	15'–20'	Sp	Grn	F,P	S,I	4–6	1,2	S,O	M	1	?	2,3

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Small Deciduous Trees — under 25 feet cont.													
Sumac, smooth	*Rhus glabra*	10'–15'	—	Grn	F	B,S,N,X	3	All	S,W	F	3	—	1
Sumac, staghorn	*Rhus typhina*	15'–25'	Su	Grn	F	B,S,X	3–6	All	S	F	3	—	2,3,5
Small Evergreen Trees — under 25 feet													
Arborvitae	*Thuja occidentalis* 'Globosa' 'Little Gem'	15'–25'	—	Grn	F,P	B	4	All	C,G,U	M	2	?	1
Pine, bristlecone	*Pinus aristata*	8'–20'	—	Grn	F	S,B,I	4–6	All	P	S	1	?	1–4
Pine, mugo	*Pinus mugo* 'Mugo'	15'–25'	—	Grn	F	B,I	3–6	All	S,U	S	2	?	2,4,5
Yew, Hicks	*Taxus* x *media* 'Hicksii'	10'–15'	—	Grn	F,P,S	B,I	4–6	1,2	C,O	F	2	?	3,4
Large shrubs — over 8 feet													
Cherry, Nanking	*Prunus tomentosa*	6'–8'	Sp	Grn	F,P	B,W	3–6	All	P,M	F	3	?	5
Chokeberry, black	*Aronia melanocarpa*	10'–15'	Sp	Grn	F	B,S	4–6	All	G,M	M	4	?	4
Chokeberry, purple fruited	*Aronia prunifolia*	10'–15'	Sp	Grn	F	B,S	4–6	All	G,P	M	3	?	4
Cranberry bush, American	*Viburnum trilobum*	10'–15'	Sp	Grn	F	B	2–7	All	G	F	4	?	3,4
Firethorn	*Pyracantha coccinea*	10'–15'	Sp	Grn	F,P	B,S	5–6	All	S,P	F	3	?	5
Juniper, common	*Juniperus communis*	5'–10'	—	Gry/Grn	F,P	B,N	3–6	All	S,M	M	2	?	5
Lilac, common	*Syringa vulgaris*	8'–15'	Sp	Grn	F	B,W	3–7	All	P,G	M	2	?	4,5
Lilac, late	*Syringa villosa*	8'–15'	Sp	Grn	F,P	B,W	3–7	All	P,G	M	2	?	—
Mock orange, Lewis'	*Philadelphus lewisii*	5'–10'	Su	Grn	F,P	S,B,N	4–6	All	S,O	F	2	*	5
Pea shrub, Siberian	*Cargana arborescens*	15'–20'	Sp	Grn	F	B,W	2–7	All	P	F	2	?	3
Serviceberry, Saskatoon	*Amelanchier alnifolia*	8'–15'	Sp	Gm	F	B,S	4–6	All	P,O	F	4	?	4
Serviceberry, Shadblow	*Amelanchier canadensis*	8'–15'	Sp	Gm	F,P	B,S	4–6	All	P,O	F	4	?	4
Smoke tree	*Cotinus coggyria* 'Purpureus'	10'–15'	Sp	Pur/Grn	F	B,S	5–6	All	O,P	F	2	?	2–4
Snowball, common	*Viburnum opulus* 'Roseum'	10'–15'	Sp	Grn	F,P	S,B	4–6	All	P	F	2	?	5
Snowball, fragrant	*Viburnum* x *carlcephalum*	8'–10'	Sp	Grn	F,P	S,B	4–6	All	P	F	2	*	5
Spirea, bridalwreath	*Spiraea* x *prunifolia*	5'–10'	Sp	Grn	F	B,S	5–6	All	V	F	2	*	8
Spirea, Vanhoutte	*Spiraea* x *vanhouttei*	5'–10'	Sp	Grn	F	B,S	4–6	All	V	F	2	*	8
Viburnum, arrowwood	*Viburnum dentatum*	6'–8'	Sp/Su	Grn	F,P	S,B	2–7	All	P,G	M	2	*	4

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large shrubs — over 8 feet cont.													
Viburnum, Siebold	*Viburnum sieboldii*	15'–20'	Sp	Grn	F,P	B,S	4–6	1,2	U,O	F	4	?	3
Yew, hybrid	*Taxus* x *media*	5'–15'	Sp	Grn	F,P,S	B	4–6	All	C	M	2	?	5
Yucca	*Yucca flaccida*	4'–7'	Su	Gry/Grn	F	S	4–6	All	O	M	2	*	5
Small shrubs — 3–5 feet													
Almond, dwarf flowering	*Prunus glandulosa*	4'–6'	Sp	Grn	F,P	B	4–6	All	M,S	M	4	*	5
Almond, dwarf Russian	*Prunus tenella*	4'–5'	Sp	Grn	F,P	B	2–6	All	M,S	M	4	*	4
Barberry, Japanese	*Berberis thunbergii*	3'–6'	Sp	Red/Gry	F,P	S,B	4–6	—	P,S	M	3	*	5
Burning bush, dwarf	*Euonymus alatus* 'Compactus'	3'–6'	Sp	Grn	F,P	B,S	3–6	1,2	G,P	F	3	*	4,5
Ceanothus, Fender	*Ceanothus fendleri*	1'–2'	Sp	Gry/Grn	F,P	S,B,N,X	4–6	All	S,P	F	2	*	5
Cinquefoil, shrubby	*Potentilla fruticosa*	1'–4'	Su	Grn	F	B	2–6	All	M	M	1	*	4
Cotoneaster, cranberry	*Cotoneaster apiculatus*	3'–4'	Sp	Grn	F,P	B	5–6	1,2	M	F	3	*	4,5
Cotoneaster, rock	*Cotoneaster horizontalis*	3'–4'	Sp	Grn	F,P	B	4–6	1,2	M	F	3	*	5
Currant, alpine	*Ribes alpinum*	3'–5'	Sp	Grn	F,P	S,B,N	3–6	All	G,M	F	3	*	5
Dogwood, red twig	*Cornus sericea*	7'–9'	Sp	Grn	F,P	B,W,N	2–6	All	S,U	F	3	—	—
Dogwood, Tatarian	*Cornus alba*	8'–10'	Sp	Grn/Red	F,P	B,W	2–6	All	S,U	M	—	*	4
Firethorn, compact	*Pyracantha angustifolia* 'Gnome'	12"–15"	Su	Grn	F	I	5–6	All	S	M	3	*	8
Juniper, Chinese	*Juniperus chinensis* 'Gold Coast' 'Mint Julep'	2'–10'	—	Grn/Yell	F	B,S	4–6	All	Various	M,F	1	*	4
Oregon grape holly	*Mahonia aquifolium* 'Compactum'	3'–6'	Sp	Red/Grn	F	S,B	4–6	All	S	M	3	*	4,5
Rhodendendron, azalea	*Rhododendron* spp.	0.5'–5'	Sp	Grn/Gry	P	B,S	4–6	1,2	U,M	M,S	2	*	4
Sand cherry, western	*Prunus besseyi*	7'–10'	—	Grn/Gry	F	B,N	2–6	All	M	M	3	*	4
Snowberry	*Symphoricarpos albus*	3'–6'	Sp	Grn	F,P	N	3–6	All	U,M	M	4	*	4
Spruce, dwarf Norway	*Picea abies* 'Nidiformis' 'Procumbens'	2'–4'	—	Grn/Gry	F	B,S	2–6	All	Various	S	1	*	4
Sumac, scented	*Rhus trilobata* 'Lemonade Sumac' 'Skunkbush Sumac'	3'–5'	Sp	Grn	F	N,X	3–6	All	P,S	M	3	*	8

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Ground Covers													
Bunchberry	*Cornus canadensis*	6”–9”	Sp	Grn	P,S	I,N	5–6	1,2	S	M	3	*	8
Checkerberry, mountain	*Gaultheria ovatifolia*	8”	Su	Grn	P,S	N	5–6	All	S	M	4	*	8
Cotoneaster, creeping	*Cotoneaster adpressus*	8”–12”	Sp	Grn	F,P	S	4–6	All	S	M	2	*	5
Crowberry	*Vaccinium vitis-idaea*	12”	Sp	Grn	P	I	3–6	1,2	S	S	3	*	8
Germander	*Teucrium chamaedrys* var. *prostratum*	4”–12”	Su	Grn	F	I	3–6	All	S	M	1	*	8
Honeysuckle, Halls	*Lonicera japonica* ‘Halliana’	6”–12”	Sp	Grn	S	I	3–6	All	S	F	2	*	5
Juniper, creeping	*Juniperus horizontalis* ‘Bar Harbor’ ‘Blue rug’ (also called ‘Wiltoni’)	12”–16”	—	Grn/Blu	F,P	S,N	3–6	All	S	M	2	*	4,5
Juniper, singleseed	*Juniperus squamata*	4”–6”	—	Grn	F	N,X	5–6	1,2	S	M	1	*	4
Kinnikinnick	*Arctostaphylos uva-ursi*	4”–6”	Sp	Grn	S,P	N,X	3–6	1,3	S	M	4	*	5
Mahonia	*Mahonia repens*	6”–12”	Sp	Red/Grn	S,P	N,X	4–6	All	S	M	4	*	5
Paxistima, Canby	*Paxistima canbyi*	1’–2’	Sp	Grn	F,P	B,N,I	4–6	All	M	M	1	*	4
Periwinkle	*Vinca minor*	4”–6”	Sp	Grn	S	I	3–6	All	S	F	2	*	5
Saint-John’s-wort	*Hypericum calycinum*	12”–18”	Su	Grn	F,S	X	5–6	All	S	F	1	*	8
Silverwood	*Genista pilosa*	12”–15”	Su	Grn	F	N	5–6	1,2	S	F	1	*	8
Spurge, Japanese	*Pachysandra terminalis* ‘Green Carpet’	6”–10”	Su	Grn	P,S	I	4–6	All	S	F	1	*	8
Sun rose	*Helianthemum nummularium*	6”–8”	Su	Grn/Gry	F	X	3–6	All	S	M	1	*	8
Wintergreen, creeping	*Gaultheria procumbens*	6”	Su	Grn	P	I	3–6	1,2	S	M	4	*	8
Vines													
Akebia, fiveleaf	*Akebia quinata*	15’–20’	Sp	Grn	All	I	4–6	All	S	M	2	?	8
Bittersweet	*Celastrus* spp.	10’–40’	Sp	Grn	F	I	3–6	All	S	M	2	?	8
Clematis	*Clematis* spp. x *jackmanii* ‘Henryi’ ‘Nelly Moser’	8’–20’	Sp, Su, F	Grn	P	I	4–6	All	S	F	1	*	8
Clematis, evergreen	*Clematis armandii*	15’–20’	Sp	Grn	P	I	7	1,2	S	F	1	*	8
Euonymus, wintercreeper	*Euonymus fortunei* ‘Canadale Gold’ ‘Coloratus’ ‘Emerald Gaiety’	20’–30’	Sp	Grn	F,P	I	3–6	All	S	F	2	*	8

Table 1. (cont). Woody plants for Idaho landscapes. (See page 25 for the key to abbreviations used in this table).

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Vines (cont.)													
Grape	*Vitis riparia*	10'–15'	Su	Grn	P	I	3–6	All	S	F	4	*	9
Honeysuckle, Japanese	*Lonicera japonica* 'Aureo-reticulata' 'Halliana' 'Purpurea'	10'–15'	Sp	Grn	P	I	4–6	All	S	F	1	?	8
Honeysuckle, trumpet	*Lonicera sempervirens*	10'–15'	Sp	Grn	P	I	4–6	All	S	F	1	?	8
Hop	*Humulus lupulus*	15'–30'	Su	Grn	F	I	3–6	All	S	F	1	?	8
Hydrangea, climbing	*Hydrangea anomala* subsp. *petiolaris*	8'–15'	Sp	Grn	P	I	3–6	All	S	S	2	*	8
Ivy, Boston	*Parthenocissus tricuspidata*	20'–50'	—	Grn	All	I	4–6	All	S	F	2	?	8
Ivy, English	*Hedera helix* 'Arborescens' 'Baltica' 'Bulgarica'	10'–30'	—	Grn	P,S	I	4–6	All	S	F	1	?	8
Kiwi, hardy	*Actinidia arguta* 'Ananasnaja' 'Hood River' 'Issai'	20'–50'	Sp	Grn	F	I	4–6	All	S	F	3	*	8
Rose	*Rosa* spp. 'Blaze' 'Royal Sunset' 'White Dawn'	6'–15'	Sp,Su,F	Grn	F,P	I	3–6	All	S	M	3	*	8
Trumpet vine	*Campsis radicans*	10'–40'	Sp	Grn	F,P	I	4–6	All	S	F	1	?	8
Virginia creeper	*Parthenocissus quinquefolia*	10'–50'	—	Grn	All	I	3–6	All	S	F	2	?	8
Wisteria	*Wisteria* spp.	10'–40'	Sp	Grn	F,P	I	5–6	All	S	F	1	?	8

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UNIVERSITY OF IDAHO EXTENSION PUBLICATIONS

BUL 644	*How to Prune Coniferous Evergreen Trees*
CIS 1054	*Low Input Landscaping*
PNW 5	*Trees Against the Wind*
PNW 496	*Propagation of Plants by Grafting and Budding*

WEBSITES

Arnold Arboretum. **http://www.arboretum.harvard.edu/.**

National Arbor Day Foundation. **http://www.arborday.org.**

Pacific Northwest Chapter, International Society of Arboriculture. **http://pnwisa.org/.**

MAPS

Arbor Day Foundation. Hardiness Zone Map. **https://www.arborday.org/media/zones.cfm.**

USDA Plant Hardiness Zone Map. **https://planthardiness.ars.usda.gov/.**

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CHAPTER **NINETEEN**

HERBACEOUS ORNAMENTALS

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Learning Objectives

- Learn the art of designing with herbaceous ornamentals, using color, texture, shape, and size
- Learn about the number of different ways that herbaceous ornamentals are used
- Learn about container gardening and how to maintain them
- Learn about annual plantings and the maintenance requirements
- Learn about a selected list of annual flowers commonly used in Idaho
- Learn about biennials and perennials and how to care for and maintain them
- Learn about a selection of perennials for Idaho gardens

Introduction

Herbaceous ornamentals comprise the nonwoody portion of the garden landscape. These plants generally add color and interest to a basic landscape design and landscape structure. Whether that structure is a backdrop or basic design of trees and shrubs or a purposeful laying out of beds and other types of planting areas, the addition of herbaceous ornamentals can enhance a landscape significantly. These plants are also forgiving because they are easier to dig and rearrange than most landscape trees and shrubs. Learning to use herbaceous ornamentals to the best advantage is easy; simply follow the guidelines outlined in this chapter.

The Art of Design

COLOR

Herbaceous ornamentals are generally grown for their addition of color, through their flowers and foliage, to the landscape. Understanding the impact of colors and how to combine them can form a basis for use of these versatile landscape plants (Figure 1).

Several color schemes can be created in a single garden by planting early season blooming plants in one color scheme and late-blooming plants in a different scheme. An interesting overlap can occur in plans of this type.

The primary colors are red, yellow, and blue. Other colors are combinations of these primary colors. A pure color is a hue. A lighter version of a hue is a tint, which is accomplished by combining a hue with white. A darker version of a hue is a shade, a color made by combining a hue with black. A tone is made by combining various amounts of black and white, or gray, with a hue. The value of any color is the brightness of that color compared to another. Pure yellow has a greater value than pure blue.

The warm colors of yellow, red, and orange brighten cool, shady areas. These colors are attention getting and can be used to shorten the perspective at the back of a long bed. The cool colors of violet and blue, by contrast, recede and are good for close-up viewing. Cool colors also give the impression that an overheated area, like a concrete patio, isn't as hot.

Color schemes effectively used with herbaceous ornamentals are

1. **Polychromatic** — Uses all the colors and their tints, shades, and tones. This can produce a carnival effect and often results in some very pleasing color combinations.
2. **Monochromatic** — Uses the various tints, shades, and hues of only one color. Gardens using this color scheme are particularly dramatic.
3. **Analogous** — Uses adjacent colors on the color wheel such as blue, violet, and red. Such a color scheme can be expanded by using the various tints and shades of each of the colors.
4. **Complementary** — Uses opposite colors on the color wheel such as red and green, orange and blue, and yellow and violet. This type of color scheme is most effectively used with pure hues (not tints or shades) and creates a very bold effect. This color scheme is not recommended for the small garden.
5. **Split Complementary** — Uses a pure color and a color from either side of its complementary counterpart. An example of this is starting with blue and combining it with red or yellow, the colors bordering orange on the color wheel.

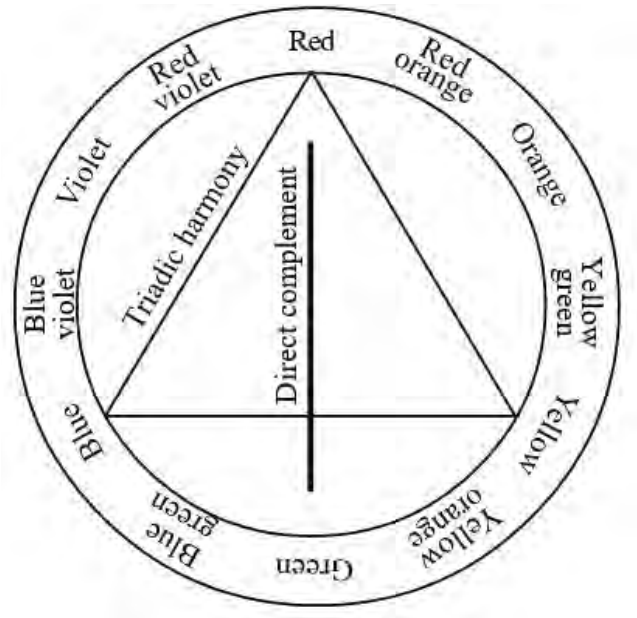

Figure 1. The color wheel.

6. **Triadic** — Uses three colors that are equidistant from each other on the color wheel. The result of this unusual combination is striking.
7. **White** — This color deserves a special comment. There have been many famous gardens planted in white flowers alone. There is a special appeal in the contrast of white against the green foliage of plants. White will give your garden a well-planned and orderly look. It is the last color to fade from sight as darkness falls, so it is a good choice for "evening" gardens. Cream and ivory flowers blend well with all colors except yellow.

TEXTURE

This is dictated by the density and size of individual leaves and flowers. Plants with large leaves and large bold flowers have a coarse texture, tend to be dominant in a garden, and appear to advance to your field of vision. Plants with tiny leaves and small flowers lend a fine texture to the landscape and tend to recede in your field of vision. Choose herbaceous ornamentals according to the textural "feel" you wish to attain. Often a mix of all textures is the most visually pleasing.

SHAPE AND SIZE

Herbaceous ornamentals come in all sizes and shapes. Size is comprised of **height** (tallness) and **spread** (the extent to which the herbaceous ornamental covers the ground at maturity). A shape

is the same as the habit or form of a plant. Some herbaceous ornamentals hug the ground, while others tower 6 feet or more; others are vines. Some are compact ball-shaped plants while others are open and upright. There are herbaceous ornamentals perfect for any location. Be sure to space plants far enough apart to allow room for each to develop to maturity.

What to Plant

EXPOSURE

Herbaceous ornamentals can be adapted to all types of sites from full sun to pure shade. Choosing a plant according to the exposure of the site ensures success with these plants.

SEASON OF FLOWERING

Some herbaceous ornamentals are tolerant of cool temperatures and bloom in early spring. Others need warmer weather and bloom in the summer. Still others bloom in the fall. Choose the proper herbaceous ornamental based on when color in a particular area is most desirable.

CUT AND DRIED FLOWERS

Some kinds of herbaceous ornamentals hold up better as cut flowers while others dry beautifully. Choose herbaceous ornamentals that are adapted to fresh or dry display.

Special cutting gardens can be completely harvested for flowers without concern for how the garden looks. However, plants valuable for cut flowers can usually be incorporated into the main garden.

When cutting for air drying, choose flowers just reaching maturity. Strip off the foliage and hang it upside down in small bunches in a dry, shady spot. Some flowers will dry well standing upright in a container.

HERBACEOUS ORNAMENTALS THAT NATURALIZE

Some herbaceous ornamentals, such as native plants or wildflowers, reseed themselves prolifically and eventually naturalize an area. Know which plants have this tendency and choose the proper annuals for naturalizing. Remember, any hybrid ornamentals that reseed will not come true-to-type and usually produce an offspring of inferior plant quality. Seedlings of this type are not desirable.

SPECIAL-USE GARDENS

Herbaceous ornamentals are used to create gardens with special qualities such as rock gardens, bog gardens, prairie and meadow gardens, cottage gardens, cutting gardens, fragrance gardens, herb gardens, or traditional herbaceous perennial gardens.

How to Plant (Design)

FORMAL AND INFORMAL

Once you have decided where to plant herbaceous ornamentals, decide on a design. Formal designs are composed mostly of straight lines and symmetry. What appears on the right side of the garden is matched on the left. A formal design is easy to lay out and, because of its visual simplicity, is the best choice for a small lot. Informal gardens are composed of curved flowing lines and a disregard for symmetry.

BEDS AND BORDERS

Beds are large blocks of planted areas. The bed requires a relatively large area around it to look its best. If you have a large yard you may have the perfect spot for a bed.

Borders run along the edges of shrub beds, buildings, fences, walkways, and lawns. They conserve space and soften the edges of whatever they border.

As a general rule, the sum of the widths of the beds and borders should not exceed one-third of the width of the yard. Also, individual beds should be no more than five-eighths to two-thirds as long as the long axis of the yard.

Herbaceous ornamentals can also be tucked here and there in a shrub or perennial bed or border to provide a spot of seasonal color. Avoid spots, however, where water-greedy roots of trees and shrubs will interfere with growth. In these spots, a container of herbaceous ornamentals provides better results.

PLANT CHOICE

Choice of materials to use depends on the desired effect and will be influenced by color scheme, season of flowering, texture, diversity, type of background plants, and available space. When designing the bed or border, remember to place the lower-growing plants to the front so that they will be visible and not shaded out by taller types.

Since it is easier to place the tallest plants first, design the border from the back to the front and the bed from the middle to the edge. Design from fall to spring rather than spring to fall. This ties in with the suggestion to design from the back to the front of the border and from the middle to the edge of the bed, since fall plants are often taller and would logically be placed in the back of the border or the middle of the bed. Finally, because you read from left to right, design from left to right.

Plant in clumps or drifts of plants using groups of the same species or cultivar. When planting in groups of less than ten, plant odd rather than even numbers of the same plant. These design suggestions help avoid the "zoo" effect (a collection of one of everything) by leading the eye through the planting.

Gardening in Containers

Almost any annual can be grown in a container. Plants that spread or cascade are suitable for the outer rim of regular containers and for hanging baskets. If plants are mixed in a container, all should have similar sun and water requirements. Containers and hanging baskets allow the gardener to provide spots of color almost anywhere around the home grounds.

CONTAINERS

Choose a container with holes in the bottom to drain the water. A tray underneath will catch any drainage. Avoid letting pots rest in standing water, as roots may begin to rot. Glazed clay pots and plastic containers do not breathe and will not need watering as often as clay. Darker colors absorb more heat, which warms the soil but causes more water loss. Therefore, light-colored containers may be the best choice for most gardeners.

SOIL

For containerized plants, purchase a commercial potting mix that is a blend of peat, pearlite, and other components and contains no soil. Mixes are blended to hold water and nutrients and to drain well. Mix some slow-release fertilizer with the mix or liquid feed about every two weeks. Water containers well before applying the liquid fertilizer.

PLANTING

Containers look best when packed with plants. A planted container should look attractive immediately after or within a few weeks of planting.

WATERING

Plants in containers require regular watering. Always water until the water runs out of the drain holes. Water can run right through very dry soil without actually wetting it. If you have doubts, tip the container up to test that it has become much heavier with water.

MAINTENANCE

Herbaceous annuals make excellent long-flowering container plants. However, perennial container plants can be placed in the garden after their limelight. If containerized perennials are not planted out in the garden, place them in a cold frame or garage to protect their roots from freezing during the winter.

Getting Started with Annuals

An annual plant completes its life cycle in a single year. Unless the plants reseed themselves, new annuals need to be planted every season. Some hardy annuals have seeds that germinate and grow in cooler soil. The plants withstand some freezing and thawing. Half-hardy annuals take some cool, damp weather but a frost will kill them. Tender annuals can take no cool weather at all. Some annuals reseed depending on the variety and climatic conditions.

Annuals serve many functions in the garden, but their primary use is to provide color. They grow quickly and easily, are great for cutting, and are generally inexpensive. Annuals generally bloom for most of the season. An added bonus is the fragrance that some annuals bring to the garden. Annuals come in a variety of sizes, shapes, and colors.

PROPAGATION

Seeds—Come in mixtures and single cultivars. Hybrid seeds are usually more expensive but often produce spectacular flowers. If you save your own seed, be aware that most flowers, and especially hybrids, will not breed true-to-type. Seeds will lose their viability if stored for many years, so starting with fresh seed packaged for the growing year will get you off to the best start.

Seeds that are started indoors or in a greenhouse should be growing 4–6 weeks before you place them in the garden. The warm weather annuals should be transplanted outdoors after the danger of frost.

The easiest way to begin annual plants is to plant the seeds directly where you wish the plants to grow. The seedlings can be thinned to achieve the desired density. Follow the seed package instructions for time and depth of planting.

Transplants — Plants from the garden center save you time and effort. They are, however, more expensive than growing your own. Some flowers such as petunias, impatiens, and geraniums have very small seeds, are slow to germinate, and their seedlings take longer to reach transplant size. They can be started indoors, but they demand precise growing conditions and vigilant care. It is easier to buy transplants for these types of plants.

Pick good plants. Make sure plants are healthy and growing vigorously. Plants that have obviously dried out, have overgrown their containers, or are yellow or leggy should be avoided because they will bloom poorly and require constant watering.

Slip plants out of their containers to check the roots. Look for a fine network of healthy roots supported by visible soil. Avoid plants with a mass of dense, white, tangled roots.

GROWING, CULTURE, AND MAINTENANCE

Soil preparation — A soil test is always a good idea if there is any doubt about the fertility or pH of the soil. Amend the soil appropriately before planting to adjust the acidity and provide the proper nutrients for growth.

Amendments, such as compost, peat moss, and manure added to the soil will increase organic matter and thereby increase water-holding capacity and soil fertility. Covering the soil surface with a 3-inch layer of amendment and digging it into a 12-inch depth provides a good planting area.

Planting — Seeds will germinate when the soil is warmed to the proper temperature. The exact temperature will depend on the annual species being planted.

After the soil is prepared, sprinkle the seed either randomly or in rows with indentations in the soil. Cover the seed with loose, organically amended soil, so the soil will not crust over the seeds. Water with a light misting of water and keep the soil evenly moist until germination occurs. Be sure not to plant the seed any deeper than suggested on the seed package label.

Acclimate transplants before placing them in the soil. Place them in a protected space outdoors for several days and make sure the plant does not dry out. At planting time, tap or tip the plants out of their pots and set them in a prepared hole large enough for the root ball to fit comfortably. Set the plant in the hole, making sure the top of the root ball is even with the surrounding soil surface. Recent research has shown that breaking up the root ball of even the most pot-bound of annuals only slows down their development. Plant the roots as they come out of the container. Do not let the root ball dry out. Firm the soil around the roots and water well. Protect plants against excessive sun, wind, or cold while they are getting started. Inverted pots or milk cartons or row covers can be used.

Fertilizing — Dry or liquid fertilizers work for annuals. Nitrogen stimulates leafy growth, while phosphorus and potash promotes flowering, fruiting, and root growth. Fertilizers with a ratio of 1-1-1, 1-2-1, or 1-2-2 are best for annuals. Remember that the numbers on the package indicate both the ratio and the percentage of active ingredients per pound of nitrogen-phosphorus-potassium.

Dry fertilizer amendments added at planting will last for about 6 weeks. Application of dry fertilizers, followed by a watering (or liquid fertilizer applied to damp soil) maintains the quality of the plants and blooms.

Watering — Young plants need more frequent watering until their roots get established. Sown seeds may need multiple daytime watering. As plants become established, gradually water less frequently. Watering established plants depends on plant size, soil characteristics, and weather. During hot weather, large plants in sandy soil require frequent watering. Strive to keep the plants evenly moist. If plants are allowed to dry out, they may be permanently stunted.

Overhead watering with sprinklers is a common technique. However, some flowers are more susceptible to disease if their leaves and flowers are constantly wet. Overhead watering can also cause taller plants to tip over.

Furrow watering is a common technique if planting is done in rows. Furrows must be tended so the water flows properly and there must be a gentle slope from one end to the other. Once plants get large, the furrow system can be difficult to maintain.

Drip irrigation is the most efficient way to deliver water. Use drip emitters or perforated tubing to deliver water directly where you want it. Infrequent deep watering is better than frequent light applications.

Mulching — This helps annual plants conserve moisture and keeps the soil cooler. Be sure to apply the mulch after the soil has warmed in the spring, otherwise warming will be delayed. Mulches also help in weed control and provide an attractive appearance. Organic materials, such as bark or sawdust, can be incorporated into the soil at the end of the season as an organic amendment.

Mulch materials must allow water to move through. Organic materials must be loose and coarse. Remember that many organic materials draw nitrogen to the soil to aid in breakdown. These materials, when used as mulch, must be augmented with nitrogen fertilizer. Wood by-products, such as bark chips and sawdust, as well as compost make good mulch for annuals. Pine needles and grass clippings can also be used. Spread grass clippings in one thin layer and allow them to dry before adding another layer. Landscape fabric can be spread over the soil surface and covered with bark chips or other organic materials. The fabric stops weed growth, but allows air and water to penetrate the soil.

Thinning — Seedlings grown from directly planted seeds need to be thinned. This process is little more than pulling out the excess seedlings to establish the proper spacing for the type of annual grown.

If pulling disrupts the roots of the remaining plants in the garden, clip off the extras at the soil line with shears. Leaving more plants than necessary at this first thinning will provide some plants for transplantation elsewhere and also allow a margin of safety in case of disease or frost problems. After plants are well established, a second thinning will leave plants with plenty of room to attain a mature growth. Properly spaced plants are healthier and produce more blossoms.

Pinching — Removing the terminal growth on young annual plants helps make them bushier and more compact. Many annuals are now bred to be compact and well branched. However, any plant that has become too leggy or too tall will be improved by pinching. Examples are petunias, geraniums, and many chrysanthemums.

Pinching out the first blossoms that form on some plants stimulates more overall bloom. Examples are marigolds and zinnias.

Weeding — Weeds rob annual plants of nutrients and water and make them look unkempt. Weed problems can be reduced by proper soil preparation and mulching immediately after transplanting. In direct-seeded areas, apply mulch to retard weed growth after the plants have been thinned. If weeds grow among annuals, hoe only deep enough to sever the weeds just below the surface. This will avoid any damage to the shallow feeder roots common to annuals. If weeds are large, pull them by hand.

Deadheading and grooming — Removing the faded flowers (deadheading) will help keep the garden looking neat and will prolong bloom on most garden annuals. A plant that is ripening seeds produces less blossoms. Pinch off or cut spent flowers back to the next branch. Shearing the flower heads with pruning shears works well for smaller-flowered plants. Be careful not to cut back too far. Remove less than one-third of the plant.

Grooming annuals involves removing dead leaves and thinning extra branches. Grooming keeps plants looking good and, by removing dead foliage before it can mold on the plant, keeps diseases from gaining a foothold.

Thinning the foliage keeps the air circulating through the plants, keeps the plants dry, and cuts down on diseases. Thinning also allows light to penetrate the interior of the plant. Often insect pests, which otherwise might be overlooked, are discovered during the grooming.

Staking — Tall-growing annuals such as larkspur and marigolds need protection from wind and rain or overhead sprinklers. Stakes help them grow straight and keep them from being knocked over.

Stakes can be made of wood, bamboo, or any similar material. To be less conspicuous, stakes should be small in diameter and about 6 inches shorter than the mature plant to avoid being visible above the plant. Secure the stems to the stakes with paper-covered wire, plastic ribbon, or other material that will not cut into the stem. You can also support the plants with a framework of stakes and strings in crisscrossing patterns. Commercial support frameworks are available for herbaceous annuals.

Stake plants before they have a chance to fall over or begin to grow crooked. When the plants are about one-third of their mature size, begin staking. Place stakes or frames close to the plant, but take care not to damage the root system. Secure the plant stems to the stake or frame as the plant grows taller.

Insects — Although ornamental annuals are generally pest-free, the following insects can sometimes cause problems: aphids, beetles, caterpillars, thrips, whiteflies, earwigs, and mites.

Annuals that are well maintained can withstand most attacks by insects. Plants under water stress or those lacking plant nutrients become more susceptible to insect attack. Keeping annuals healthy and growing is the first line of defense. Many insect pests are naturally controlled by predator insects. Chemical sprays destroy these predators and should be avoided.

Insects, such as aphids, mites, thrips, and whiteflies, can be controlled with insecticidal soaps. Caterpillars can be controlled with Bt (*Bacillus thuringiensis*) spray. Earwigs can be trapped in rolled newspapers and then destroyed.

If chemical treatment becomes necessary, make sure your pest is positively identified and use a chemical appropriate for its control. Always follow label directions.

Diseases — Since annuals are only in the garden for one season, diseases are not as serious a problem as they are for perennials. The following diseases, however, can sometimes cause problems: the fungus diseases botrytis blight (gray mold), damping-off fungus, powdery mildew and rust, and the virus diseases mosaic and aster yellows.

Moist conditions and splashing water favor and spread the fungus diseases rust, powdery mildew, damping-off fungus, and botrytis blight. Spacing and grooming plants correctly to maintain a good airflow helps to prevent these diseases. Sprinkler watering in the morning so the foliage will dry during the day or drip irrigating so the foliage stays completely dry is also useful. Damping-off can be prevented by planting seeds after the weather warms and not keeping the seeds and seedlings too wet.

Botrytis gains a foothold in dead plant parts. Deadheading and grooming can help to keep this disease out of annuals. Insects such as aphids and leafhoppers spread the virus diseases mosaic and aster yellows. Starting with virus-free plants and then excluding insect pests detours these diseases. No control is available for the virus diseases. Plants must be pulled and destroyed. The fungus diseases are controlled with fungicides. Check the label of each chemical for the organisms it controls and the proper application methods.

Other pests — Slugs and snails are very common and can chew small annuals down to nothing. Handpick, trap, and destroy the pests or use commercial baits.

DESCRIPTION OF SELECTED ANNUALS

***Antirrhinum majus* (Snapdragon)** — Available in many colors. Grows in full sun. Height varies from 12 inches for dwarf plants to 36 inches for the tall varieties. Plants can be directly seeded or transplanted in early spring. These plants often reseed themselves under Idaho conditions.

***Begonia semperflorens* (Bedding begonia)** — Colors in shades of red and pink and white. Leaves are bright green or bronze red and waxy looking. Grows in partial sun to shade. Height is 6–12 inches at maturity. Seeds are slow to start and are best used as bedding plants or houseplants.

***Calendula officinalis* (Pot marigold)** — Flowers are white, cream, orange, yellow, and apricot. Grows in full sun. Mature height is 12–30 inches. Sow seeds directly in early spring. Flower petals are edible and the flowers make long-lasting cut flowers. These plants are very easy to grow and will reseed profusely.

***Callistephus chinensis* (China aster)** — Asters come in white, light yellow, pink, red, blue, and lavender or purple. Grows in full sun. Height varies from 6 to 30 inches. Sow seeds directly into garden in spring. These plants dislike being transplanted. Many flower forms are available and they all make excellent cut flowers.

***Centaurea* sp. (Bachelor's button)** — Colors vary from blue, pink, rose, purple, yellow, and white. Grows in full sun. Height is 12–36 inches tall. The different species have differing planting and growth requirements.

***Cosmos* sp. (Cosmos)** — Colors are yellow, orange, red, white, pink, and bicolors. Grows in full sun to partial shade. Height is 2–7 feet. Easy-to-grow plants make good backgrounds for other annuals. Several different species have differing planting and growth requirements. These plants will reseed.

***Dahlia* sp. (Dahlia)** — Comes in all colors except blue. Requires full sun for at least half the day. Height is 12–20 inches. These seed-grown plants form tubers that can be dug and stored over the winter. To assure vigorous bloom, however, replant each spring from seed. These showy plants bloom profusely in the first year.

***Ipomoea tricolor* (Morning glory)** — Colors include blue, white, pink, red, chocolate, crimson, lavender, and violet. Grows in full sun. This climbing plant grows to 10 feet, but some dwarf forms are available that grow to 5 inches. This fast-growing vine is attractive on trellises and fences. Flowers on old varieties are open only at night, but the newer varieties stay open most of the day. Several different species are available. Some reseed.

***Lathyrus odoratus* (Sweet pea)** — Comes in pink, red, purple, lavender, white, cream, apricot, salmon, maroon, and bicolors. Prefers full sun. Climbing types will grow to 5 feet while bush types grow to 12–36 inches. Can be planted very early. Keeping seedpods off plants will keep it blooming.

***Limonium sinuatum* (Statice)** — Colors include blue, lavender, white, rose, yellow, apricot, and peach. Prefers full sun. Grows 10–48 inches tall. This plant is easily dried and is decorative in bouquets. Various forms yield plants of differing heights. *L. sinuatum* has flowers in flat-topped clusters while *L. suworowii* has curved spikes of bright rose or lilac flowers.

***Lobelia erinus* (Lobelia)** — Colors include white, cream, rose, pink, purple, violet, and lavender. Grows in full sun to light shade. Height is 4–6 inches. Lobelias are easy to establish as transplants. Flowers best when nights are cool. Attractive in front of other annuals and in containers and hanging baskets.

***Pelargonium* sp. (Geranium)** — Comes in shades of red, pink, orange, violet, white, and bicolors. Grows in full sun to partial shade, depending on variety. Height is 8–36 inches. These popular annuals can be planted as rooted cuttings or as transplants in spring. Several different species have differing growth habits. All make good houseplants. They can also be overwintered in a cool, unheated cellar.

***Petunia hybrida* (Garden petunia)** — Colors available include shades of pink, red, salmon, coral, yellow, cream, blue, purple, white, and bicolors. Plants prefer full sun. Height is 8–27 inches. They are best started as transplants. The long blooming period of petunias make them a popular annual. Flowers are single or double. The plants adapt to a wide range of soil and water conditions. They also make good cut flowers.

***Portulaca grandiflora* (Moss rose)** — Colors include white, cream, yellow, orange, red, and pink. Grows in full sun. Height is 6 inches. Sow seeds directly or set out transplants. This favorite grows in sunny, dry areas where many other plant will not grow. Plants have a trailing habit and the leaves are succulent. Flowers are single or double and open in the sun and close in late afternoon. These plants look good in rock gardens, containers, and hanging baskets.

***Tagetes* sp. (Marigold)** — Colors available include white, off white, yellow, orange, and orange red. Plants grow in full sun. Height is 4 inches–4 feet. They easily establish from seed or as transplants. Marigolds bloom continuously from early summer until frost. All are good as cut flowers. The many different species have various flower forms and plant-growth habits.

***Tropaeolum majus* (Nasturtium)** — Colors include cream, yellow, orange, red, and pink. Plants grow in full sun. Height varies from 15 inches in the dwarf varieties to 10 feet in the climbing types. They easily establish from seed, but plants do not transplant well. Young leaves and blossoms have a peppery flavor and are edible. Blooms profusely throughout the summer until frost.

***Viola* sp. (Pansy)** — Colors available include white, yellow, orange, red, purple, blue, and bicolors. Plants grow in full sun or partial shade. Height of plants is 8 inches. Violas establish easily as transplants and are popular to bed in containers, hanging baskets, and rock gardens. These plants grow best in early spring through early summer. Some varieties are more heat tolerant than others. The various species have various flower and growth characteristics. They bloom all summer in cool regions if plants are dead-headed but need to be replaced in hot summer climates.

***Zinnia elegans* (Garden zinnia)** — Comes in shades of white, yellow, orange, red, pink, purple, and bicolors. Plants grow in full sun. Height is 6–36 inches. Zinnias are easily started from seed. These plants grow easily and bloom through the heat of summer and into late summer when most other annuals have finished. Available in dwarf and tall-growing varieties.

Getting Started with Biennials

Biennial plants complete their life cycle in two years. During the first year plants produce leaves that are often close to the ground and arranged in circular patterns. The rosette of leaves overwinters; the winter cold period stimulates flowering during the second year. The plants bloom and then die.

Biennial seeds can be planted in midsummer to produce plants that develop in the fall. The plant then blooms the next year. Popular biennials are stock, foxglove, silver dollar, and hollyhock.

Culture of biennials is the same as for annuals except the plants remain for two years.

Getting Started with Perennials

Historically, herbaceous perennials have always been an important component of the ornamental garden. Recently there has been an upsurge of interest across the United States in the culture of herbaceous perennials. Despite this renaissance, many gardeners are reluctant to try growing herbaceous perennials because they still lack appreciation and knowledge about them.

Herbaceous perennials take the name *herbaceous* from the word **herb**, a seed-producing annual, biennial, or perennial that does not produce woody stems. Herbaceous perennials are termed **perennial** in that they take one or more seasons to go from seed to seed and then generally, but not necessarily, live for three or more seasons. Some such as columbine may be short-lived, while others such as peony will outlast several generations of the same family in the same site without being divided or moved.

The tops of the plants, the flowers, the leaves, and the stems of herbaceous perennials usually die back to the ground with the first fall frost. The hard, fleshy subterranean portions of the plant, the crown and roots, survive the winter and resume growth in spring. Those herbaceous perennials that survive the winter with little or no protection are termed **hardy**. Those herbaceous perennials that need some protection to survive the winter outdoors are said to be **half-hardy**. Some herbaceous perennials must be lifted as tubers, rhizomes, or bulbs, stored overwinter or placed in a greenhouse, and then be replanted in spring. These plants are termed **tender** herbaceous perennials.

Herbaceous perennials are available in an unlimited variety of flowers, foliage colors, textures, forms, spreads, and height. As a group, they are the first plants to bloom in the spring and the last to fail with the fall frosts. They seldom bloom more than a few days to several weeks as individuals, but afford a continuity of bloom as a bed or border.

Being herbaceous rather than woody, herbaceous perennials have the capacity to bend in the breeze and lend interest and movement to a static landscape. They have the advantage, unlike trees and shrubs, of obtaining a definite size each season, somewhere between a few inches to 10 feet tall. Generally, they need division and no pruning. They vary in their environmental preferences from wet to dry, fertile to infertile, low to high pH, sandy to loam to clay soils, as well as shady to sunny sites. They also vary widely in the amount of care they need. While there are no maintenance-free herbaceous perennials, many require low maintenance.

THE PURPOSE OF A PERENNIAL GARDEN

A perennial garden may have different purposes and fill many needs. The great English gardener, Gertrude Jekyll (1843–1932), perhaps said it best when she penned:

> *The first purpose of a garden is to give happiness and repose of mind, which is more often enjoyed in the contemplation of the homely border . . . than in any of those great gardens where the flowers lose their identity, and with it their hold of the human heart, and have to take a lower rank as mere masses of color filling so many square yards of space.*

The benefits and opportunities a perennial garden offers include the following:

- Enhances those outdoor areas where you will spend much of your time from spring to fall.
- Creates an attractive privacy screen.
- Softens and makes attractive a steep slope by terracing it and planting herbaceous perennials.
- Creates a bog garden where it is too wet for a lawn.
- Creates an inviting entrance to your house.
- Grows flowers that provide indoor or outdoor fragrance.

- Integrates the other features of the landscape into a whole.
- Creates a special place to exhibit your skill at raising specimen plants.
- Masks unattractive aspects of a yard such as toolsheds, garbage cans, compost bins, etc.
- Allows you to use a rocky outcropping as a rock garden (no need to remove the rocks).
- Creates a stunning view from inside the house.
- Adds color, shape, and dimension to small yard patches next to entrances, which softens the hard features of an existing backdrop.

SEXUAL PROPAGATION BY SEED

This method is advantageous because disease is not as easily carried over on the seed as it may be through vegetative propagation. To start herbaceous perennials from seed, harvest the seed when it is ripe but before the spent flower heads self-sow. Keep in mind that seeds of many horticultural cultivars will not come true-to-type owing to their hybrid parentage. To start perennials from seed indoors, start them in midwinter to early spring so some of them will bloom during the first growing season. Seeds may be started in a greenhouse or on a sunny windowsill but most commonly are started under lights.

VEGETATIVE PROPAGATION BY DIVISION, STEM CUTTINGS, ROOT CUTTINGS, LAYERING, GRAFTING, OR TISSUE CULTURE

Vegetative propagation guarantees that the offspring will be identical to the parent. Usually it takes far less time to have a fully mature blooming herbaceous perennial when it is vegetatively propagated.

Division — This is the simplest and most certain way to propagate, control the size of, and rejuvenate herbaceous perennials. Generally, perennials become larger each year and eventually begin to choke out other plants. Their outer edge thrives while the center of the clump suffers from competition for water, nutrients, root run, and sunlight. Often an advanced-age clump looks like a doughnut with a thriving outer ring and a dead center. Such a clump is a prime candidate for division. Shasta daisies, chrysanthemums, and phlox are good examples of plants where this condition exists after 2–3 years.

The time to divide a perennial clump depends upon the particular perennial, the time of year that the perennial blooms, and the climate. In United States Department of Agriculture Plant Hardiness Zone 5 or colder (less than 5), most division is done in the spring while the perennials are still slightly dormant. Division is usually necessary only every 2–4 years for most perennials. Some perennials, such as the chrysanthemum, benefit from being divided every year while others, such as the oriental poppy, are best left undisturbed for as long as possible or never divided.

Different types of perennials are handled in other ways depending upon their growth habit when they are dug and divided. For example, compact shallow-rooted plants are divided by digging the entire clump and pulling it carefully apart into smaller plants. Solid clumps of plants such as daylilies, hosta, phlox, and Siberian iris are divided by digging up the entire clump and using two spading forks back-to-back to pull the clump into sections. If the center of the clump is deteriorated, it must be discarded. If you wish to have a small section of an existing clump for use elsewhere, use a sharp spade to dig a healthy section away from the parent clump without disturbing the parent clump.

Shallow-rooted ground covers such as vinca and creeping phlox are divided anytime during the growing season by digging them up and cutting them apart. Fibrous- to woody-rooted perennials such as lupine must be dug carefully, the soil rinsed from the roots, and then the crown carefully divided with a sharp knife, making sure that each segment contains two to four strong taproot segments and two to four eyes or shoots.

Tip or stem cuttings — These are rootless sections of plants that are placed in a rooting medium where they are induced to develop adventitious roots. Cuttings may also be taken from actively growing roots.

Tip or stem cuttings are propagated by taking a terminal, 3–6-inch long firm portion of a vigorous nonblooming shoot that includes several nodes. Spring is the best time to take cuttings from herbaceous perennials that bloom in summer. Early summer is the best time to take cuttings from those that bloom in spring or fall.

Most perennials cuttings should begin to develop roots in 1–2 weeks. Bottom heat will speed the rooting process but is not necessary.

Sometimes young, virtually rootless tufts of shoots develop at the base of the perennials. These may be pulled away from the parent plant and treated the same as any cutting.

Root cuttings — These cuttings are best made in early spring. While it is easiest to take cuttings from perennials when they are being lifted from the bed or border, cuttings can also be taken from the parent plant by digging around the periphery of the parent plant with a shovel. Fine-rooted plants, such as *Achillea*, are propagated from root cuttings by scattering 1–2-inch long sections of root horizontally on the surface of a 2–3-inch deep layer of moist soilless medium in a flat (a shallow box in which seedlings are started). Cover the pieces of root with ½ inch of moist sifted, soilless mix.

Fleshy-rooted perennials such as baby's breath, bleeding heart, peonies, and oriental poppies are propagated by taking 1½–2-inch long sections of roots, dusting the bottom end with a rooting compound, and sticking the root cutting bottom end down in a 50-50 mixture of peat moss and sand in pots or deep flats, with ¼ inch of the cutting sticking above the rooting medium. For peonies, take 3-inch-long root cuttings and keep the medium moist but not wet. When the cuttings begin to grow, treat them the same as any other seedlings.

Layering — This is an easy way to propagate vine-type plants and ground covers. Bend the supple stems, without severing the stem from the parent plant, down to the soil into a shallow trench and cover several nodes with soil or bend the stems into pots of soil.

Notching or wounding the area just below a soil-covered node will encourage rooting. Many upright plants can also be rooted with this technique by carefully bending their younger, more flexible stems downward to the ground.

Grafting — This is the joining of the top of one plant, the **scion**, to the bottom of another plant, the **stock**. This technique is possible but rarely used in propagating perennials.

Tissue culture — Millions of disease-free plants from a single small clump of apical cells in a single season can be generated from a tissue culture. This method is beyond the facilities and capabilities of the ordinary homeowner.

VEGETATIVE PROPAGATION BY SPECIALIZED STEMS AND ROOTS

These function primarily as food-storage organs and can also function in vegetative reproduction.

Bulbs — Tunicate bulbs have outer-bulb scales that are dry and membranous and are typical of the tulip, hyacinth, bulbous iris, and daffodil.

Nontunicate or scaly bulbs are represented by the lily. These bulbs do not have the dry covering and the scales are separate and attached to a basal plate. Propagation is accomplished by periodically removing the small bulbs or offsets that grow off the main bulb. This is usually done whenever the plants are dug. Digging these perennials is necessary when the clumps become too crowded and is done after the foliage has died down naturally in the late summer or fall. Bulbs should be planted or replanted at that time. The small bulbs may need to grow for several seasons before they are large enough to flower. Lilies are propagated by removing some of the outer scales of the mother bulb, planting them, and allowing them to develop small bulbs.

Corms — Gladiolus and crocus are typical plants with corms. Gladioli are semihardy to tender in Idaho and must be stored overwinter in areas with severe winters. The corm is a swollen base of the stem that is enclosed by dry, scaly leaves. Propagation is accomplished by separating the small corms or cormels from the mother corms. Plant these small corms shallowly and expect no flowers until they grow large enough, usually 1 or 2 years.

Tubers — These are a modified stem that serves as a storage organ. Caladium is an example of a tuberous plant. Tubers can be propagated by planting the whole structure or by cutting tubers into sections, each containing one or more buds or "eyes." This division is done shortly before planting.

Tuberous roots and stems — These thickened structures are botanically different from true tubers but are often simply called "tubers." Tuberous roots are typical of several types of perennials, including the dahlia. Propagation is done by separating the tuberous roots, making sure that each root has a section of the crown with a shoot bud. Divide in late

winter or spring, shortly before planting. Tuberous roots are biennial, meaning the old root disintegrates in the second year after new tuberous roots are produced.

Tuberous stems include the tuberous begonia and cyclamen. These structures are usually vertical in orientation and have vegetative buds on the upper end. These tuberous stems continue to grow larger and larger from year to year. Divide these structures early in the spring, making sure each has a bud.

Rhizomes — These specialized stem structures grow horizontally on top of or just below the soil surface. Rhizomatous iris and lily of the valley are two perennials that can be propagated by their rhizomes. Remove sections of shoots and roots early in the spring or in late summer or fall.

GROWING, CULTURE, AND MAINTENANCE

Site selection — Because herbaceous perennials can be left in a given place for a long period of time, proper site selection is critical. Most plants prefer a site that has a fertile, well-drained, organically rich soil with a pH of 5.5–6.5. Good drainage is important, especially during the winter, and most soils will have to be improved. The site should receive full sun or shade all day. Be sure to consider not only the present shade, but also the future shade. Take into account the growth of your trees and shrubs as well as your neighbor's. The site should be flat to only slightly sloped. It should be out of the drying, stem-snapping wind but have enough breeze to provide the air circulation essential to minimize the slow foliage-drying conditions conducive to disease.

Soil preparation — The best opportunity to tailor the soil needs of a perennial is the first time it is prepared. Try to start soil preparation long before planting the bed or border. Start in spring for a fall planting and in fall for a spring planting. This will allow plenty of time for any organic soil amendments and/or pH modifications to take effect. To prepare the site for planting perennials,

- Clear all large debris from the site. Kill and remove all existing vegetation from the site for composting. It may be necessary to re-treat the site to kill persistent perennial weeds such as quack grass.
- Spread 2–3 inches of organic matter such as well-decomposed compost, aged manure, or peat moss over the surface of the soil before beginning to work it. Rototill or spade the organic matter into the soil to a depth of 8–12 inches. Add no more organic matter than one-third of the final amended soil volume. Do not work the soil when it is wet. Organic matter incorporation improves soil structure by providing the lignin that glues together the soil particles. Improved soil structure encourages water percolation and retention, aeration, and root penetration. Spread an organic mulch over the prepared bed or border. It is easier and tidier to spread the mulch before planting.
- Edge the bed or border in some fashion. An edging will be attractive and will help reduce the encroachment of the lawn.

Planting and transplanting — While bare-rooted perennials are best planted either in the spring or fall, container-grown perennials may be planted at any time during the growing season, though it is more difficult during the drought months of July and August. Freshly dug plants are best transplanted in spring or fall but may be moved all summer if you are careful. Perennials such as bearded iris, bleeding heart, peonies, and oriental poppies are best transplanted immediately after their brief dormant period after bloom. When planting herbaceous perennials,

- Dig a hole two times the size of the root spread of bare-root perennials and one and one-half times the size of the root ball of container-grown perennials.
- Soak the roots of bare-root plants for several minutes in a starter solution of 1 tablespoon of 16-12-10 or 20-20-20 water-soluble fertilizer dissolved in 1 gallon of water.
- Water the potted herbaceous perennials with a starter solution before knocking them out of the container. Place your hand over the top of the pot with your fingers grasping the main stems, turn the pot upside down, and tap the pot rim on the edge of a hard surface or tap the bottom of the pot sharply with a planting trowel. Remove fiber pots from perennials because often pots do not decompose. Be sure to at least peel back the rim

of peat pots below soil level or the rim will act as a wick, drying out the pot and the contained soil.

- Some pot-bound plants may have to have the container cut away with snips. Score the soil ball, making three to five vertical cuts into it, top to bottom, with a sharp knife. The depth of the cuts will vary from ½–1½ inches deep, depending upon its size. Tease some of the soil away from the top, sides, and bottom of the soil ball.
- Place the plant in the planting hole, making sure that the crown of plant is at the same depth as it was while previously growing.
- Work some organic matter one-fourth to one-third by volume into the soil. Place this mixture around the roots until the hole is half full. Settle the soil around the root system by mucking it in with the starter solution. Finish filling the hole with the soil–organic matter mixture.
- Tamp the soil firmly around the root system. Leave a berm to facilitate watering. Water the newly planted perennials with the starter solution. Label the plants or make a map of the garden for future reference.

Fertilizing — Perennials need steady, but light fertilizing first in late March to early April, right after the last of the mulch is removed and growth starts. Use a 5-10-5 fertilizer at the rate of 2 pounds per 100 square feet of bed space. Fertilize two more times at the same rate about 6 weeks apart. Fertilize a final time in very late summer for fall-blooming perennials.

If the perennial bed or border begins to lag a bit in midsummer, use a water soluble foliar fertilizer as a boost. Foliar feeding should always be thought of as supplemental to, rather than as a substitute for, granular fertilizers.

MASTER GARDENER TIP

Overfertilizing, especially with nitrogen, promotes vegetative growth at the expense of flowering and increases the need of staking for support.

Watering — Frequency is dictated by climate and the presence of a mulch. Water early in the day to avoid going into the evening with wet, disease-susceptible foliage. Water thoroughly, to a depth of 8–10 inches, to encourage deep root penetration. Soil should dry out a bit between watering. Waterlogged soil will encourage root disease and excludes oxygen, resulting in shallow-rooted, drought-prone, unstable plants.

Mulching — Helps control weeds, reduces water loss, moderates soil temperature changes, prevents mud splattering of foliage and flowers, helps preserve surface soil structure, and adds nutrients to the soil as the mulch biodegrades.

Winter mulch can protect perennials from excessive cold temperatures and harmful thawing on freezing cycles. Apply after the first cold weather has occurred and after the soil has frozen. Cover crowns with 2–6 inches of light, porous mulch. Remove mulch in the spring or before plant growth begins.

Summer mulch can be applied after the soil warms up, about 4–6 weeks after the last of the winter mulch is removed. Try to coordinate the placement of the summer mulch so that it follows one of the fertilizations and weed-destroying cultivations. Apply between 1–2 inches of mulch. Be sure to keep the mulch away from the crown of the herbaceous perennial.

The best mulches to use are those that biodegrade to the point that they can be worked into the soil in late fall or early spring. Mulches in this category include compost, peat moss, or smaller-sized bark.

Thinning — Removing some of the stems increases the potential size of the individual blooms produced by the plant. For the most part, thinning is not necessary as it decreases the mass of the plant and may reduce the overall bloom impact of the plant.

Pinching — Inhibits the natural legginess of many perennials such as chrysanthemums. Pinching the growing tips or shoots of the individual stems once in May or June removes the inhibition of the shoot tip, producing multibranched shoots. This produces a whole bouquet of smaller-than-usual individual blooms. The combined branched shoots give the entire plant a much greater overall blooming mass despite the smaller individual blooms. Chrysanthemums are pinched every 3–4 weeks with the last pinch occurring about July 15.

Pinching also delays blooming. A soft pinch, just the tip of the stem, does not delay flowering as long as a

hard pinch, which removes several inches and several nodes from the stems. Pinching also decreases the need to stake herbaceous perennials as the plants are more compact.

Weeding — This is important because weeds compete for nutrients and water. Weeds may be grassy or broad-leaved and annual, biennial, or perennial. The unwanted offspring of existing perennials may also be considered weeds since many of them, especially those from hybrid parents, will not come true-to-type. Your first chore is to be able to distinguish weeds, even at the seedling stage, from desirable perennials. Once so distinguished, weeding can be done by hand, with shallow cultivation or herbicides, or largely avoided by using mulches.

Deadheading — Removal of spent blooms or inflorescence improves the appearance of herbaceous perennials and prevents the investment of energy in seed production. It also encourages the plant to continue blooming and stimulates a second flush of weaker blooms in those plants such as delphinium and foxglove.

A few perennials such as sedum 'Autumn Joy,' black-eyed-Susan, and ornamental grasses should be allowed to retain their seed heads for their winter interest.

Disbudding — The removal of all except the tip-most bud on each individual stem or branch of a multibranched stem produces large flowers on each stem or branch of that stem. Peonies are often disbudded in this fashion. The most spectacularly sized blooms can be achieved by taking a rooted cutting and limiting it to a single terminal bud on a single stem. One shortcoming of disbudding is that the second flush of bloom, which occurs after the terminal bud blooms and the axillary buds develop, is lost. Some gardeners remove the terminal bud to obtain a host of relatively large axillary blooms.

Staking — Giving a physical support to individual stems or to the plant as a whole is often necessary for those perennials with a natural tendency to fall over because of their height, habit, or weight of blooms and foliage.

Tall, single stems of perennials such as delphiniums, gladioli, and hollyhocks may require individual stakes for support. Select bamboo, plastic, or metal stakes that will be at least three-quarters as tall as the individual stems they are to support when firmly anchored in the soil.

Tie the stems to the stakes with a figure-eight loop with one loop around the stake and the other around the stem. This double loop acts as a spring giving the stem a chance to sway in the breeze. The loops can be made with paper-covered wire, floral tape, or other soft material.

Stake bushy, multistemmed, floppy perennials such as asters, chrysanthemums, and coreopsis by pushing a ring of stakes into the soil at a point slightly to the interior of the perennial. Select stakes that are 6–12 inches shorter than the ultimate height of the plant. Weave a cats' cradle of support between the stakes with green yarn or floral tape. Start 1 foot above the soil level and continue upward at 1-foot intervals until the last cats' cradle is 8–12 inches below the top of the stems.

Alternatively, push appropriate lengths of multibranched tree or scrub prunings or branched bamboo canes into the soil at the fringes of the perennial. Let the interweaving branches supply most of the support. Some twine or floral tape may still be needed to contain the stems of the perennials.

Place very strong, multilegged 18–20-inch-tall wire hoops around perennials such as peonies and oriental poppies that have very heavy blooms on supple stems.

Insects and diseases — Practices to prevent or reduce the chance of insect and disease problems include:

- Select insect and disease-resistant perennials.
- Give your perennials the very best growing conditions possible from the standpoint of soil, nutrition, watering, spacing, sunlight, and air circulation.
- Grow a variety of plants. A monoculture of a cultivar or of a few cultivars will be far more susceptible to insect and disease problems.
- Remove spent flowers, dead leaves, and other plant litter during the growing season when it can be a source of infestation. Clean up the bed or border thoroughly before winter to avoid building up any refuse-harboring insects and disease over the winter.

- Keep weeds out of the bed or border and the immediate area because they are a source of both insect and disease problems.
- Know what the most likely common pests of your perennials are and then monitor for them.
- Do not compost any diseased plants. If your compost pile reaches 140°F–160°F, most disease organisms and insect eggs will be killed. However, most piles never get this warm, especially in the outside portion. Fungus organisms will spread along with compost.
- When a problem is encountered, act immediately without using pesticides if possible. Cut off diseased portions of the herbaceous perennial or remove seriously damaged plants entirely. Handpick large insects.

Pesticide control—Consult with your county Extension educator for the most biorational pesticide to use for your particular problem.

Spot treat if possible. Use nonchemical, nonbiological pesticides such as horticultural oils and insecticidal soaps. Use biological pesticides such as Bt for caterpillars or pesticides derived from natural sources such as pyrethrum, rotenone, ryania, or sabadilla. When using any pesticide, follow the label instructions. Always apply at the labeled rate. Buy small quantities of the pesticide to avoid disposal problems.

A Selection of Perennials for Idaho

Idaho growing conditions are difficult on plants. During the summer, temperatures and light intensity are high and humidity is low. This combination causes some plants listed for the eastern United States and lower coastal elevations to perform poorly in Idaho. On the following pages, Table 1 lists perennials available through the Idaho nursery trade or by mail order that have performed well or are deemed worthwhile for trial in Idaho.

COMMON NAME

Lists several names that the perennial might be called. Cross-referencing is done through the text for convenience. For example, hollyhock is listed under alcea. Hollyhock is also found under the common name, which refers back to alcea for more information.

SCIENTIFIC NAME

Since the common name creates a lot of guesswork, the scientific name is included for clarity. Under the scientific name is a listing of cultivars (cultivated varieties) that may be available in your local nursery. The cultivar name (e.g., 'Pink Star') often indicates flower color.

HEIGHT

Varies with fertilizer practices, placement with respect to light, soil conditions, and plant vigor. A range of heights is given for most plants. Determining exact heights will be the part of the joy of gardening. Keep records of your discoveries so that plants can be moved into more correct locations in the future. A perennial garden can be arranged and rearranged like furniture in your home.

BLOOM TIME

Gives you the chance to "orchestrate" and synchronize the blooming sequence. Use a sheet of paper to list and orchestrate your flower display.

FLOWER COLOR

Refers to flower colors available in the nursery trade. It does not necessarily refer back to the specific cultivars in the scientific name column.

LIGHT NEEDED

Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial shade is filtered sunlight through tree leaves or a minimum of 6–8 hours of sunlight per day; full shade indicates filtered sunlight through a dense foliage canopy or less than 6 hours of sunlight each day.

LANDSCAPE USE

Suggests planting locations as well as indoor uses such as cut flowers or dried flower arrangements.

Table 1. Perennials for Idaho.

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Achillea, dwarf (Woolly Yarrow)	*A. tomentosa* German hybrids, e.g., paprika	8”–10”	June–Aug	Yellow	Full sun	Borders, ground cover
Achillea, tall (Fernleaf Yarrow)	*Achillea* spp.	2½’–3’	June–Aug	Yellow	Full sun Partial shade Full shade	Borders, cut flowers dry flowers
Aegopodium (Bishop’s Goutweed)	*A. podagraria variegatum*	8”–14”	June–Aug	White	Full sun Partial shade Full shade	Ground cover, will grow in poor soil
Ajuga	*Ajuga* spp. ‘Alba’ ‘Bronze Beauty’ ‘Gaiety’	6”–9”	April–May	Blue White	Full sun Partial shade Full shade	Ground cover, edging rock gardens, beneath trees
Alcea (Hollyhock)	*Alcea rosea* (also *Althaea rosea*) ‘Majorette’ ‘Silver Puffs’ ‘Summer Carnival’ ‘Chater’s Double Mixture’	2’–9’	June–Aug	White Yellow Pink Lavender Red	Full sun	Background borders, against fence or wall
Allium (Stars of Persia or Persian Onion)	*A. christophii*	15”–24”	Early summer	Silvery violet	Full sun	Herb gardens, edging vegetable plots, containers, edible foliage, rockeries
Allium (Giant Onion)	*A. giganteum*	3’–4’	Early summer	Pink purple	Full sun	Herb gardens, edging vegetable plots
Allium (Turkestan Onion)	*A. karataviense*	8”–10”	Late spring	Lilac pink	Full sun	Herb gardens, edging vegetable plots
Allium (Golden Garlic or Lily Leek)	*A. moly*	10”–14”	Late spring	Bright yellow	Full sun–partial shade	Herb gardens, edging vegetable plots
Allium (Chinese Chive or Garlic Chive)	*A. tuberosum*	20”	Late summer	White	Full sun–partial shade	Herb gardens, edging vegetable plots
Alyssum (Basket of Gold or Gold Dust)	*A. saxatile* ‘Compacta’	9”–10”	April–June	Golden yellow	Full sun	Rock gardens, dry walls, banks, fronts of borders
Anchusa (Forget-Me-Not)	*A. myosotis*	6”–8”	May–June	Blue	Full sun Partial shade	Borders, groupings
Anemone (Greek Anemone or Greek Windflower)	*A. blanda* ‘Blue Star’ ‘Bridesmaid’ ‘White Splendor’ ‘Pink Star’	3”–6”	April–May	Blue Pink Purple White	Full sun Partial shade	Rock gardens, perennial borders, naturalized

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Anthemis (Golden Chamomile or Golden Marguerite)	*A. tinctoria* 'E.C. Buston' 'Kelwayi' 'Moonlight'	2'–3'	June–Sept	Yellow	Full sun	Perennial borders, cut flowers
Aquilegia (Columbine)	*A. hybrida* 'McKana Giant' 'Mrs. Scott Elliot' 'Rose Queen' 'Spring Song'	2'–3'	May–June	Blue Pink Purple Red Yellow White	Full sun Partial shade	Borders, naturalized settings
Arabis (Rock Cress)	*A. caucasica* 'Snow Cap' 'Spring Charm'	12"	Late March May	White Rose-tinted	Full sun	Rock gardens, dry stone walls, border, small area ground cover
Arenaria (Irish Moss) (Sandwort)	*Arenaria* spp.	2"–6"	May–June	White	Full sun Partial shade Full shade	Evergreen, ground cover, rock gardens, around stepping stones
Armeria (Sea Pink) (Sea Thrift)	*A. maritima* 'Brilliant' 'Laucheana' 'Royal Rose'	6"–15"	May–June	Pink White	Full sun	Edging, rock gardens, cut flowers
Artemisia (Wormwood) (Angel's Hair)	*A. schmidtiana* 'Silver Mound' 'Powis Castle' 'Silver Brocade'	8"–12"	Foliage plant	—	Full sun Partial shade	Perennial borders
Asclepias (Butterfly Weed) (Pleurisy Root)	*A. tuberosa*	2'–3'	June–Aug	Orange	Full sun	Borders, dry flowers
Asperula (Sweet Woodruff)	*A. odorata*	8"	May–July	Pink Blue White	Partial shade	Ground cover, rock gardens
Aster, short/dwarf (China Aster) (Annual Aster)	*Callistephus chinensis* 'Pinocchio' 'Dwarf Queen' 'Color Carpet'	4"–10"	Spring Summer or fall	Many	Full sun	Cut flowers, bedding plants
Aster, tall (New England Aster) (Stokes Aster)	*Aster* spp. *Callistephus* spp. *Stokesia* spp.	1½'–3'	Spring Summer or fall	Many	Full sun	Cut flowers, borders
Astilbe (False Spirea)	*Astilbe* x *arendsii* 'Deutschland' 'Fanal' 'Red Sentinel'	2'–3'	June–July	Red Pink White	Full sun Partial shade	Border plant
Aubretia (False Rock Cress)	*A. deltoidea* 'Bengale' 'Purple Cascade' 'Red Cascade'	6'	April–May	Rose lilac Purple Red	Full sun Partial shade	Rock gardens, dry stone walls, edge of perennial borders
Baby's Breath (see Gypsophila)						

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Basket of Gold (see Alyssum)						
Bellflower, Chinese or Japanese (see Platycodon)						
Bellis (English Daisy)	*Bellis perennis*	4”–6”	April–June	White Pink	Full sun Partial shade	Edging, borders
Bergenia (Heartleaf Bergenia) (Pig Squeak)	*B. cordifolia*	12”–15”	April–May	Pink White	Full sun Partial shade	Evergreen, rock gardens, stream banks, pools, perennial borders
Betonica (Lamb’s Ear) (Wooly Betony)	*Stachys byzantina*	6”–12”	July–Oct	—	Full sun Partial shade	Front of borders, ground cover, rock gardens
Bleeding Heart (see Dicentra)						
Campanula (Carpathian Harebell)	*C. carpatica* ‘Blue Carpet’ ‘China Doll’	6”–12”	June–Aug	Blue lilac White Purple	Full sun Partial shade	Borders or rock gardens
Campanula (Danesblood) (Clustered Bellflower)	*C. glomerata*	1’–1½’	June–Aug	White Blue Purple	Full sun Partial shade	Borders, bedding between shrubs, cut flowers
Campanula (Canterbury Bells)	*C. medium* ‘Cup and Saucer’	2’–4’	June–Aug	White Pink Blue Mauve	Full sun Partial shade	Borders, isolated clumps, balconies
Campanula (Peach Bells)	*C. persicifolia*	2’–3’	June-Aug	White Blue	Full sun Partial shade	Borders
Canterbury Bells (see *Campanula medium*)						
Carnation (see *Dianthus caryophyllus*)						
Cerastium (Snow-in-Summer)	*C. tomentosum* ‘Columnae’ ‘Yo Yo’	6”	May–June	White	Full sun	Evergreen, ground cover, dry stone walls, edging
Ceratostigma (Plumbago)	*C. plumbaginoides*	8”–10”	July–Sept	Dark blue	Full sun Partial shade	Rock gardens, ground cover
Cheiranthus (Wallflower)	*C. cheiri*	9”–30”	March–May	White Yellow Brown Red Pink Purple	Full sun	Balconies, terraces, mixed borders, flower beds, banks, rockeries, slopes
Chive (see Allium)						
Chrysanthemum (Shasta Daisy)	*Chrysanthemum* x *superbum* ‘Alaska’ ‘Esther Read’ ‘Little Miss Muffet’ ‘Marconi’ ‘Snowcap’	2’–4’	June–Oct	White	Full sun Partial shade	Cut flowers, borders
Columbine (see Aquilegia)						

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Convallaria (Lily of the Valley)	*C. maialis*	6”–12”	May	White	Full sun Partial shade	Ground cover, cut flowers
Coral Bells (see Heuchera)						
Coreopsis (Tickseed)	*C. lanceolata* ‘Baby Sun’ ‘Brown Eyes’ ‘Goldfink’ ‘Mayfield Giant’ ‘Sunburst’ *C. rosea* *C. verticillata* ‘Moonbeam’ ‘Zagreb’	2’–3’	June–July	Yellow Yellow chestnut	Full sun	Borders, cut flowers
Creeping Jennie (see Lysimachia)						
Crocus and Hybrids	*Crocus* spp.	2”–6”	Early spring	Golden yellow Blue Lavender Purple White Purple striped	Full sun to partial shade	Excellent for early color; large-flowered “Dutch hybrids” bloom later than most spring-flowering types
Crocus (Autumn)	*Colchicum autumnale*	4”–6”	Early spring	Lavender pink Rose White	Full sun to partial shade	Foliage grows in spring, then dies, flowers appear in fall without foliage
Daffodil (see Narcissus)						
Daisy, English (see Bellis)						
Daisy, Gloriosa (see Rudbeckia)						
Daisy, Painted (see Pyrethrum)						
Daisy, Shasta (see Chrysanthemum)						
Daylily (see Hemerocallis)						
Delphinium (Larkspur)	*D. elatum*	3’–6’	June–July	Many	Full sun	Background accent, cut flowers
Dianthus	*D. barbatus*	4”–6”	May–Aug	White Pink Scarlet	Full sun	Cut flowers, balconies, terraces, borders, rockeries, flower beds
Dianthus (Carnation) (Clove Pink) (Divine Flower)	*D. caryophyllus* ‘Chabaud’s Giant Improved’ ‘Dwarf Fragrance Mixed’ ‘Enfant de Nice Mixed’ ‘Juliet’ ‘Oriental Hybric Mixed’ ‘Spotti’ ‘Tiny Rubies’	1’–2’	June–Aug	White Pink Red Purple Yellow Apricot Orange	Full sun	Cut flowers, flower beds, pot plants, borders
Dianthus (Pinks)	*D. chinensis*	6”–12”	Summer–Fall	Red White Pink	Full sun Partial shade	Edging, cut flowers bedding

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Dianthus (Maiden Pink) (Meadow Pink) (Spink)	*D. deltoides* 'Brilliant'	4"–12"	May–Aug	White Pink Red	Full sun	Rock gardens, border plants
Dicentra (Bleeding Heart)	*Dicentra* spp.	2'–3'	May–June	Red and white	Partial shade	Cut flowers, shaded borders
Digitalis (Common Foxglove) (Fairy Glove) (Finger Flower) (Purple Foxglove)	*D. purpurea* 'Leopard Foxglove'	2'–5'	May–July	Purple and White	Full sun Partial shade	Borders, cut flowers
Doronicum	*D. cordatum* 'Finesse' 'Madame Mason'	2'	April–May	Yellow	Full sun Partial shade	Front or middle perennial borders, cut flowers
Echinops (Glove Thistle)	*E. exaltatus* 'Tapglow Blue'	3'–5'	July–Sept	Blue	Full sun	Cut and dried flowers, back of borders
Erigeron (Fleabane)	*E. speciosus*	1'–2'	June–July	Blue	Full sun	Cut flowers, rock gardens, borders
Euphorbia	*E. myrsinites*	8"–10"	March–May	Yellow	Full sun	Border plants, cut flower, rock gardens
Euphorbia (Cushion Spurge)	*E. polychroma* (epithymoides)	1½'	March–May	Yellow	Full sun	Border plants, cut flowers
Fustuca (Blue Fescue)	*F. ovina glauca*	6"–10"	—	—	Full sun Partial shade	Edging, banks, ground cover
Flax (Golden Flax)	*Linum flavum*	1'–2'	June–Aug	Golden yellow	Full sun	Rock gardens
Forget-Me-Not (see Anchusa)						
Foxglove, Common (see Digitalis)						
Fritillaria (Crown Imperial)	*F. imperialis*	2'–3'	Spring	Red Yellow Orange	Sun or light shade	A very showy old-fashioned plant, but odor may be offensive
Fritillaria (Checkered Lily or Guinea-Hen Flower)	*F. meleagris*	8"–12"	Spring	Checkered purple	Sun or light shade White	Fragile appearance; makes an interesting rock garden plant
Fritillaria (Persian Fritillary)	*F. persica*	10"–30"	Spring	Maroon Purple White	Full sun	Flowers have a slight skunk odor
Gaillardia (Indian Blanket)	*G. pulchella* 'Baby Cole'	1'–2'	Summer Fall	Yellow Orange Scarlet	Full sun	Cut flowers, window boxes, planters
Geranium (Cranesbill)	*Geranium* spp. 'Biokova' 'Johnson's Blue'	1'–2'	May–Sept	Blue Purple	Full sun Partial shade	Rock gardens, perennial gardens
Geum	*Geum* spp.	2'–2½'	May–Aug	Scarlet Orange	Full sun	Groupings in perennial borders, cut flowers

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Glory-of-the-Snow	*Chionodoxa luciliae*	3”–6”	Early spring	Blue Pale pink White Yellow	Full sun	Rock gardens, borders and edgings
Gypsophila (Baby’s Breath)	*Gypsophila* spp.	1’–3’	June–July	Rose Purple White Pink	Full sun	Borders, dry flowers, rock gardens
Helianthemum (Rock Rose) (Sun Rose)	*H. nummularium*	1’	June–July	Yellow Rose Red and crimson White	Full sun	Rock gardens, slopes and pockets, crazy paving
Hemerocallis (Daylily)	*Hemerocallis* spp.	2’–4’	Spring Summer Fall	Many	Full sun Partial shade	Foundation plants, borders
Hen-and-Chickens (see *Sempervivum*)						
Heuchera (Coral Bells) (Alum Root)	*H. sanguinea* ‘Bressingham Hybrids’ ‘Chartreuse’ ‘Chatterbox’ ‘June Bride’ ‘Matin Bells’ ‘Pluie de Feu’ (Rain of Fire) ‘White Cloud’	1’–2½’	May–July	Red Pink White	Full sun Partial shade	Rockeries, borders
Hollyhock (see *Alcea*)						
Hosta (Plantain Lily)	*Hosta* spp.	1’–2’	July–Sept	White Lavender Lilac	Full sun Partial shade Full shade	Borders, rock gardens, masses
Hyacinth (Armenian Grape)	*Muscari armeniacum*	6”–8”	Early spring	Blue	Full sun or partial shade	Multiplies rapidly, excellent for edging or indoor forcing, fragrant
Hyacinth (Grape Hyacinth)	*Muscari botryoides*	6”–8”	Early spring	Blue White	Full sun or partial shade	Produces clusters of tiny flowers, double flowers hold color longer
Hypericum (Aaron’s Beard) (Rose of Sharon) (Saint-John’s-wort)	*H. calycinum*	1’–1½’	June–Sept	Yellow	Full sun Partial shade	Shady slopes, banks, flower beds, borders, ground cover
Iberis (Evergreen Candytuft) (Edging Candytuft)	*I. sempervirens* ‘Autumn Snow’ ‘Little Gem’ ‘Purity’ ‘Snowflake’ ‘Snowmantle’	6”–1’	April–May	White	Full sun	Rock gardens, edging
Incarvillea (Hardy Gloxinia)	*Incarvillea spp.*	1’	June–July	Red Pink	Full sun	Perennial gardens, rock gardens

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Iris (True-Bearded) (Siberian) (Japanese)	200+ species and many cultivars	4”–48”	Spring to fall, Most May–June, some rebloom	Wide range	Full sun	Beyond flowers, leaves provide texture, contrast of colors and combinations
Kniphofia (Red Hot Poker) (Torch Lily) (Tritoma) (Poker Plant)	*K. uvaria*	2’–4’	May–Sept	Red Yellow	Full sun	Borders, cut flowers
Lamb’s ear (see Betonica)						
Lamium (Spotted Dead Nettle)	*L. maculatum* ‘White Nancy’	1’	April–Sept	Purple-red White	Partial shade Full shade	Shaded perennial borders, rock gardens, summer filler
Lavandula (Sweet Lavender)	*Lavandula* spp. ‘Hidcote’ ‘Mustead’	1’–3’	June–Sept	Purple	Full sun	Borders, rockeries, cut flowers, evergreen
Liatris (Gayfeather) (Blazing Star)	*Liatris* spp. ‘Kobold’	1 ½’–5’	July–Oct	White Purple Pink	Full sun Partial sun	Cutting, drying, borders
Lily (Asiatic Hybrids)	Genus *Lilium* has 100+ species and many cultivars	2’–7’	June–July	Wide range	Full sun to partial shade	Accent plants
Lily (Oriental Hybrids)	Genus *Lilium* has 100+ species and many cultivars	2’–7’	July–Aug	Wide range	Full sun to partial shade	Accent plants
Lily (Surelians)	Genus *Lilium* has 100+ species and many cultivars	2’–7’	July	Wide range	Full sun to partial shade	Accent plants
Lily (Trumpets)	Genus *Lilium* has 100+ species and many cultivars	2’–7’	July	Wide range	Full sun to partial shade	Accent plants
Lily of the Valley (see *Convallaria*)						
Limonium (Sea Lavender) (Statice)	*L. sinatum*	1 ½’–2’	June–Aug	White Yellow Blue Red	Full sun	Flower beds, borders, small clumps, rockeries, cut and dried flowers
Liriope	*Liriope* spp.	10”–15”	Aug–Sept	Purple	Full sun Partial shade Full shade	Evergreen, borders, perennial gardens, rock gardens
Lupine (Lupin)	*L. polyphyllus* George Russell hybrids	2 ½’–5’	May–July	Blue Purple Reddish purple Yellow	Full sun Partial shade	Cut flowers, borders
Lychnis (Maltese Cross) (Jerusalem Cross)	*L. chalcedonica*	2’–3’	June–July	Scarlet	Full sun	Small groupings in borders
Lysimachia (Creeping Jennie) (Moneywort) (Creeping Charlie)	*L. nummularia*	6”–8”	June–Nov	Yellow	Full sun Partial shade Full shade	Shaded slopes and banks, walls, hanging baskets, bag gardens, submerged aquarium plant

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Maltese Cross (see *Lychnis*)						
Monarda (Wild Bergamot)	*M. fistulosa* 'Gardenview Scarlet'	to 3'	June–Aug	Lilac Purple White	Full sun Partial shade	Borders
Narcissus (Daffodil) (Jonquil)	spp. and hybrids	3"–14"	Early to midspring	Yellow White Pink (Cups: yellow, white, pink, orange, or nearly red)	Full sun or light shade	Borders, shrub beds, or naturalized, good for cut flowers
Ostrich Fern (see *Pteretis*)						
Pachysandra (Japanese Pachysandra)	*P. terminalis* 'Variegata' (Silver edge)	6"–8"	May	White	Partial shade Full shade	Ground cover, slopes, level ground, beneath trees
Paeonia (Peony)	*P. lactiflora*	3'	May–June	Many	Full sun Partial shade	Accent, cut flowers
Papaver (Iceland Poppy)	*P. nudicaule*	2'–4'	May–June	Many	Full sun Partial shade	Borders, cut flowers
Papaver (Oriental Poppy)	*P. orientale*	2'–4'	May–June	Many	Full sun	Borders, cut flowers
Peony (see *Paeonia*)						
Phlox, Creeping	*P. subulata*	6"–10"	April–June	White Pink Salmon Purple	Full sun Partial shade	Edging, bedding, rock gardens
Phlox, Tall (Summer Phlox) (Garden Phlox)	*P. paniculata* 'Symons-Jeune'	2'–3'	July–Sept	White Pink Red Blue Purple	Full sun Partial shade	Borders
Physostegia	*P. virginiana* 'Bouquet Rose' 'Vivid' 'Summer Snow'	2'–3'	July–Sept	Rose-purple White	Full sun Partial shade	Cut flowers, back of wildflower gardens borders, informal wildflower gardens
Platycodon (Chinese Bellflower) (Balloon Flower) (Japanese Bellflower)	*P. grandiflorum* 'Apoyama' 'Shell Pink'	2'	July–Sept	Blue Pink White	Full sun Partial shade	Cutting, rock gardens, borders
Plumbago (see *Ceratostigma*)						
Polemonium (Jacob's Ladder)	*P. caeruleum* 'Blue Pearl'	1½'	May–June	Blue	Full sun Partial shade	Rock gardens, foreground of perennial borders
Poppy, Iceland (see *Papaver nudicaule*)						
Poppy, Oriental (see *Papaver orientale*)						

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Potentilla	*P. verna*	4"–6"	May–Oct	Yellow	Full sun Partial shade	Ground cover
Primrose, Polyanthus	*Primula x polyantha* 'Colossea Hybrids' 'Pacific Giants'	6"–12"	April–June	Many	Partial shade	Shaded areas in perennial borders, shaded streams
Pteretis (Ostrich Fern)	*P. modulosa*	3'–4'	Foliage	—	Partial shade Full shade	Northern exposures, under trees or any place where light is not abundant
Pyrethrum (Painted Daisy)	*Pyrethrum* spp.	1½'–2'	June–July	Pink Red White	Full sun Partial shade	Rock gardens, borders, naturalizing, cut flowers
Red Hot Poker (see *Kniphofia*)						
Rudbeckia (Gloriosa Daisy)	*R. hirta pulcherima* 'Gloriosa Daisy' *(Rudbeckia* x *hybrida)* 'Gloriosa Double Daisy' 'Gloriosa Irish Eyes' 'Goldstrum' 'Marmalade' 'Rustic Colors'	2"–3"	July–Sept	Golden yellow Brown	Full sun Partial shade	Cutting, background
Santolina (Lavender Cotton)	*S. chamaecyparissus*	1'	June	Yellow	Full sun	Evergreen, rock gardens, low hedge, carpet bedding
Saponaria (Bouncing Bet) (Soapwort)	*S. officinalis*	1'	July–Sept	Pink White	Full sun Partial shade	Wild gardens, rough corners
Saxifraga	*Saxifraga* spp.	3"–18"	June–Aug	Yellow White Red Pink Purple	Partial shade	Rock gardens, borders, edging, potted plants
Scabiosa (Caucasian Scabious) (Pincushion Flower)	*S. caucasian* 'Butterfly Blue' 'Pink Mist'	2'	June–Sept	Blue White Mauve	Full sun	Borders, flower beds, cut flowers
Sea Lavender (see *Limonium*)						
Sedum	*Sedum* spp. 'Dragon's Blood'	6"	Aug–Oct	Red	Full sun Partial shade	Rock gardens, borders
Sedum (Showy Stonecrop) (Live Forever)	*S. spectabile* 'Autumn Joy' 'Brilliant' 'Indian Chief' 'Meteor' 'Star Dust' 'Variegatum'	1½'–2'	Aug–Oct	Pink Red White	Full shade Partial shade	Rock gardens, borders
Sempervivum (Hen-and-Chickens) (Old Man and Woman) (Houseleeks) (St. Patrick's Cabbage)	*S. tectorum*	6"–30"	July	Purple-red	Full sun	Rock gardens, dry walls, edging, front of perennial borders, carpet bedding, containers

Table 1. Perennials for Idaho (cont.)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Snowdrop (Common Snowdrop)	*Galanthus nivalis*	4"–6"	Early spring	White	Partial shade	One of the earliest spring bulbs for rock gardens, borders, naturalizing, easy to grow, increases rapidly
Snowdrop (Giant Snowdrop)	*Galanthus nivalis*	6"–9"	Spring	White	Full sun	Good for borders and rock gardens
Snow-in-Summer (see *Cerastium*)						
Stachys (see *Betonica*)						
Statice (see *Armeria* or *Limonium*)						
Sweet Lavender (see *Lavandula*)						
Sweet William (see *Dianthus barbatus*)						
Teucrium (American Germander)	*T. canadense*	6"	June–July	Rose	Full sun	Edging, rock gardens
Teucrium (Germander)	*T. chamaedrys*	4"–12"	June–July	Purple	Full sun	Edging, rock gardens, hedges
Thymus (Thyme)	*T. serpyllum*	3"–6"	June–July	Purple White Red	Full sun	Rock gardens, herb gardens, stone walls
Tradescantia (Virginia Spiderwort) (Widow's Tears)	*T. virginiana* 'Purple Dome'	1½'–2'	June–Sept	White	Full sun Pink Red	Borders, foundations Partial shade
Tritoma (see *Kniphofia*)						
Trollius (Globe Flower)	*T. europaeus*	1'–2'	May–July	Lemon Orange	Shade	Borders
Tulip	*Tulipa* spp. and hybrids	3"–30"	Spring	All colors except true blue	Full sun	Variety of colors, shapes, blooming times for all uses, may use annuals to cover ground above bulbs in summer
Valeriana	*V. officinalis* 'Rubra'	3'–5'	June–July	Pink White Red Purple	Full sun Partial shade	Perennial gardens, background
Veronica	*Veronica* spp. 'Red Fox' 'Sunny Border Blue'	1½'	June–Aug	Blue Pink Red White	Full sun	Borders, cut flowers, rock gardens
Vinca (Lesser Periwinkle) (Myrtle)	*Vinca minor*	6"–8"	March-May	Blue Purple	Partial shade Full shade	Ground cover in flower beds or rockeries, shrubberies
Wallflower (see *Cheiranthus*)						
Yarrow (see *Achillea*)						

Further Reading

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FOR MORE INFORMATION

Hardy Plant Society of Oregon, PO Box 5090, Oregon City, OR 97045

Northwest Perennial Alliance, PO Box 45574, University Station, Seattle, WA 98145-0574

Perennial Plant Association, Attn: Dr. Steven M. Still, 3383 Schirtzinger Road, Hilliard, OH 43026

Perennial Study Group, Arboretum Foundation, Washington Park Arboretum, University of Washington, Box 358010, Seattle, WA 98195-8010

BOOKLETS AND PAMPHLETS

University of Idaho Extension

CIS 1062	*Starting a Home Lawn*
CIS 1063	*Thatch Prevention and Control in Home Lawns*
CIS 1225	*Weed Control in Idaho Lawns*
PNW 151	*Propagating Herbaceous Plants from Cuttings*
PNW 299	*Turfgrass Seedings: Recommendations for the Pacific Northwest*
PNW 550	*Encouraging Beneficial Insects in Your Garden*

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CHAPTER **TWENTY**

PRINCIPLES OF VEGETABLE CULTURE

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20 PRINCIPLES OF **VEGETABLE** CULTURE

Learning Objectives

- Learn the principles of planning a vegetable garden through a series of questions to help determine the needs of a gardener
- Learn how to choose the best varieties and to place and rotate crops
- Learn about the different vegetable production systems and garden designs
- Learn the techniques of buying, saving, and storing vegetable seeds
- Learn the basics of garden soil preparation, including soil testing, adding organic matter, fertilizing, and tillage
- Learn how to start and care for your own transplants and how to correctly plant them in the garden
- Learn the fundamentals of caring for your garden, including irrigation, weed, pest, and disease control

Introduction

Few things in life are more rewarding than savoring a meal of homegrown vegetables. Vegetable gardening can be enormously satisfying. However, there can be no argument that it also is complex and fraught with problems, requires hard work, and involves many personal decisions.

The most successful vegetable gardeners understand basic concepts of botany, plant growth and development, plant health, irrigation, soil fertility, and pest and disease control. Many of these principles are covered elsewhere in the *Idaho Master Gardener Handbook*. Detailed information about specific vegetable crops is found in the next chapter. Many good books about vegetable gardening are also available.

Planning the Garden

For some gardeners, planning a garden is an interesting and satisfying activity. If this is you, have fun with the process and take all the time you want. Get out the gardening books during the deep, dark months of winter, explore options for new crops and varieties, make a graph-paper map, and dream about summer harvests.

For others, planning seems to get in the way of accomplishment. If this describes you, cut the planning to a bare minimum and get on with buying seed. However, some planning is essential to success in vegetable gardening.

Planning can be broken into two phases: garden design and annual planning.

GARDEN DESIGN

Some decisions need to be made early in the planning process. A good approach is to take a few minutes to answer some fundamental questions. Here are a few (but surely not all) of the questions to consider.

How Much Time Do I Have for Vegetable Gardening?

This question may seem trivial, but it will affect everything else you do. Planting a garden and discovering you lack the time and resources to care for it properly leads to frustration. If you have only a few minutes a day to dedicate to gardening, plan a small garden that contains two or three of your favorite vegetables. You may opt to grow plants on your porch in pots or containers. At the other extreme, if you have plenty of time and energy, the garden can be more extravagant and include hobby activities such as testing unique varieties or growing unusual or marginally adapted crops. Or, if gardening is a life-sustaining activity, the scale of production may be quite large and your plans should be based on food-storage potential.

What Do I Like to Eat?

Plan to produce only crops that you and your family like and will prepare and consume. It's a waste of time and resources to grow produce that serves only as compost. Determine which vegetables you will consume fresh and which will be preserved and stored. Consider making room to experiment with small amounts of new crops or varieties. Over time, you may find a new favorite.

How Much Room Do I Have for Vegetable Gardening?

Sometimes the limitations for producing vegetables have less to do with time than with space. In this case, prioritize your goals and fit in only those crops you consider most valuable (your favorites). Plant crops that produce large quantities in limited space, such as tomatoes or cucumbers. Crops such as corn and squash require a lot of space; place them lower on the priority list.

Where Should I Locate My Garden?

This can be a difficult question to answer, as it is influenced by personal preference, impact on the appearance of the landscape, plant needs, and occasionally property ordinances. Public visibility creates a need for more intense design and maintenance. Selecting a warm microclimate, e.g., next to a south-facing fence or wall, may make it possible to grow crops, such as melons, that are otherwise marginally adapted.

Regardless of all other considerations, one requirement must always be met: sunlight. Almost all vegetable crops require full sunlight to grow and produce properly. Many books say that a vegetable garden should get at least six hours of sunlight per day. The origin of this recommendation is unknown, but it probably did not come from an experienced gardener. To maximize production and quality, a garden needs all-day sun, with the possible exception of an hour or two of shade at dawn and dusk; the more sunlight, the better.

Property features can place extreme limitations on garden placement. If options are available, here are a few tips to consider:

- Avoid placing the garden in a low swale, at the base of a hill, or at the foot of a slope bordered by a solid fence. Frost settles in these places because cold air naturally drains toward the lowest spot in the yard.
- Avoid windy locations (hard to do in Idaho!). If you must plant in a windy spot, build or plant a windbreak.
- Avoid planting near trees and shrubs that will compete for sunlight, nutrients, and water. Stay 10–20 feet outside of tree drip lines (an imaginary line on the ground at the edge of the tree canopy), if possible (Figure 1).
- Choose a spot near your home so it is convenient to work in the garden when you have a few minutes.
- Locate the garden near a good and easily accessible supply of water.
- Avoid contaminated areas. Water runoff from roads, sidewalks, or driveways can contaminate

the soil with salt, herbicides, or soil sterilants. Do not plant near chemical manufacturing or storage facilities without investigating safety issues. Sites where lead-painted buildings once stood may contain toxic amounts of soil lead. If you are unsure about your chosen location, check the lead (and other heavy metals) content by having the soil or leafy vegetable tissue analyzed.

Figure 1. Locate vegetable gardens in full sun and at least 20 feet from the drip line of trees and shrubs to avoid competing roots.

What Type of Vegetable Production System Should I Use?

There are as many ways to lay out a vegetable garden as there are gardeners (Figure 2). Many people use some form of the traditional victory garden (straight, wide rows). Others use small beds, raised beds, trellis and stake systems, or containers. Part of this decision is based on garden size. Large gardens are usually best planted in rows so that tillers and other equipment can reduce the need for hand labor. Small gardens usually work best when laid out as intensively managed beds in order to maximize production in a limited space. Intensive production systems can also reduce the amount of work needed for weed and pest control. Common production systems are described later in this chapter.

Where Should I Place Perennial Beds?

Consider this question early in the design process. Some vegetables, such as asparagus, rhubarb, chives, and many herbs, are perennial; they regrow each spring and are a permanent part of the garden. Locate these crops where they will not interfere with annual garden operations. Perennials are typically grouped along one side or in one corner of the garden. Another technique is to use them as landscape features outside of the annually managed portion of the garden.

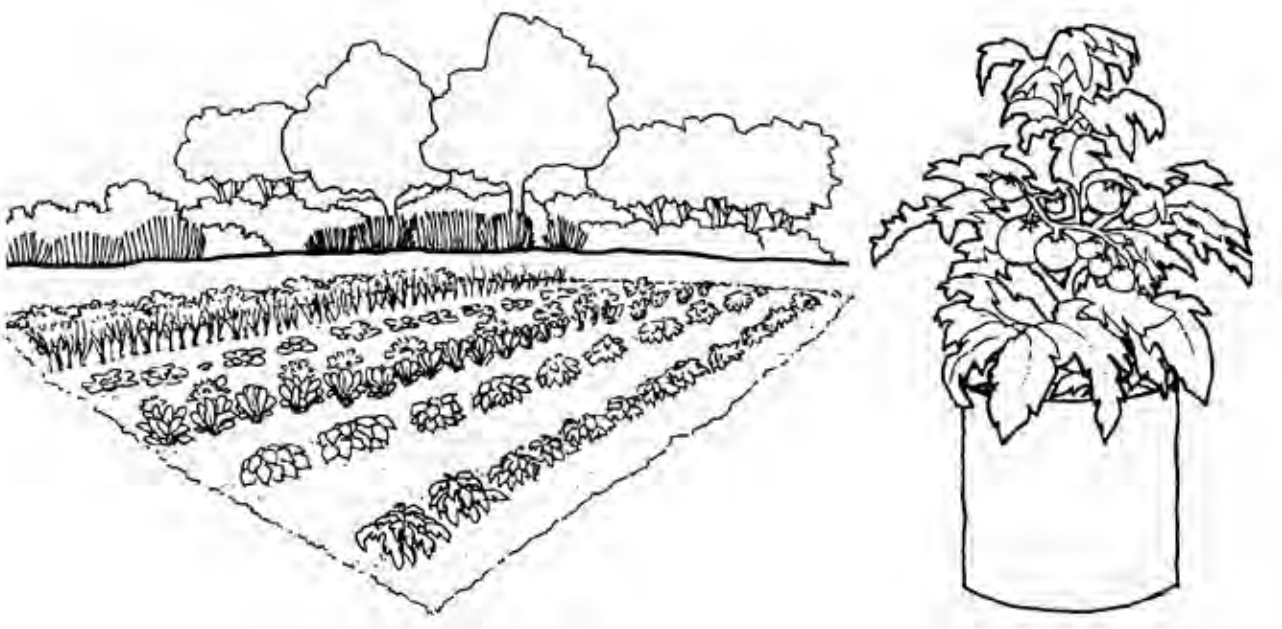

Figure 2. Productive vegetable garden designs range from the traditional open rows of a "victory garden" to space-saving containers.

ANNUAL PLANNING

Determination of gardening objectives, garden size, and production system needs to be done only once, although you probably will modify your plan in subsequent years. Good gardeners are never happy with the status quo. However, some planning must be done every year in order to maximize crop yield and quality.

Choose the Best Vegetable Varieties

Varieties differ not only in appearance and flavor, but also in earliness, adaptation, and many other characteristics that influence growth in a specific climate. In the short-season climates typical of much of Idaho, choosing the right varieties is critical to success. Information provided on seed packets, such as days to harvest and general descriptions of best production conditions, are typically inadequate for determining suitability, given Idaho's propensity for frost, cool nights, intense sunshine, low humidity, and/or alkaline soils. Obtain information about the best varieties from experienced gardeners, Master Gardener volunteers, local nurserymen, and county educators.

Place and Rotate the Crops

Deciding where to plant individual crops each year can be frustrating. However, these decisions are critical. Crop rotation, the practice of changing the location of crops to avoid disease and nutritional problems, is a sound agricultural principle. Many vegetable crops become weak and unproductive if they are planted in the same place every year.

You can simplify these decisions by taking the time to group plants into blocks based on genetic relatedness and growth habit. Plants in the same family often have the same needs and problems.

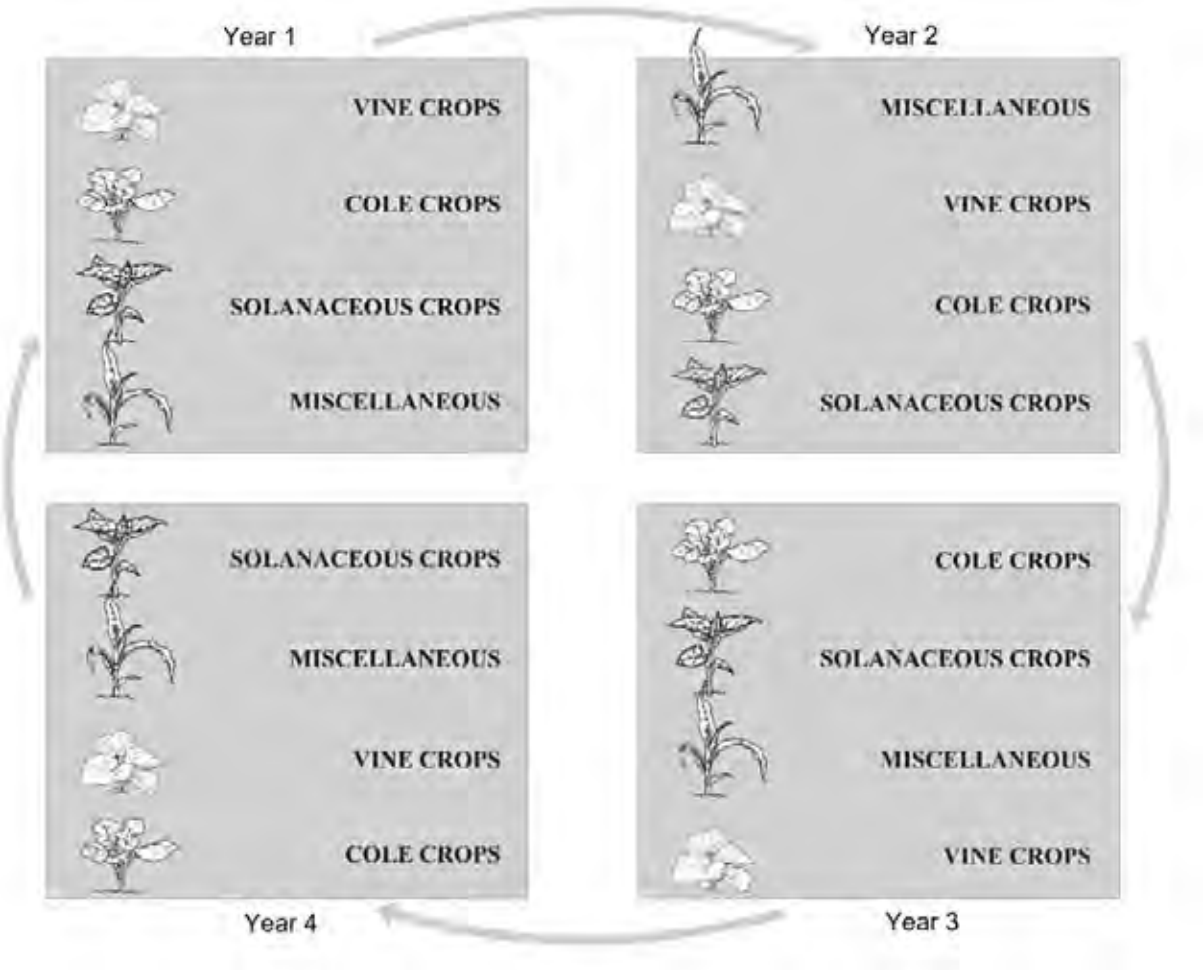

Figure 3. Example of crop rotation by grouping crops with similar growing requirements. Each shadowed square represents the garden in a given year. Categories within the squares represent crop groups that are rotated within the garden space. Cole crops include broccoli, cauliflower, cabbage, brussels sprouts, and all of the kales and mustards. Vine crops include melons, cucumbers, squash, and pumpkins. Solanaceous crops include tomatoes, potatoes, peppers, and eggplant.

Each year, keep the crops in their established blocks and simply rotate the blocks through the available space (Figure 3). If done properly, each block of similar plants should end up in the same plot of soil once every 3–5 years.

Rotation to prevent disease problems is more important for some crops than others. It is critical for the solanaceous crops (potatoes, tomatoes, peppers, eggplants, etc.), cucurbits (cucumbers, melons, squash, pumpkins, etc.), and cole crops (cabbage, broccoli, cauliflower, brussels sprouts, etc.).

Take into account plant height, spread, and growth habit. Don't plant tall or aggressive plants where they will overgrow or shade smaller plants.

Vegetable Production Systems

Vegetable gardening systems fall into two major categories: (1) low-intensity victory gardens planted in wide rows or hills and (2) intensive gardening systems planted in beds or containers. Victory garden layouts are best used in large gardens (more than 500 square feet) where simplicity of operations and use of motorized equipment is required. If space and/or time is limited, intensive garden designs are best. The production systems described here are only a sampling of the possibilities, but the concepts apply to most garden systems.

VICTORY GARDEN DESIGNS

The term *victory garden* originated during World War II and was used to describe a vegetable gardening system consisting of wide, straight rows running the length of a garden (Figure 4). It is the simplest design for a vegetable garden and the best method when large amounts of produce are needed for preservation, storage, or local sale. Any vegetable can be produced in a victory garden arrangement, but it is especially good for crops needed in large quantities, such as corn, peas, beans, potatoes, and broccoli.

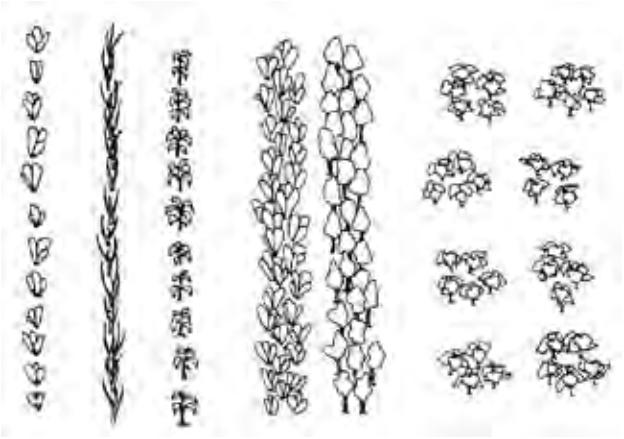

Figure 4. Possible row arrangements within a standard victory garden design.

There are many adaptations to the single-row planting design typical of the victory garden. The following are some common planting arrangements:

- **Row planting**. This arrangement consists of long, straight rows, usually 2 or more feet apart, with a single line of plants in each row (Figure 4, left). A string stretched between stakes or homemade row markers can provide a guide for straight rows. Use a hoe handle, a furrow hoe, or a grub hoe to make a furrow of the appropriate depth. Space the seed uniformly and at a distance suitable for the crop.
- **Broadcast row planting**. In the victory garden, broadcast planting usually involves placing seed in rows arranged as wide bands rather than single-wide plants (Figure 4, center). Many crops, especially root crops such as carrots, radishes, and beets, produce higher-quality vegetables when planted this way. Sow seed evenly across the planting band and rake it in. Lightly cover and press the soil over the seeds.
- **Hill planting**. Larger vegetables, such as melons, squash, corn, and cucumbers, may be planted in hills (Figure 4, right). The hills can be arranged in extra-wide rows to facilitate cultivation. Distance between hills is based on recommendations for individual crops. Mound soil a few inches high and a foot or so in diameter and plant in the center of the mound. Plant four to six seeds per hill, firming the soil well.

INTENSIVE GARDEN DESIGNS

Intensive garden designs require considerable effort to plan and install, but are relatively easy to maintain. Plans should include dimensions, construction materials, soil media, variety choice, and plant arrangement. Proven intensive garden designs include raised beds, vertical gardens, and container gardens. When combined with production techniques such as interplanting, succession planting, relay planting, and edible landscaping, these garden designs maximize the use of limited space.

Raised Beds

The typical "raised bed" garden consists of defined borders of wood or masonry filled with heavily amended soil to a level above the surrounding ground (Figure 5). Raising the bed above ground level accomplishes two very important things: it improves drainage and it allows the soil to warm up faster in the spring. Both factors can improve plant growth and production potential.

The actual garden design and the selection of border materials are personal choices. Typical beds are raised 6–8 inches, but they may be as much as 3 feet above grade. Borders may be permanent structures (made from concrete or other immovable materials) or temporary. Wood landscape timbers are a common choice. Redwood or cedar timbers will minimize deterioration due to constant exposure to moisture. Pressure-treated landscape timbers are commonly available. There is no evidence that the new generation of treated timbers are toxic or harmful to plants or consumers, but older timbers or railroad ties were commonly treated with creosote or pentachlorophenol (penta), both toxic to plants and people. If unsure, you may want to use only untreated wood.

There are no standard dimensions for raised bed gardens. Typically they are narrow enough to allow the gardener to reach to the center of the bed without stepping on the soil. The length is usually a function of the location; beds may be only a few feet long or stretch across the yard.

Soil preparation is an important aspect of raised bed gardening. The final soil mix commonly consists of one part native soil and one part compost or aged organic matter. Many other choices for soil components exist; for example, manure, peat, sand, vermiculite, or perlite may be added in various quantities. The simplest method for preparing the soil is to remove the top 12 inches of soil from the completed bed, place it in a pile, mix the pile with an equal amount of organic matter, and shovel the mixture back into the bed. At this point, the bed will be ready for plants.

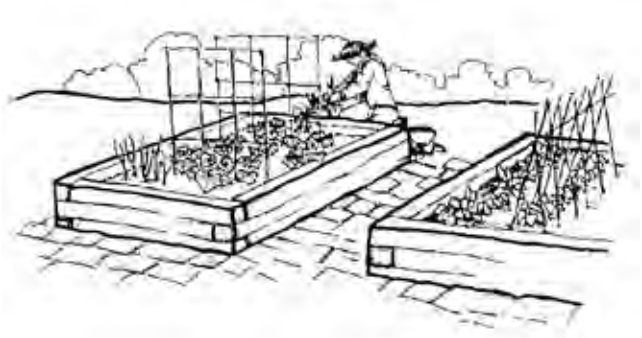

Figure 5. Example of a raised bed intensive-gardening system.

Plant arrangement should optimize the use of the limited space. Give each plant a square space large enough for it to grow properly. The goal is to space plants equidistant from one another on all sides so that, at maturity, plant leaves touch or slightly overlap. Spacing recommendations for raised beds are summarized in Table 1. The use of dwarf or bush-type varieties will minimize space needed for many crops, such as beans, cucumbers, tomatoes, and squash.

Table 1. Plant-spacing guide for raised bed or other intensive vegetable garden designs.

Plant	Spacing[a] (inches)	Plant	Spacing[a] (inches)
Asparagus	15–18	Leeks	3–6
Beans, bush	4–6	Lettuce, head	10–12
Beans, lima	4–6	Lettuce, leaf	4–6
Beans, pole	6–12	Melons	18–24
Beets	2–4	Mustard	6–9
Broccoli	12–18	Okra	12–18
Brussels sprouts	15–18	Onions	2–4
Cabbage	15–18	Peas	2–4
Cauliflower	15–18	Peppers	12–15
Chard, Swiss	6–9	Rutabaga	4–6
Chinese cabbage	10–12	Pumpkins	12–36
Collards	12–15	Spinach	4–6
Cucumbers	12–18	Radishes	2–3
Eggplants	18–24	Squash, summer	18–24
Endive	15–18	Squash, winter	24–36
Kale	15–18	Tomatoes	18–24
Kohlrabi	6–9	Turnips	4–6

Note: To determine spacing for interplanting, add the inches for the two crops to be planted together, and divide the sum by two. For example, if radishes are planted next to beans: 2 inches + 4 inches = 6 inches. Then, 6 inches ÷ 2 = 3 inches. Plant the radishes 3 inches from the beans.

The use of miniature varieties or vertical gardening techniques may allow closer spacing and increase the square-foot productivity.

[a] Arrange plants in square grid patterns. The indicated spacing is the distance to other plants in all directions. These recommendations for intensive gardening typically are for slightly closer spacing than the spacings suggested in the next chapter, which are based on recommendations for a traditional victory garden.

Vertical Gardening

The use of trellises, nets, strings, cages, or poles to hold plants upright and limit horizontal spread constitutes vertical gardening (Figure 6). Vining and sprawling plants, such as cucumbers, tomatoes, melons, and pole beans, are obvious candidates for this type of gardening. Tomatoes, for example, require about 10 square feet per plant when unstaked, but can be grown in 1 square foot of space if supported and trained upward. Vertical gardening can be used in victory gardens, raised beds, containers, or by itself.

Supports for plants can be simple or extravagant. They can take advantage of existing structures, such as buildings or fences, or can stand alone. The height of the support depends on the crop. Shorter plants, such as tomatoes, cucumbers, and pole beans, grow to a height of 5–6 feet. Squash may need 15–20 feet of vertical space or a structure that will allow some horizontal growth at the top (e.g., a high tunnel). In Korea, gardeners plant squash and other vine crops next to the walls of buildings, allowing them to climb a trellis and eventually set fruit on the roof.

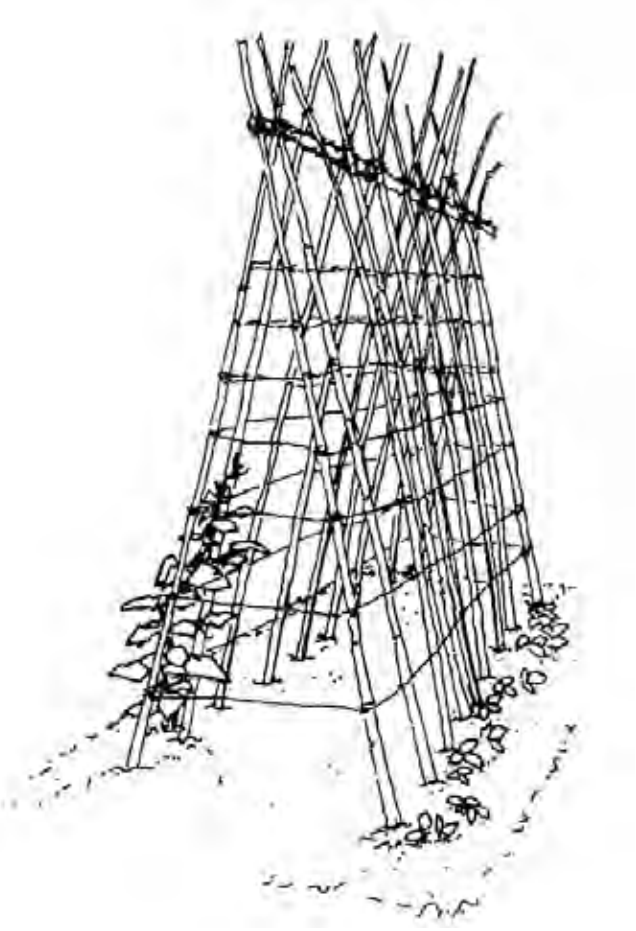

Figure 6. Example of a structure used for vertical vegetable gardening.

Vertical gardening saves considerable space but is labor-intensive. Staking, tying, pruning, and training new growth upward takes time. Most plants do not climb naturally, so simply planting next to a vertical structure will not necessarily convince plants to reach skyward.

Because vertically growing plants are more exposed, they dry out faster and may need to be watered more frequently than those allowed to spread over the ground. A vertical planting will cast a shadow, so be sure to locate the structures where they will not shade nonvertical parts of the garden.

Container Gardening

If you don't have yard space for a vegetable garden or if your garden is too small to produce everything you want, consider raising vegetables in containers (Figure 7). A windowsill, patio, balcony, or doorstep can provide sufficient space for a productive container garden. Container gardens can also make gardening simpler by reducing problems with weeds and many other pests.

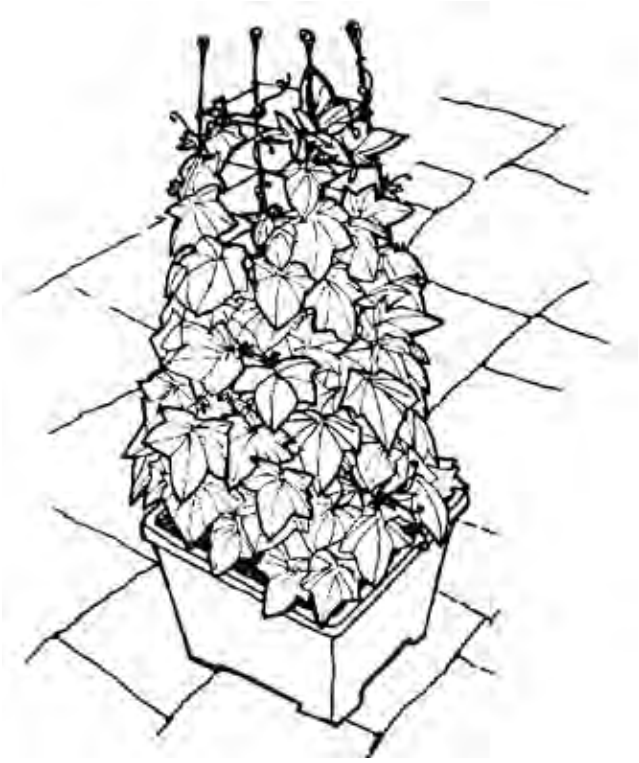

Figure 7. The ultimate in intensive vegetable gardening is container gardening. Tomatoes, peppers, cucumbers, and many other crops can be grown in containers.

Gardening in containers requires more attention to detail than any other gardening method. The plants have only a small amount of soil for root growth, meaning that water and nutrients are limited. Also, the plants are subject to heat and other stresses. As a result, care requirements are more stringent than in a traditional garden. In addition to the general vegetable gardening techniques discussed later in this chapter, the following considerations apply specifically to container gardens.

Choosing containers. Containers can be made of clay, wood, plastic, or metal. They can be purchased or homemade. It's best to use new containers to ensure that they are free from contamination (e.g., herbicide residue). The most important considerations are size, mobility, and drainage.

Selecting the proper container size is a balance between supplying adequate soil volume and making sure containers can be moved in case of inclement weather or for winter storage. Table 2 provides recommendations for minimum pot sizes for several common vegetable crops, as well as other information needed to make good container production decisions. Container depth is important because most plants need at least 6–8 inches of soil for proper rooting.

Wooden barrels make excellent vegetable pots. Wooden planting boxes also work well and can be purchased or constructed to preferred dimensions. Choose redwood or cedar, which resist breakdown and rot. Wood for container construction should not be treated with creosote (used to preserve railroad ties) or pentachlorophenol (penta) wood preservatives. These preservatives may be toxic to plants and harmful to people. Other options for homemade containers include vertical planters made out of wood lattice lined with black plastic or welded wire shaped into cylinders.

Regardless of whether you purchase or construct a container, be sure there are holes in the bottom of adequate size and number to allow drainage of excess water.

Choosing soil media. Native garden soil by itself does not make good potting soil because it does not provide adequate drainage or air exchange. The best soil media, ironically, are called "soilless mixes." These mixes usually are porous combinations of peat moss, perlite, and sand. Some contain wood chips or bark. Packaged potting soil (available at local garden centers) is relatively lightweight and makes a good container medium. It's much cheaper to make your own soilless mix, but a lot more work.

Soilless mixes are sterile and contain few nutrients. Manufacturers usually add major plant nutrients to mixes, but may not add trace elements that are necessary for good plant growth. This problem can be solved by using the soilless mix as a base and adding compost or a small amount of native garden soil (about 25% by volume).

Placing the containers. Providing adequate sunlight for the plants is the most important consideration when placing a container. Ideally, the container should be positioned where plants receive sun all day. However, in limited space situations, this is

Table 2. Growing vegetables in containers.

Vegetable	Light requirements[a]	Minimum container size (gallons)	Spacing between plants in containers[b] (inches)	Days from planting to harvest
Beans	FS	2	2–3	45–60
Beets	FS/PS	½	2–3	50–60
Cabbage	FS/PS	5	1 plant	65–120
Carrots	FS/PS	1	2–3	65–80
Cucumbers	FS	5	1 plant	70–80
Eggplants	FS	5	1 plant	75–100
Kale	FS/PS	5	10–15	55–65
Lettuce	PS	½	4–6	30–35
Mustard greens	PS	½	4–5	35–40
Onions	FS/PS	½	2–3	70–100
Peppers	FS	2	8–12	110–120
Spinach	PS	1	4–6	30–40
Squash	FS	5	1 plant	50–60
Swiss chard	FS/PS	½	4–6	30–40
Tomatoes	FS	5	1 plant	55–100
Turnips	FS/PS	3	2–3	30–60

a FS = full sun (10 or more hours of direct sun each day), PS = part shade (6 or more hours of direct sun each day).

b Any vegetable that produces large plants should have only one plant per container.

not always possible. Consequently, the amount of sunlight your container garden receives may determine which crops can be grown. Leaf crops generally can tolerate some shade, while vegetables grown for their roots or fruits need a minimum of 8–10 hours of direct sunlight each day. Available light can be concentrated somewhat by providing reflective materials around the plants (e.g., aluminum foil, white-painted surfaces, marble chips on the soil surface). Containers should also be placed to avoid frequent strong winds.

Choosing vegetable crops and varieties for containers. Almost any vegetable crop can be grown successfully in a container. However, the best container crops are those that allow you to make the best use of available space. Examples include many types of herbs, carrots, radishes, lettuce, and crops that bear fruits over a period of time, such as tomatoes, peppers, and cucumbers. Dwarf or miniature varieties of many crops are available, making them suitable for containers even if the standard varieties are too large. With increasing interest in container gardening, plant breeders and seed companies are working to develop vegetables specifically for container culture. These varieties may or may not be miniature or dwarf, but they do grow well in pots and produce as well as standard varieties if properly maintained.

Establishing plants in containers. Because containers can be moved indoors during frost or inclement weather, you can plant vegetables 2–3 weeks earlier than in the outdoor garden. Be careful not to plant too early, however, because plants that spend too much time indoors will not adapt well to outdoor conditions once the weather moderates. However, if a container is too large to move or is designated to remain permanently outdoors, plant the crops at the same time as you would in a traditional garden.

Make sure the potting soil is adequately moist. Plant the seeds as you would in the garden. Use the spacing recommendations listed in Table 2. It is a good idea to overplant and thin after emergence to the recommended spacing. If cages, stakes, or other supports are needed, install them just after planting or thinning to avoid root damage later.

Table 2 also provides information on the expected amount of time to first harvest. Your actual growing period may vary, depending on weather conditions and pot location.

Irrigating container gardens. Improper irrigation is the most frequent cause of failure in container gardens. Limited soil volume and extreme exposure results in a high demand for water. Inadequate or erratic irrigation will quickly reduce plant health and productivity.

However, overwatering is just as serious and may be the more common problem. Overwatered plants do not show immediate detrimental effects, but will eventually decline and die due to a reduction in root health. Overwatering is often caused by the presence of a water saucer or catch-pan under the pot. If the catch-pan is constantly full, water will wick back into the pot through the drainage holes and keep the soil too wet. Water only when the plants and soil indicate a need. The soil should never be soggy or have water standing on the surface.

Knowing when to water container plants is a little tricky, but there are a few techniques that may help. Check containers at least once a day (twice on hot or windy days). Use your fingers to feel the soil. It may be dry on top, but should be damp (not sopping wet) below a depth of about 1 inch. If the soil feels dry to a depth below the length of your finger, apply water until it runs out of the drainage holes in the bottom. Another trick is to watch the plants for the earliest signs of water stress — a change in color to dark green followed by mild wilt symptoms. Don't allow wilting to become severe.

In the hottest part of the summer, you may need to water daily or twice a day, depending on the size of the pot. In cool spring weather or on cloudy days, plants may need water only once every 3 or 4 days. If you must be away from the garden for long periods of time, consider installing an automatic drip irrigation system.

Clay pots and other porous containers allow evaporation through the sides of the pots. Plants grown in these types of containers require irrigation more often than those grown in impermeable containers.

To conserve water in containers, try the following techniques:

- Group containers so they shade one another and reduce evaporation.

- Place something impermeable, such as a plastic or rubber mat, under pots to prevent moisture from moving out of the pots and into cement or masonry surfaces.
- Use mulches and windbreaks.

Fertilizing containers. If you purchase a soil mix that includes fertilizer, your plants should have enough nutrients to last 8–10 weeks. If plants grow for a longer period of time, you will need to add water-soluble fertilizer, dry fertilizer (slow-release), well-aged manure, or compost at the rate recommended on the product label. Repeat every 2–3 weeks. An occasional dose of fish emulsion or compost will add trace elements to the soil.

Do not add more than the recommended rate of any fertilizer, because excess fertilizer may damage or kill the plants. Container soils do not have the buffering capacity provided by large volumes of soil and humus to protect them from overfertilization. Just because a little fertilizer is good for your plants does not mean that a lot will be better.

Pest control. Vegetables grown in containers can be attacked by the same insects and diseases that are common to any vegetable garden. They are more prone to damage from some pests, such as spider mites. Inspect plants periodically for foliage- and fruit-feeding insects as well as disease symptoms. Treat as needed. For insects, control may be as easy as spraying the plants with a hard stream of water. See "Controlling Pests" for more information.

Other Intensive Gardening Techniques

Interplanting. Growing two or more types of vegetables within the same space at the same time is known as interplanting (Figure 8). Interplanting has been practiced for thousands of years in Europe and Japan, but is just now gaining widespread support in this country.

Interplanting can be accomplished by alternating rows within a bed (for example, a row of peppers next to a row of onion), by mixing plants within a row, or by distributing various species throughout a bed. For the beginner, alternating rows may be the easiest system to manage.

To successfully plan an interplanted garden, consider these factors for each plant:

- Length of the plant's growth period and its growth pattern (tall or short, belowground or aboveground)
- Possible negative effects on other plants (e.g., sunflowers and Jerusalem artichokes produce chemicals that can inhibit the growth of nearby plants)
- Season of growth
- Light, nutrient, and moisture requirements

One of the best interplanting strategies is to combine an early crop, such as peas, radishes, or spinach, with a late crop, such as carrots, cucumbers, or squash. The early crop will be harvested by the time the late crop needs the space. Another technique is to plant smaller plants around larger plants (e.g., radishes at the base of beans or broccoli). Shade-tolerant species, such as lettuce, spinach, and celery, can be planted in the shadow of taller crops such as corn. Plants that require large amounts of nutrients, such as cabbage-family crops, can be interplanted with less gluttonous plants such as beans or beets.

Succession or relay planting. Succession planting involves growing multiple crops of the same or different plants in the same space by replanting as soon as harvest is complete. You may laugh at this idea if you live in one of Idaho's short-season climates, which limit the potential of this technique. However, some rapidly maturing crops are amenable to succession planting. Spinach, lettuce, kale, radishes, beets, and peas are good candidates. A fall

Figure 8. Interplanting — planting different crops together in the same space — is a good way to maximize production in limited space.

Figure 9. Relay planting can be used to extend the harvest season of many crops, such as corn. Plants on the right were planted first; those on the left planted later.

Relay planting is an effective option in cold-climate areas. This technique involves planting crops over several weeks to allow for continuous harvest (Figure 9). This method does not improve efficiency of land use, but does keep fresh vegetables available for a longer period of time. This method is especially effective for most salad crops and sweet corn.

Edible landscaping. Although not a new idea, edible landscaping has recently come into its own as an effective vegetable and fruit production technique. It consists of utilizing vegetable and fruit crops as landscape elements. For the vegetable gardener, it usually consists of planting edible crops among permanent elements of the landscape. Vegetables replace or are intermixed with flowers and other ornamental plants in annual and perennial beds.

Edible landscaping has much in common with the interplanting technique described above. You must consider compatibility among vegetables and other landscape plants. Because they are integrated into the landscape, the vegetable plants must not only be productive and healthy, but also must look good and contribute to the overall appearance of the property. They should enhance rather than detract from the landscape.

Vegetable crops are not all equal as edible landscape specimens. Appropriate edible landscape vegetables are those that can be planted in limited numbers, remain green for most of the summer, and provide unique and attractive visual appeal. Some of the best crops for use in edible landscapes include beets, cabbage, cauliflower, carrots, chard, collards, cucumbers, lettuce, onions, parsley, peppers, spinach, and tomatoes.

Maintenance of an edible landscape is similar to that of other intensive production systems. The processes of soil management, fertilization, irrigation, weed control, and pest management are similar to those described throughout this chapter. The unique part of edible landscaping is that the needs of vegetable crops must be balanced with the needs of permanent landscape elements.

Because no two edible landscapes have the same plants and situation, it is difficult to provide detailed instructions for installation and care. Experience will provide the best recipe for success.

Buying, Saving, and Storing Seed

BUYING SEED

Choose seed from a reputable seed company. Make sure the seed was grown and packaged the previous year, rather than stored by the seed company. The seed packet should show a package date.

After buying seed, keep a record of the seed company, variety names, plant performance, production problems (including diseases), and your personal feelings about the quality and flavor of the produce. This record will prove invaluable when selecting varieties in the future. Don't try to rely on memory to recall your favorite varieties; even the best minds create memories that may last a shorter time than the gardening season!

SAVING YOUR OWN SEED

Saving your own seed can create a sense of self sufficiency and save money. However, the true benefit is the ability to maintain a vegetable variety that is not available commercially. "Heirloom" or "heritage" varieties are fun to grow and can have a unique appearance and/or quality, but the seed is often hard to obtain. You can keep a steady supply of seed available by saving your own. Participation in a seed-saver's exchange can also be rewarding. You can trade extra seeds for unusual varieties not available through other sources.

Keep the following factors in mind when saving seed:

- Hybrid varieties (usually designated as "hybrid" or "F1 hybrid" as part of the variety name) produce seed that does not breed true. In other words, if you plant seed harvested from these plants, the resulting offspring will vary in appearance, productivity, and quality. Use only open-pollinated varieties (those that are not

hybrids) for home seed production. Some seed dealers have responded to the increasing interest in seed saving by clearly marking open-pollinated varieties in their catalogs.

- Seed can carry diseases into the next year's crop. This concern is minimal in most Idaho climates, but be safe by taking seed only from very healthy plants.
- Completely clean and dry the seed before storing it. A good method is to place the seed on a dry paper towel in a sunny window. Store the dried seed in a cool place (not more than room temperature) where it will remain completely dry.
- Some crops are self pollinated (they produce seed using their own pollen), while others are cross-pollinated (pollen is transferred from other plants). Self-pollinated crops include peas, beans, tomatoes, peppers, and eggplants. These are the simplest crops from which to save your own seed.
- Cross-pollinated crops include cucumbers, melons, squash, pumpkins, broccoli, lettuce, radishes, and sweet corn. If you want to save seed from cross-pollinated crops, you must isolate the plants or transfer pollen by hand. If you have ever saved squash seed and found the next crop to be full of unusual types, you know what can happen. You can isolate plants by growing only one variety of that crop, but only as long as there are no other varieties growing in gardens nearby (usually within about a quarter mile). The best way to ensure isolation is to cover the flowers with a paper bag before they open. Some plants have separate male and female flowers and both must be covered. When the flowers open, use a small artist's brush to transfer the pollen. Then cover the flowers again until they fade.
- For corn, save seed only from open-pollinated heirloom types.
- Some crops, such as beets, carrots, and onions, produce seed in their second year of growth. It is difficult to save seed from these crops, but you can do so by storing roots or bulbs over the winter in the refrigerator and replanting them in the spring.

Many books and web sites provide more detailed information about saving vegetable seed. For example, see seedsave.org (**http://seedsave.org/#**).

STORING SEED

Under proper conditions, seeds of some vegetable crops can be stored for several years. Table 3 lists common vegetables and the number of years that seed can be held. However, it can be difficult to provide proper storage conditions. If seeds are

Table 3. Number of years vegetable seeds will remain viable under proper storage conditions.

Vegetable	Average years seeds can be saved
Beans	3
Beet	4
Broccoli	3
Brussels sprouts	4
Cabbage	4
Carrot	3
Cauliflower	4
Celery	3
Chinese cabbage	4
Collard	4
Corn	2
Cucumber	5
Eggplant	4
Endive	5
Kale	4
Kohlrabi	3
Leek	2
Lettuce	1
Muskmelon	5
Mustard	4
Onion	1
Parsley	1
Parsnip	1
Pea	3
Pepper	2
Pumpkin	4
Radish	4
Rutabaga	4
Spinach	3
Squash	4
Tomato	4
Turnip	4
Watermelon	4

not stored properly, the length of time they can be held drops dramatically. To ensure plant vigor, the safest practice is to purchase or produce new seed every year.

Vegetable seed can be stored in the refrigerator or freezer inside a sealed container. It should at least be stored in a cool (below room temperature), dry place. A cool basement storage room can be ideal.

Preparing the Soil

Proper soil preparation is the basis for good seed germination and growth of garden crops. The ideal vegetable garden soil is deep, friable (easy to cultivate), well drained, and has high organic matter content. You may ask if such a soil exists! Only a few regions in Idaho have soils that naturally supply these conditions. Appropriate use of soil amendments can improve garden soil and provide the best possible conditions for your crops. Effective soil improvement begins with understanding the current status of your soil.

TESTING THE SOIL

Soil testing is the process of sampling soil and completing a laboratory evaluation to determine nutrient availability and chemical characteristics important for plant growth. At a minimum, have your soil tested for basic nutrient content and pH. Soil tests are especially critical in a new garden plot, but soil should be analyzed at least once every three years because conditions change over time. Soil tests are done for a nominal fee by the University of Idaho (UI) or by private laboratories. Contact your Extension office for instructions and sample bags.

One piece of information that comes from a soil test is pH. Soil pH is a measure of acidity or alkalinity. Vegetables differ to some extent in their response to soil pH, but most do well within a pH range of 6.2 (slightly acid) – 7.5 (slightly alkaline). If soil pH is too high or too low, poor crop growth may result, largely because of the effects of pH on the availability of nutrients.

Unfortunately, in most cases we are stuck with the soil we have regardless of whether pH is favorable. It is possible to raise the pH of low-pH soils (common in northern Idaho and some high mountain valleys) by liming. It is nearly impossible, however, to lower the pH of the alkaline soils common to much of southern Idaho. But you can partially compensate for the lack of nutrient availability in these soils by adjusting fertility practices. One of the best ways to improve nutrient availability is to increase the amount of organic matter in the soil.

ADDING ORGANIC MATTER

Organic matter is derived from decomposing plants. It is important because it improves tilth, increases water-holding capacity, improves fertility, and reduces problems with soil diseases. There is no replacement for organic matter in improving soil health and providing good growing conditions for vegetables.

Most Idaho soils are low in organic matter. It can be added in the form of plant waste (such as leaves or lawn clippings), composts, green manures, or aged animal manures. You'll need to add organic matter consistently (every year or two) because it breaks down rapidly in the soil.

Compost is one of the simplest, safest, and most effective organic amendments. You can purchase compost or make it from landscape or household plant-based waste. See chapter 8, "Backyard Composting," to learn the basics of this process. Apply compost by spreading a layer 3–6 inches deep on the soil surface. If possible, till it in to a depth of 10–12 inches.

Green manure is living plant material that is added to the soil. Effective green manure crops include oats, corn, vetch, clover, and mustard. Grow the green manure crop on the area you want to amend. Mow the crop while it is still green and till in the residue.

In short-season areas, planting a green manure crop may exclude planting a garden in that spot during the amending season. Regardless, this is still a very good practice in a new garden plot. A less disruptive method is to schedule green manure crops into the garden rotation system; reserve a different portion of the garden for a green manure crop each season.

Animal manures should be aged for a year or two or properly composted before application. Manures can be fairly high in salts and may be harmful in excessive amounts. Add 2–4 inches of manure and till it in to a depth of 10–12 inches. It's best to apply manure in the fall so it has time to completely decompose and salts can partially leach out of the root zone before spring planting.

FERTILIZING

Decisions related to fertilizing vegetable gardens can be complex. The type and amount of fertilizer needed depends on factors such as the natural fertility of the soil, soil texture, and amount of organic matter present. Thus, it is impossible to provide universal fertilizer recommendations that apply to every gardening situation.

Fertilizer requirements for individual vegetable crops vary widely, further complicating fertilizer-rate decisions. Some crops, such as peas, beans, and beets, need very little fertilizer. Most long-season crops, such as corn, potatoes, and melons, require fairly large amounts. Fertilizer application decisions for a vegetable garden should take into account these crop differences.

Nothing can replace a soil test for providing the information required to make good fertilizer application decisions. If soil test results are not available, you must base fertilizer decisions on reasonable assumptions about existing conditions. Three such assumptions are possible for most Idaho soils:

- Nitrogen (N) is the nutrient most likely to be in short supply. Base fertilizer application rates on the N requirement.
- Consistent applications of phosphorus (P) and potassium (K) are usually needed. Use a "complete" fertilizer — one that contains all three major nutrients (N, P, and K). The fertilizer should contain at least as much P and K as N. This assumption is not always true, however; hence, the value of an occasional soil test.
- Your garden soil is probably reasonably fertile to begin with and would grow a reasonable crop of vegetables even if you added no fertilizer. This last assumption can be validated only through experience.

If you feel these assumptions are reasonably valid for your garden soil, the following three-step process should work as a starting point for fertilizer applications. These recommendations are appropriate for a typical Idaho clay loam, silt loam, or sandy loam soil with average nutrient content and a low amount of organic matter.

1. Purchase a fertilizer that contains a moderate amount of N, high levels of P, moderate to high levels of K, and possibly some sulfur. Fertilizer labels list the content of these nutrients in the order N-P-K. Examples of appropriate fertilizer grades for vegetables are 4-10-6, 5-10-5, 5-10-10, 6-10-10, 10-20-10, 10-45-10, and 15-30-15. It's not necessary to use a product that matches one of these grades exactly, but do seek a product with a similar ratio of major nutrients.
2. Before planting, add fertilizer at the rate of 2–3 pounds of actual N per 1,000 square feet of garden area. (See chapter 5, "Soils and Fertilizers," for information on how to determine the nutrient content in fertilizers.) This will supply the full seasonal needs for crops that are considered to be light feeders (beans, beets, carrots, chard, lettuce, parsnips, peas, early harvested potatoes, radishes, rutabagas, spinach, tomatoes grown in a short-season area, and turnips).
3. After the crops are up and growing, side-dress the heavy feeders (broccoli, cabbage, cauliflower, celery, collards, corn, cucumbers, eggplants, kohlrabi, leeks, melons, onions, peppers, late-harvested potatoes, pumpkins, squash, and tomatoes grown in a long-season area) with an additional 2–3 pounds of N per 1,000 square feet. Apply this fertilizer just as the plants start their major growth phase — typically 3–6 weeks after planting or transplanting, depending on the crop. Apply the fertilizer near the base of the plants. For this application, you might use ammonium sulfate (20-0-0), which does not contain P or K.

If you use a lot of compost or manure, you can use less fertilizer. For example, if you apply 4–6 inches of manure or compost each year, you can reduce the amount of fertilizer applied by one-half to two-thirds.

The principles described above apply to both organic and chemical fertilizers. However, the fertilizer products used are different. Organic fertilizer products include bonemeal, blood meal, feather meal, etc. Organic gardeners often rely more heavily on consistent applications of composts, manures, and green manures to supply plant nutrients.

Sandy garden soils require some modification in fertilizer application practices. If your soil is sandy, apply less of the total fertilizer before planting. Instead, make frequent, small applications throughout the growing season. This will provide the plants with the nutrients they need, while reducing leaching losses. A soil test will help you determine your soil texture.

See chapter 5 for more about soils, soil fertility, fertilizer grades, and application methods.

TILLAGE

The final step in soil preparation is tillage. Ideally, soil should be tilled to a depth of at least 10 inches. This can be very difficult with small garden equipment, however. If you can't till deeply, it may be beneficial to occasionally fracture the soil to a greater depth. Push a long-tine garden fork deep into the ground and pull the handle backward to break up the hard lower layers.

It is important to avoid working soil when it is very wet. Tilling wet soil breaks down the soil structure, causing it to become cloddy and hard. The negative impact of tilling wet soil may last for years. You can tell if your soil is dry enough to work by taking a handful and squeezing it tightly into a ball. If the ball breaks into granular pieces when pressed lightly between your fingers, the soil is ready to work. If the ball remains intact and feels sticky when you squeeze it, wait a few days before tilling.

Planting

PLANTING VEGETABLE SEEDS OUTDOORS

No amount of care can rescue plants that get off to a bad start due to incorrect planting. In order to germinate properly, seed must be planted at the right depth and must remain moist.

As a general rule, vegetable seeds should be planted to a depth about three times their width (not their length). However, there are exceptions. Some seeds require light for germination and should be covered with no more than ¼ inch of soil. Most seed envelopes contain planting instructions.

You can cover shallow-planted seed with clear plastic film (such as plastic food wrap) or wet burlap to raise the soil temperature and hold moisture. Remove the covering immediately after the seedlings emerge to prevent burning or abnormal growth of the new plants.

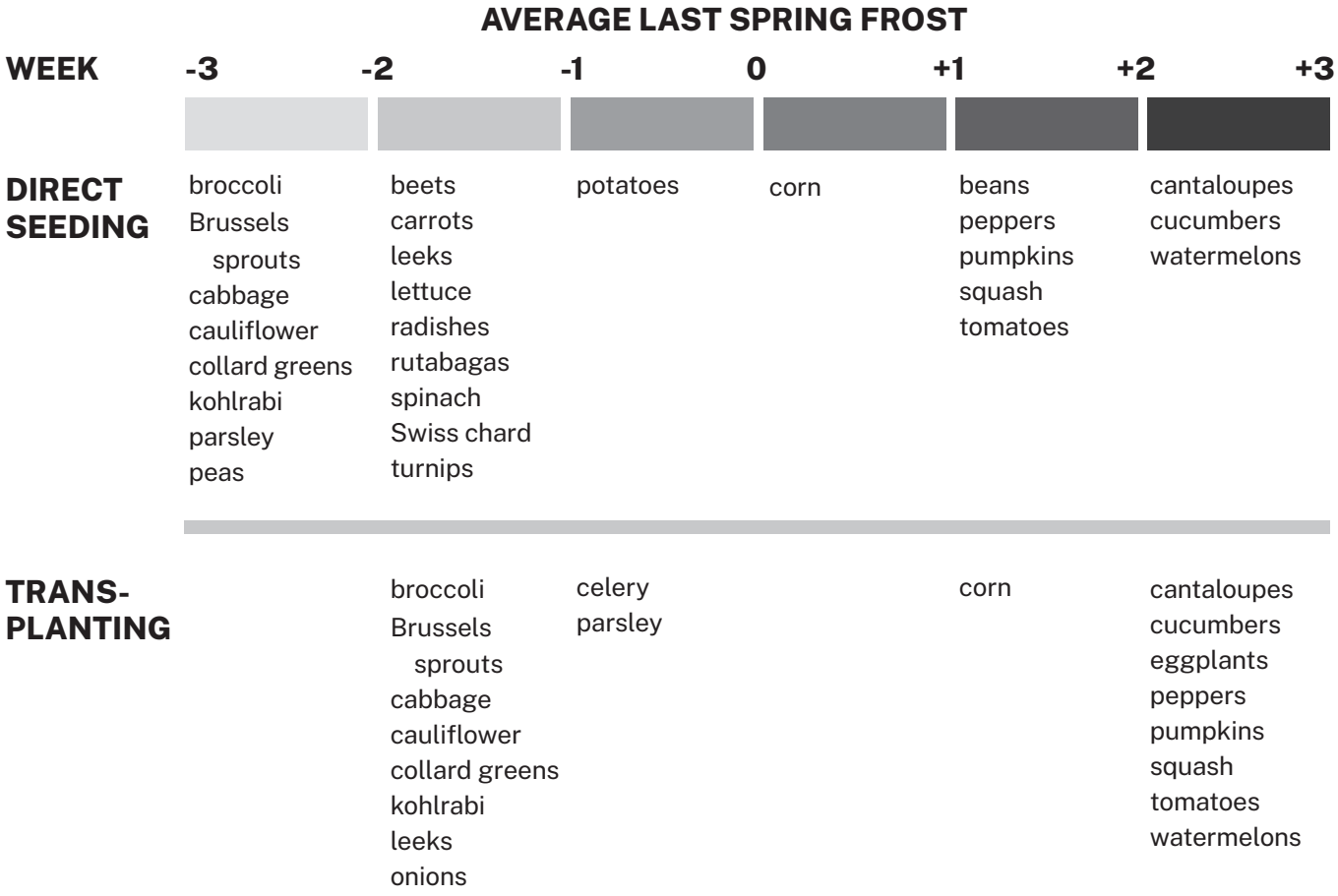

Figure 10. Planting and transplanting guide for vegetable crops based on the date of the last spring frost. On the bar, zero (0) is the date of the last spring frost, as determined for your locale. Each number to the right or left is the number of weeks before (-) or after (+) the average last frost. Crops listed under each number are those that typically can be successfully planted or transplanted during that time.

Optimal planting times vary from crop to crop. There is no "one time fits all" for vegetables. Some plants grow well in cool spring weather. Plant these crops well before the last frost. Other vegetables can be severely damaged by cold weather or light frost.

The first step in deciding when to plant is to determine the average date of the last frost in your area. This information can be found in many publications, websites, or from your local Extension office.

Next, schedule planting based on the frost hardiness of each crop (see Figure 10). Some general guidelines are

- **Three to four weeks before the average last spring frost**: Plant cold-hardy crops, including onions, peas, kale, cabbage, broccoli, and cauliflower. (The last three can be transplanted within the same time frame.)
- **A week to two weeks before the average last frost**: Plant moderately hardy crops, such as beets, carrots, spinach, Swiss chard, leeks, and lettuce. You can also plant sweet corn at this time if you are willing to take a chance on minor frost damage in order to get an earlier crop.
- **Within a week or two after the average last spring frost**: If the weather forecast does not call for cold weather, plant warm-season crops, including beans, cucumbers, eggplants, melons, squash, pumpkins, peppers, and tomatoes. If transplanting these crops, you may need to wait a few more days, depending on the weather forecast.

Bouts of cold temperatures and frost are not the only things that cause problems with emergence and early growth. Soil temperature also affects germination. In the spring, soil is often cold and seeds of some plants will rot before they have a chance to sprout. Even if the calendar indicates it's time to plant, it is wise to make sure the soil temperature is high enough to allow germination. For cold-hardy crops, the minimum daytime high soil temperature for planting is 50°F. Moderately hardy crops need soil temperatures of at least 55°F, and warm-season crops need 65°F. Table 4 outlines the minimum and optimal soil temperatures and expected time to emergence for common vegetable crops.

Once planted, you must keep the soil moist until the plants begin to emerge. In some years, spring rain and cool weather make irrigation unnecessary. However, in most years, frequent light watering is required to get seed off to a good start. You may need to water deeply seeded crops every two or three days and shallow-seeded crops as often as two times a day.

Table 4. Vegetable germination and emergence as related to soil temperature.

Crop	Days to emergence from seeding[a]	Optimal soil temperature for germination (°F)	Minimum soil temperature for planting (°F)
Beans	5–10	70°–80°	65°
Beet	7–10	50°–85°	50°
Broccoli	5–10	65°–75°	50°
Cabbage	5–10	65°–75°	50°
Carrots	12–14	70°–80°	55°
Cauliflower	5–10	65°–80°	55°
Celery	10–18	65°–75°	55°
Collards	5–10	65°–75°	50°
Corn, sweet	7–10	70°–80°	65°
Cucumbers	7–10	70°–85°	65°
Eggplants	8–12	70°–85°	65°
Endive	10–14	65°–75°	55°
Kohlrabi	5–10	65°–75°	50°
Leeks	10–14	65°–70°	50°
Lettuce	7–10	65°–70°	55°
Melons	5–10	80°–85°	65°
Onions	10–14	65°–70°	50°
Parsley	10–25	65°–70°	55°
Parsnips	14–21	65°–70°	55°
Peas	7–14	65°–70°	50°
Peppers	10–14	75°–85°	65°
Potatoes	10–18	65°–70°	55°
Pumpkins	7–10	65°–75°	65°
Radishes	5–7	65°–70°	50°
Rutabagas	7–15	65°-70°	50°
Spinach	7–14	65°–70°	55°
Squash	7–14	70°–85°	65°
Swiss chard	7–14	65°–75°	55°
Tomatoes	7–14	75°–80°	65°
Turnips	7–14	65°–70°	50°

[a] Emergence may take several days longer if soil temperatures are consistently below the optimum, as often occurs during spring in much of Idaho.

PRODUCING AND ESTABLISHING TRANSPLANTS

Many vegetable crops do better when transplanted rather than direct seeded in the garden. Transplanting makes weed control simpler, enhances the growth and quality of crops that prefer cool, spring weather (such as broccoli and cauliflower), shortens the time to harvest of many fruit-bearing crops (such as peppers and tomatoes), and allows us to grow many crops that are marginally adapted to short-season climates (such as melons).

Some vegetables are very difficult to transplant. (The length of this list varies, depending on the gardener's skill level.) Other vegetables fall into a middle category; they can be transplanted successfully, but only if proper precautions are followed. The last group includes vegetables that can be transplanted with minimal frustration. See Table 5 for a list of vegetables that can be successfully transplanted.

You can purchase transplants or grow them yourself from seed. It's easier to purchase plants and greenhouse-produced transplants are often healthier than those produced at home because they are grown under ideal conditions. However, growing your own transplants does have advantages. You can produce unusual varieties, save money, and ensure that your transplants are at the proper growth stage when you are ready to plant.

Growing transplants without good greenhouse facilities can be a challenge. The most important factors are light, soil mix, irrigation, proper size and growth stage, and hardening.

Table 5. Ease of transplanting vegetables.

Appropriate for transplanting and easy to handle	Appropriate for transplanting but require extra care for success	Inappropriate for transplanting or do not easily survive the process
Broccoli	Cantaloupes[a]	Beans
Brussels sprouts	Celery	Beets[b]
Cabbage	Corn	Carrots[b]
Cauliflower	Cucumbers[a]	Peas
Chinese cabbage	Pumpkins[a]	Radishes[b]
Collards	Squash[a]	Rutabagas[b]
Eggplants	Swiss chard	Spinach
Leeks	Watermelons[a]	Turnips[b]
Lettuce		
Onions		
Parsley		
Peppers		
Tomatoes		

[a] Transplant vine crops when seedlings are very young (one or two true leaves) and very vigorous. Cover transplants and protect them from wind and sunburn for about two weeks after transplanting.

[b] Root crops (beets, carrots, radishes, rutabagas, and turnips) are often easy to transplant, but the roots will branch or have other quality problems as a result of root disturbance.

Starting Transplants

It can be tricky to know when to plant seeds for transplants. The objective is to have the seedlings at the optimal stage of growth when it's time to transplant — assuming the unpredictable Idaho

Table 6. Number of weeks required to produce transplants from seed.

Crop	Weeks to produce transplants from seed[a]
Broccoli	5–7
Brussels sprouts	5–7
Cabbage	5–7
Cantaloupes	3–4
Cauliflower	5–7
Celery	8–10
Collards	5–7
Corn, sweet	3–4
Cucumbers	3–4
Eggplants	6–8
Endive	4–8
Kohlrabi	5–7
Leeks	4–6
Lettuce	3–5
Onions	6–8
Parsley	6–8
Peppers	6–8
Pumpkins	3–4
Squash	3–4
Tomatoes	5–9

[a] The number of weeks needed to produce transplants is based on growth at room temperature.

weather will be suitable for planting on the day you expect to transplant. It takes planning to ensure that transplants are neither too big nor too small when you are ready to move them to the garden.

You need two pieces of information in order to develop a planting schedule for vegetable transplants: (1) the date the transplants will be planted in the garden and (2) the amount of time needed to produce appropriate-sized transplants. You can calculate the transplanting date if you know the last average frost date for your locale. Use the following guidelines (also see Figure 10):

- **Cole crops (cabbage, broccoli, cauliflower, kale, brussels sprouts, etc.) and onions**: Transplant 2–3 weeks before the average last frost.
- **Most salad crops (lettuce, Swiss chard, spinach, etc.)**: Transplant a week or so before the average last frost.
- **Tender crops (tomatoes, peppers, eggplants, squash, melons, etc.)**: Transplant about 1 or 2 weeks after the average last frost if the weather forecast is for reasonably warm and stable conditions.

If you protect your transplants with hot caps, row covers, etc., you sometimes can move the transplant date forward by a week or two.

Once you know the anticipated date of transplanting, see Table 6 to find the number of weeks needed to produce transplants of your chosen crops. Then count backward from the transplanting date to find the date you should plant seeds.

It is best to use a soilless planting mix containing peat to start seedlings. Soilless mixes are usually free of disease organisms that can cause damping-off, a fungal disease that causes young seedlings to fall over and die. They also hold a large amount of water and maintain the integrity of the root ball when it is time to transplant. You can purchase premixed potting soil or mix your own. A mix of 50% vermiculite or perlite and 50% fine sphagnum peat (plus a little fertilizer) is excellent for starting seeds.

To save space, you can plant the seeds in flats and then transplant the small seedlings into small pots or other individual containers to complete growth in preparation for transplanting outside. An alternative is to plant the seed directly into individual containers such as small pots, six-pack trays, peat pellets, or peat pots. With this method, it is best to plant extra seed and thin the plants after emergence to the desired number in each pot (usually two or three).

Planted seeds and seedlings are extremely sensitive to drying out. If the air in your home tends to be dry, it may help to cover the flats (shallow, rectangular pans with no dividing lines) or pots with clear plastic in order to maintain uniform moisture. Do not keep the soil soaking wet, however, since excess moisture is conducive to damping-off. You can prevent or reduce damping-off by sprinkling a thin layer of milled sphagnum moss, which contains a natural fungicide, on top of the soil.

Caring for Transplants

More homegrown seedlings are lost to inadequate light than to any other factor. Vegetable seedlings grown under low-light conditions are likely to be spindly and weak. They frequently are killed by damping-off. If they survive the early growth phase, plants are often too tender to survive the move to the garden.

For these reasons, transplants should be grown under conditions that include or mimic at least 10 hours of sunlight each day. If you do not have a sunny room or back porch with a southern exposure, you will need supplemental lights. Grow lights supply a good spectrum of light. Mount the lights just above and nearly touching the plants.

Transplants must be healthy, growing rapidly, and adapted to outside conditions before they go to the garden. Thus, you must maintain optimum moisture and fertility conditions during growth. Never allow plants to dry out or run out of nutrients. Plants should be dark green and not lose any leaves. If growth is retarded, transplants may never recover sufficiently to produce a good crop.

Hardening Off

About a week before you plan to move transplants to the garden, you should "harden them off." Hardening off means to slowly adapt the plants to outside conditions. This process reduces transplant shock and the risk of transplant death. Harden off the plants over a one-week period by moving them outdoors for increasing amounts of time. Start with less than one hour the first day and eventually leave them outside for much of the day. Move them indoors at night (unless a warm night is forecast)

and during inclement weather (especially if it is windy). Transplants will use more water outside, so water accordingly.

Transplanting

Some vegetable transplants have specific requirements (Figure 11):

- Cole crops (cabbage, broccoli, cauliflower, Brussels sprouts) should not be too large when transplanted. If the stem diameter is larger than about ¼ inch, the plants likely will "button" or "bolt," meaning they will produce very small heads or go to seed after cold weather.
- Vine crops (cucumbers, melons, squash, pumpkins) should be very young when transplanted, having at the most only one or two true leaves. They should be very vigorous. Otherwise, they develop a root-hardening problem that makes them very slow at recovering from transplant shock. Also, newly transplanted vine crops are very susceptible to windburn and sunburn. Cover them with paper or plastic for about a week after transplanting.
- Tomatoes are relatively easy to transplant. Even very large plants establish with few problems, allowing you to get an early start on production.

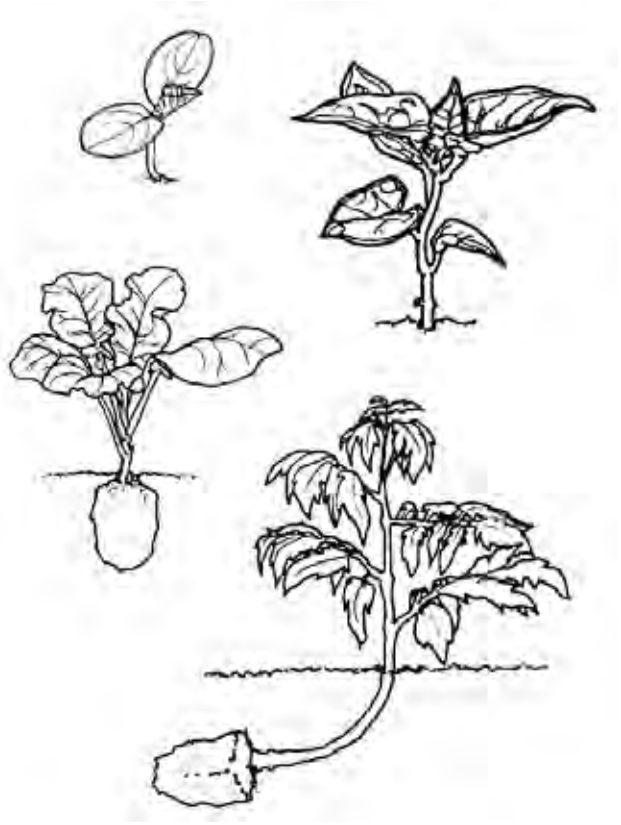

Figure 11. Optimal transplant size of vegetable crops. Transplant vine crops (cucumbers, melons, squash, and pumpkins) when very small. Plant them at the same depth as they are growing in the pot (top, left). Peppers, eggplants, and most other transplanted crops can be transplanted at a moderate size. Plant them slightly deeper than in the pots (top, right). Cole crops (cabbage, broccoli, cauliflower, Brussels sprouts, kohlrabi, and kale) should be relatively small and vigorous. Plant them at the same depth as they are growing in the pots (bottom, left). Tomatoes can be transplanted when quite large. Place tall tomato plants sideways in a trench and cover the stem to the lowest leaves (bottom, right).

Here are a few additional tips for successfully transplanting vegetables:

- Prepare garden soil before transplanting. Many soil amendments, such as aged manures, sulfur, limestone, rock fertilizers, and green manures, require time to break down. Mix these materials into the soil the fall before planting or at least several weeks before planting.
- Transplant on an overcast day, in late afternoon, or in early evening to minimize wilting. Water the potted plants thoroughly just before transplanting.
- Handle plants carefully. Avoid disturbing the roots or bruising the stems.
- Dig a hole large enough to hold the plant roots. Plant vegetables only very slightly deeper than they were growing in their pots. Tomatoes are an exception. They will develop roots all along the stems, and you can plant them deeply enough to leave only two or three sets of leaves exposed.
- Press soil lightly around the roots and water well. Pour a cup of liquid starter fertilizer solution around each plant, mixed at about half of the concentration recommended on the label.
- Protect plants from wind and sun for a few days after transplanting. Place newspaper or cardboard on the south side of the plants or cover them with commercially available devices, milk jugs, baskets, or upside-down flower pots (use clear plastic so the sunlight will pass through).
- Water the plants once or twice a day for about one week. Then water two or three times during the next week before going to a normal irrigation routine. Overwatering can cause transplants to suffer from root rots, so don't overdo it.

Caring for Your Garden

IRRIGATING

Under Idaho conditions, proper irrigation is essential for productive vegetable gardens. Watering maintains growth during the summer. It also can improve seedling emergence, reduce soil crusting, improve germination and plant establishment, and stimulate growth of transplants. Proper irrigation — exactly meeting your plants' water requirements — is the single most important factor in growing a high yield of good quality vegetables. See the "Soils and Fertilizers" chapter in this handbook for a discussion of general principles related to soil water and irrigation.

Garden water demands and irrigation scheduling are the result of complex interactions between climate, weather, soil type, plant species, and irrigation practices. Thus, no single recipe is suitable for all gardens. Taking the time to learn about proper irrigation in your own situation will pay dividends. The following principles can help you make good irrigation decisions for your vegetable garden:

- In most locations in Idaho, nearly all of a vegetable garden's water needs must be met through irrigation. Once they approach full size, most vegetable plants use ¼ inch of water per day or slightly more. Thus, a summer garden will need around 2 inches of water per week. Most soils will not hold this much water. In order to avoid plant stress, plan to irrigate twice each week, with the total of the two irrigations being about 2 inches.
- In the spring, when the weather is cool and plants are small, vegetable plants may use less than half the amount of water given. In the fall, when plants start to mature, water use also declines.
- You can measure the amount of water applied by a sprinkler by putting a can under it. If the water in the can is ¼-inch deep at the end of the irrigation, you have applied ¼ inch.
- Plants use the same amount of water regardless of soil type. However, sandy soils hold less water, so plants use the available water very quickly and then become stressed. If your soil is sandy, water more frequently but apply less water each time.
- Sprinkler irrigation is a simple method for applying water uniformly. However, sprinklers wet the leaves and encourage disease development. They also splash dirt on leaves, which may add some "grit" to your meals. If these are problems in your garden, consider using a bottom-up irrigation method such as soaker hoses or a drip system.

CONTROLLING WEEDS

Weeds are a constant source of frustration to vegetable gardeners. Weeds not only reflect negatively on the gardener's expertise (the neighbors are always watching!), but they also use water and nutrients, compete for available light, and reduce the yield and quality of vegetables.

Keeping the garden clean of weeds one year doesn't mean they won't be back the next. The old saying, "one year's weed, seven years' seed," contains more truth than myth. Although weeds will always be present, some control methods make them easier to live with.

Cultivation

Hand pulling and digging weeds is probably the best choice for small gardens and raised beds. You can make the task more pleasant with the use of kneepads. Hoeing is preferred in larger spaces. Hoeing can damage root systems of large plants, so push the blade of the hoe into the soil just deeply enough to sever weed roots. Stay several inches away from the base of vegetable plants. Manually powered rotary cultivators can supplement the use of a hoe. They do a good job on long rows and pathways if the soil is not too wet or dry and if the weeds are not too big.

A power tiller may be the tool of choice for large gardens that are arranged in wide rows. If you plan to use a power tiller for weed control, plant the vegetable rows far enough apart to till between the rows without damaging the plants. Make rows at least 8 inches wider than the tiller blades. Once plants are large enough to touch neighboring plants across the rows, stop power tilling in order to prevent damage to the roots or leaves.

Cultivation is best done when the soil is somewhat moist, but not wet. The best time to cultivate is 2 or 3 days after rain or irrigation. Working wet soil damages the soil structure, especially in the case of fine-textured soils, making the soil compacted and cloddy. However, when the soil is dry, weeds are difficult to pull and hoeing is a chore.

After hand pulling weeds, you can lay them on top of the soil to dry out and then turn them under (if they are not yet flowering). Turning under weeds provides organic matter to the soil. Avoid irrigating for a day or two to prevent the weeds from rooting and "coming back to life."

Some common weeds, such as purslane, nut grass, quack grass, and other rhizomatous grasses, will re-root with the first added water and continue to grow. It may be best to remove such difficult weeds from the garden. Also, if weeds are mature enough to produce seed, remove them from the garden to prevent seed dispersal.

Mulching

Mulching can reduce the need for weeding. A thick layer of organic mulch will prevent most annual weed seeds from germinating and those that do germinate are usually easily pulled. Organic mulches can include straw, grass clippings (make sure they are free of herbicides), bark (small enough to be tilled under at the end of the season), wood chips, or sawdust.

Mulching with black plastic film can also be very effective at reducing weed growth. Using black plastic mulch on the rows and an organic mulch between the rows will nearly eliminate annual weed problems. Mulches are less effective at controlling perennial weeds such as quack grass and bindweed. Elimination of these difficult weeds will probably require off-season (early spring or late fall) applications of herbicides over a period of years.

Close Spacing

When spaced close to each other, established vegetable plants shade the soil and prevent the growth of many weed seedlings. Close spacing is easily achieved in a well-planned raised bed, but it also works in victory gardens. Place plants closely enough together so that the foliage of adjacent plants forms a closed canopy when the plants are mature.

Other Practices

One unusual weed-control method is to plant grass between rows and keep it mowed throughout the summer (Figure 12). This grass is called "living sod" and is a good choice for controlling weeds between raised beds.

The use of a cover crop (such as alfalfa, clover, vetch, or rye) over several seasons or years can reduce weed problems. This method requires leaving the cover crop area uncultivated, which reduces gardening space. Cover crops should be mowed or harvested regularly, which can be time-consuming and difficult without appropriate tools.

A few herbicides labeled for use in home vegetable gardens can be applied over the top of growing vegetable plants. Most can be used safely and are moderately effective, but improper applications can damage crops. Herbicides are more effective when applied as a preventive measure before planting. First remove all existing weeds from the garden. Follow all label instructions.

CONTROLLING PESTS

In most Idaho vegetable gardens, you can ignore insect pests if you are willing to put up with a little damage and minor losses of edible produce. However, pests occasionally show up in numbers sufficient to be a serious problem.

The following five simple strategies will help you manage insects, slugs, and snails in a vegetable garden. The insect control chapter of this handbook includes more detailed information.

- **Be a sanitary gardener**. Insects often overwinter in garden refuse, so clean up dead plant material at the end of the year. If you want to return the organic matter to the soil, till or plow the garden after harvesting the last crops.

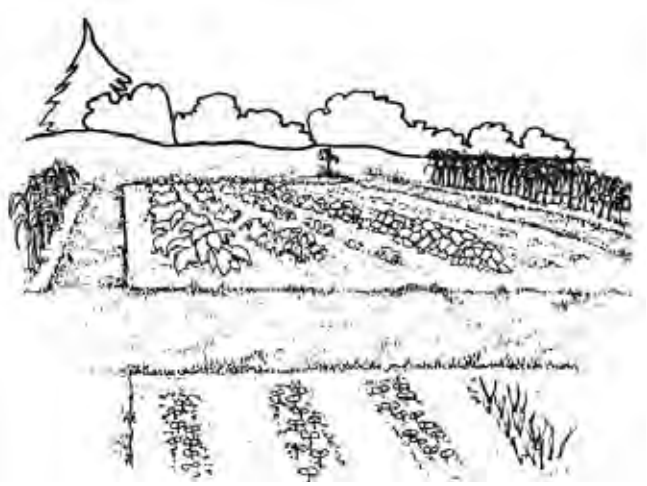

Figure 12. The use of living sod — the practice of planting and mowing grass between vegetable garden plots — is a good way to control weeds. This method is effective around both bordered or open blocks.

- **Maintain good plant health**. Healthy plants can often partially defend themselves from pests. Even if insects do some damage, the plants will have a good chance of recovering.
- **Use physical barriers and cultural controls**. You can keep some types of pests at bay by preventing access to your plants. For example, collars around the lower stems of small plants will foil cutworms. Wood ashes or sharp sand will discourage slugs and snails. Other methods include using colored plastic mulches and spraying insects with a hard stream of water.
- **Encourage or release beneficial insects**. A little patience will go a long way toward controlling many insects, such as aphids. Once pests show up, their predators will arrive and begin eliminating them. Purchasing and releasing beneficial insects such as ladybugs and lacewings may speed up the process. Two things will increase populations of predatory insects. One is to allow a few pest (prey) insects to be present. Predators will not come if there is nothing to eat, so allow a few pests to persist. The other strategy is to avoid using broad-spectrum insecticides. These products may kill pests, but they also eliminate many predators.
- **Judiciously use pesticides as a last line of defense**. Some insects become serious problems and do not respond to other control methods. For many insects, both organic and synthetic insecticide options are available. If you choose to use insecticides, direct the application to the problem rather than broadcasting an insecticide across the garden. Also, use products that target the specific pest you are trying to control. The goal is to control the pest without harming the beneficial insects that naturally reduce pest populations.

Insects and other pests that commonly infest Idaho gardens at damaging levels include the following:

Aphids

These soft-bodied insects are usually found crowded at the ends of succulent new growth. Insecticidal soaps or a hard stream of water that knocks them off the plant usually are sufficient to eliminate damage. Also, aphids will almost always be eliminated by predators if you are patient enough to let their natural enemies do their work.

Grubs and Wireworms

These soil dwellers often damage the roots and lower stems of plants. They are difficult to control and may require the use of a soil-applied insecticide before planting. Thus, you must know the garden's history and realize the problem exists before damage appears. Once damage is visible, it is hard to apply effective controls without damaging young plants.

Cutworms

This pest often kills seedlings and transplants by chewing through the stems at ground level. Cabbage, broccoli, tomatoes, and other soft-stemmed transplants are common victims. Placing cardboard collars around the base of plants is an effective way to prevent damage. Some insecticides are also effective.

Corn Earworm

This pest is common in the warmer regions of Idaho. Control usually requires the use of an organic or synthetic insecticide, applied once or twice while the plants are in silk. Begin control measures when the silks appear and continue as long as they are green and pliable.

Slugs and Snails

Slugs and snails are less of a problem in our dry climate than they are in wetter areas. In fact, if you have a slug problem, you may be watering too much and too often. Water less and the problem may be reduced. If reducing irrigation doesn't solve the problem, baits and traps can be partially effective.

Cabbage Looper

These slender green caterpillars infest all cole crops (broccoli, cabbage, cauliflower, kale, etc.). They chew holes in the leaves, deposit weblike material, and leave their frass (droppings) on the plants. They can be ignored in small numbers, but may require control with *Bacillus thuringiensis* (the organic pesticide sold as Bt) or another insecticide if they become very numerous.

Tomato Hornworms

These large, ferocious-looking caterpillars can be very damaging to tomato and potato plants. One large individual can defoliate a plant in a day or two.

Physical control is the best method for eliminating this occasional pest. Pick them off the plants and step on them or squeeze them between two rocks. For the squeamish, simply remove them from the garden.

Colorado Potato Beetles

These pests are a serious problem on potato plants and occasionally on tomatoes. If only a few are present, you can remove them from plants by hand. If numerous, they may require an insecticide. A hard stream of water may knock them from plants, but unless they are very small, they likely will climb back onto the plant and keep eating.

Mexican Bean Beetle

The bright-orange, prickly looking larvae of this beetle can quickly skeletonize leaves of bean plants. Heavy infestations may require an insecticide application.

CONTROLLING PLANT DISEASES

The dry climates common to Idaho limit the number of diseases in vegetable gardens. However, a few serious problems should be monitored.

Viruses

A number of common virus diseases occur on vegetable crops. Examples include zucchini yellows, cucumber mosaic, potato leafroll virus, tomato spotted wilt, and tomato mosaic. Viruses are difficult to control. Once a plant is infected, it cannot be cured. The only solution is to remove the affected plants to prevent its spread to healthy plants.

If you have recurring problems with any virus, you will need to identify it and learn about the disease and its vectors. **Vectors** are organisms, usually insects, that spread a disease. Develop a strategy to control them. You may need to seek help from a Master Gardener, Extension educator, nurseryman, or other qualified person.

Bacteria

Many fruit rots and some leaf spot diseases are caused by bacteria. There are no chemical products registered for control of bacteria in vegetable gardens. The best methods for controlling these diseases are cultural. Keep fruit off the ground and make sure to allow plant surfaces to dry between watering. Eliminate plant refuse from diseased plants.

Fungi

The most common plant diseases involve fungal pathogens. Some fungal diseases live in the soil and attack the plant through the roots; others directly attack leaves, stems, flowers, and fruits.

Crop rotation — moving each vegetable to a different place in the garden each year — is a good way to control soil fungi. Rotation is especially important for controlling verticillium wilt in potatoes, peppers, and tomatoes; club root in broccoli, cauliflower, and other cole crops; and vine wilts in the vine crops (squash, cucumbers, and melons).

Keeping fruit off the ground helps prevent fruit damage. Limit the impact of foliar fungi by allowing foliage to dry between irrigations. However, some fungi, such as powdery mildew, may still become a problem on many crops. Foliar fungal problems that return every year may require fungicidal applications. Most fungicides work best if they are applied before plants show symptoms. Thus, the decision to use fungicides may need to be based on past history.

Further Reading and Resources

WEBSITES

Many UI publications about gardening are available from your county's UI Extension office or online at **https://www.uidaho.edu/extension/publications**.

The UI maintains a gardening website that includes information on producing vegetables. It is called "Idaho Landscapes and Gardens" and can be accessed at **https://www.uidaho.edu/extension/landscapes**.

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CHAPTER **TWENTY-ONE**

VEGETABLE CROP RECOMMENDATIONS

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Adapted from a document originally prepared by George F. Gardner

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Florida Center for Instructional Technology, University of South Florida

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21 VEGETABLE CROP RECOMMENDATIONS

Learning Objectives

- Review the most common vegetables produced in Idaho gardens
- Adapt recommendations to unique climate, soil, property situations and personal objectives
- Estimate fertilization requirements based on soil test results
- Demonstrate comprehension of the crops covered per their histories, growing needs, soil type/preparation tips, fertilization requirements, pest information and control, prevalent diseases, harvest and storage tips, and crop production planning

Introduction

Understanding the growth characteristics and management requirements of individual vegetable crops can be important in helping gardeners achieve superior productivity and quality. This chapter provides information about some of the most common vegetables produced in Idaho gardens.

The recommendations provided here are not the final word in growing vegetables. Every gardener has a unique situation created by his or her climate, soils, property, and personal objectives. Nothing replaces experience. This chapter is a good starting place, but each gardener should rely as much on experience as on the written word.

FERTILIZER RECOMMENDATIONS

Determining the optimal fertilizer rate for each vegetable crop can be challenging. When establishing a vegetable garden, and periodically thereafter, it is a good idea to take a soil sample and have it evaluated by a competent laboratory. If a garden space has been significantly improved, such as by the addition of topsoil, it is also wise to test the soil.

The soil test will provide the basis for fertilizer application rates. Private soil laboratories often supply recommendations along with test results. If recommendations are not provided, Extension educators can help you interpret the soil test results.

In addition to helping you decide how much fertilizer to apply, soil tests can help you choose appropriate fertilizer products. Many fertilizer formulations are available, making it possible to meet plant needs in a variety of situations. For example, if a soil test indicates low levels of nitrogen (N), but high levels of phosphorus (P) and potassium (K), an appropriate product would be high in N but low in the other nutrients, e.g., 21-0-0 (N-P-K) or 46-0-0. However, if N is high and other nutrients are somewhat low, it might be best to choose a 5-10-10 or 10-10-10 formulation. See chapter 5 to learn how to calculate fertilizer application rates.

Once a garden is in successful production, it is not essential to test the soil every year. In this case, you can follow recommendations based on average soil nutrient levels, such as those included in this chapter. If they do not prove suitable to your situation, test your soil and make adjustments accordingly.

CONSUMPTIVE YIELD

Information on consumptive yield can help you determine how much of a crop to plant. The information in this chapter will enable you to calculate planting requirements based on your family's preferences. This information is valuable and difficult to find.

NUTRITION

Nutrition information can help you create a balanced diet. United States Department of Agriculture (USDA) researchers say that every person should eat 2.5–3.5 cups of vegetables every day. Vegetables contain many critical nutrients that are difficult to obtain from other foods. Researchers are learning that the nutritional value of vegetables goes far beyond vitamins and minerals. Vegetables also include many compounds that help reduce the risk of cancer, reduce the impact of aging, strengthen the immune system, and protect memory and eyesight. Any crop that supplies 5%–20% daily value (DV) of a nutrient is considered a "good source"; any crop that supplies more than 20% DV of a nutrient is considered an "excellent source."

SOIL TEMPERATURES

Successful planting involves many things, including placing seeds in an environment in which they can germinate and grow. Soil temperature is critical to the successful establishment and early growth of all crops. Some species, such as radishes, carrots, and beets, are categorized as cool-season crops and can germinate in soils as cold as 40°F. Watermelons and tomatoes, however, need soil temperatures of at least 60°F.

At minimum germination temperatures, most crops may emerge, but emergence will take a long time, and seedlings sometimes have more problems with diseases and pests than those growing in warmer soil. At optimal soil temperatures, seeds emerge most quickly and plants have the fewest problems getting established. Optimal soil temperatures are often 20°F–30°F warmer than minimum temperatures.

In Idaho, if we wait for optimal soil temperatures, it often is too late to grow a garden. Thus, we have to balance the needs of the seeds with the reality of where we live. Somewhere between the minimum and optimal soil temperature is usually good enough to get plants off to a healthy start.

Recommendations for planting-time soil temperatures in this chapter are within this range. You'll need to balance these recommendations against other factors, such as the need to start plants early enough to allow harvest within the normal growing season.

In Idaho, we often see large swings in temperature from day to night. Although soil temperatures do not vary as widely, they do somewhat mimic air temperatures. Thus, soil temperatures can be suitable for planting during the day, but fall lower at night. It is the daytime maximum soil temperature that is most important. If soil temperatures are within an acceptable range during much of the day, germination and emergence will occur normally.

Follow these steps to measure soil temperature:

1. Obtain a good soil thermometer (available at nurseries and garden stores).
2. Locate the exact spot where you will plant the crop of interest. Even a few feet away, the conditions can be different because of shade, structures, etc.

3. Insert the probe to the depth at which you will plant the seed (about 1 inch is a good average for all seeds) so you can test the actual location of the seed.
4. Wait 1–2 minutes for the probe to stabilize.
5. Read and record the temperature.

Take the temperature over a period of days. It's best to test at the time of day when maximum (5–7 p.m.) and minimum (6–8 a.m.) temperatures occur. With this information, you can compute an average daily soil temperature. Many publications use the daily average for making planting recommendations. (In this chapter, recommendations are based on daily maximum temperatures rather than on average temperatures.)

Beans

Snap beans (*Phaseolus vulgaris*), grown for the immature pod, originated in Central America. Both bush and pole types were widely used by native peoples. Bush beans ripen earlier, but pole bean yields are higher. There are several popular types of snap beans, including wax, flat pod, green, and purple beans. Other types of beans that enjoy some popularity include shell beans, fava beans, lima beans, and soybeans.

Bush beans are the most popular type of snap bean. Because these beans grow to a certain size, blossom, set fruit, and then stop growing, they are referred to as determinate. Bush beans provide the advantage of having all the pods reach harvestable size at nearly the same time. Pole beans, however, are indeterminate. They continue to grow and produce throughout the season and will have both blossoms and mature beans on the same plant. Pole beans provide fresh pods over a long period of the summer.

Growing Suggestions

Achieving an acceptable stand of beans begins with selection of quality seed. Bean seed that is damaged (e.g., cracked seed coats) will not emerge properly, if at all. Inspect seed for damage before purchasing.

Soil Type and Soil Preparation

Beans do best on lighter soils, but will grow on almost any well-drained soil. Do not till wet soils in preparation for planting beans.

Beans produce best in soils with sufficient organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps beans develop a healthy root system.

Planting

It is best to plant beans directly into the garden 1–3 weeks after the average last killing frost in the spring, when the daytime air and soil temperatures approach 65°F. Planting into cold soils will reduce seedling emergence and vigor.

Some people soak vegetable seeds overnight before planting them to hasten germination. This practice is discouraged for beans, as it often injures the seed, resulting in poor germination and weakened plants.

Planting specifications:

- Seed spacing: 1.5–2 inches
- Final spacing: 3–6 inches
- Ounces of seed per foot: 0.13
- Row width: 18–30 inches
- Seed depth: 1.5–2 inches
- Germination: 6–14 days

Fertilizer

Beans are a legume and can meet most (but not all) of their own N needs through their N-fixing ability. If you plant beans into soils where legumes haven't grown before, it might be helpful to inoculate the seed with *Rhizobium* bacteria to stimulate N fixation. Inoculum can be purchased at garden centers.

Although beans require minimal applications of N, levels of P, K, and other nutrients must be adequate to ensure productivity. Apply fertilizer during soil preparation. A 5-10-10 or similar fertilizer formulation is usually adequate. Add the equivalent of 0.1–0.2 lb N (in combination with P and K) per 100 square feet.

Weed Control

Season-long weed control is important for beans because they are only moderately competitive with weeds. Control weeds through mechanical tillage,

hand weeding, or use of a labeled garden herbicide. Be careful when cultivating close to plants to avoid damaging the roots.

Irrigation

Beans have a shallow root system and little tolerance of drought stress. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Several insects can infest beans in Idaho, but they rarely reach population levels that require control. Spider mites can be a problem in some years when the weather is hot and dry. They are best controlled by using overhead irrigation or spraying the leaves with a hard stream of water for several days in a row. Loopers, armyworms, and Mexican bean beetles can damage leaves. In cases of severe infestation, these pests may require the use of a labeled organic or traditional insecticide.

Diseases

Many fungal, bacterial, and viral diseases affect beans. However, if good-quality seed from a reputable supplier is used, diseases rarely become serious in Idaho gardens. Seed and root rots can affect seedling emergence and early plant growth. Prevent these diseases by applying little or no irrigation during germination and early seedling growth. **White mold**, a fungal disease that rots the pods if they touch the ground, can be a problem if the soil surface remains wet for long periods of time. Allowing the soil to dry slightly between irrigations usually controls this disease.

Harvest

Harvest beans when pods are about 3 inches long and before the seed is much larger than the diameter of a pencil lead. Harvest every 3 or 4 days to prevent overmaturity. Frequent picking of pole beans stimulates the plants to produce new pods and helps to ensure a heavy yield.

Storage

Quality is highest if beans are consumed or processed immediately. However, they can be held for a few days under refrigeration and high humidity without a serious loss of quality. If allowed to wilt, quality diminishes rapidly.

Consumptive Yield

Compute household planting requirements as follows:

- 6–12 lb fresh beans per person
- 12–14 lb canned or frozen beans per person
- Each foot of row will yield 0.5 lb

Plant 12–52 feet of row per person.

Nutritive Value

Beans contain zeaxanthin, which is known to improve eye health and reduce the effects of aging. They are a good source of vitamin C, vitamin K, vitamin A, vitamin B6, folate, thiamin, riboflavin, phosphorus, and magnesium. One hundred grams (3.5 oz) of fresh green snap beans without butter or salt contain 31 calories, 1.8 grams of protein, 0.2 gram of fat, 7 grams of carbohydrates, and 2.7 grams of dietary fiber. Fresh snap beans contain 90% water.

Beets

Beets (*Beta vulgaris*) are native to the Mediterranean area of North Africa, Europe, and western Asia. The leaves have been eaten since before written history. The roots were used medicinally and didn't become a popular vegetable until French chefs began popularizing them in the 1800s. Beet powder has been used as a coloring agent in many foods, including the tomato sauce used on frozen pizzas.

Among beet cultivars, there is much room for personal preference. The roots may be round, flat, or elongated. Most are red or purple, but several other colors are now available as a result of modern breeding efforts. It is best to select cultivars that mature in 55–65 days.

Growing Suggestions

Beets are cool-weather biennials that are grown as annuals for their leaves and roots. They produce the best quality when grown in cool soil and full sun.

As beets grow and the roots start to bulge out of the soil, it may be advisable to hill soil around them. Keeping the roots covered with soil will protect texture and color.

Soil Type and Soil Preparation

Beet roots develop the best shape and color in light or organic (peat) soils. However, they will grow in almost any good soil that has a good quantity of organic matter. Add organic matter if needed, preferably in the fall. Till to mix crop residues and organic matter into the top 7–8 inches of soil. Create a fairly deep, mellow (soft) seedbed to prevent compaction around the developing roots. Avoid working soil when it is too wet.

Planting

Sow beet seeds 2–4 weeks before the average last spring frost, when the soil temperature approaches 50°F. If a continual supply is desired, plantings can be made every 2 weeks until midsummer. Soak beet seeds in water overnight before planting to hasten germination. Beets can be planted in banded rows or in nonrow groupings; give each plant about 6–8 square inches of space.

Planting specifications:

- Seed spacing: 0.5–0.75 inch
- Final spacing: 2–3 inches
- Ounces of seed per foot: 0.01
- Row width: 12–18 inches
- Seed depth: 0.5–1 inch
- Germination: 10–15 days

Fertilizer

Beets require very little fertilizer. All of the fertilizer can be applied during soil preparation. A 5-10-10 or similar fertilizer formulation is usually adequate. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet.

Weed Control

Beets require full-season weed control because they are never fully competitive with weedy plants. Shallow cultivation should be used when necessary, as deep cultivation close to the plants can damage the root system, reducing yield and quality. A general garden herbicide can be effective in limiting weed populations.

Irrigation

Shallow planting and problems with soil crusting mean that beets may need several light irrigations to ensure good seedling emergence. Once emerged, beets will do fine with any irrigation regime that maintains consistent soil moisture. Apply 1.5–2 inches of water every 5 or 6 days on most soils.

Insects

Beets can be damaged by several species of caterpillars, leaf miners, and aphids. However, in most garden situations, beets can withstand these minor infestations without significant control measures.

Diseases

In Idaho gardens, beets may show mild symptoms of powdery mildew. This disease seldom requires control measures. Curly top virus, expressed as mottled or malformed leaves, may appear. Remove infected plants to minimize spread to healthy plants.

Harvest

Beet leaves can be harvested and used as a potherb at any time during the growing season. Beet roots can be harvested as soon as they are large enough to use. Roots are ready to be harvested 8–9 weeks after seeds are sown and are most tender when less than 2 inches in diameter. Harvest before roots become woody. Pull the beet and cut off the tops about 1–1.5 inches above the crown.

Storage

With tops removed, beets will keep for several months under refrigeration (just above freezing) with high humidity.

Consumptive Yield

Compute household planting requirements as follows:

- 7–12 lb fresh beets per person
- 12–30 lb canned or frozen beets per person
- Each foot of row will yield 1.25 lb

Plant 6–34 feet of row per person.

Nutritive Value

Beets, especially dark red ones, are very high in antioxidants, compounds shown to lower cancer risk, improve memory, and reduce the effects of aging. They are an excellent source of folate and potassium and a good source of vitamin C, vitamin B6, iron, manganese, P, and copper. One hundred grams (3.5 oz) of raw red beets contain 43 calories, 1.6 grams of protein, 0.2 gram of fat, 9.6 grams of carbohydrates, and 2.8 grams of dietary fiber. Beet roots are made up of 88% water.

Broccoli

Broccoli (*Brassica oleracea*) is native to the Mediterranean area, where it probably was developed from a wild cabbage species by the ancient Etruscans. The Italians seem to be the first group of people to develop a real interest in broccoli. When introduced into England, it was called "Italian asparagus." Broccoli was brought to America by immigrants, but didn't become a popular vegetable in the United States until the 1920s.

Many outstanding cultivars of broccoli are available for garden production. Newer hybrid cultivars often have very large, high-quality heads that mature uniformly. Some of the older open-pollinated cultivars produce multiple crops by reheading after harvest. These secondary heads are often small but provide a continuous supply for table use.

Growing Suggestions

Broccoli can be planted as seed, but there are many advantages to using transplants. Transplanting makes weed control easier, reduces seedling disease and insect problems, and improves quality by allowing harvest before hot weather sets in. Broccoli plants are easy to transplant, as long as the seedlings are hardened off before being placed in the garden.

Soil Type and Soil Preparation

Broccoli will grow in most soils, from sand to clay. Prepare the seedbed when the soil has sufficient moisture to form a ball that crumbles into medium-size fragments under finger pressure. Broccoli quality will be enhanced by working in large amounts of organic matter.

Planting

Broccoli can be direct seeded up to 4 weeks prior to average last frost. Direct seeding is recommended only for areas with a relatively long, cool spring season that will allow the broccoli to mature before summer heat sets in. Plant seeds 0.5 inch deep. With proper moisture, germination will occur in 3–10 days.

In most of Idaho, broccoli performs best if transplanted. Broccoli can be transplanted 2–4 weeks before average last spring frost. Transplants should be stocky, have a stem about the diameter of a pencil, and be dark green and vigorous. Overly large or weak transplants will not produce large, quality heads. New transplants may require protection from wind and extreme frost events (below 25°F).

To produce your own transplants, sow broccoli seeds indoors 5–7 weeks prior to the predicted transplant date. Before setting the transplants into the garden, harden them off by setting them outside for increasing periods of time during the last 1 or 2 weeks of growth.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Broccoli is a heavy feeder and responds positively to adequate levels of N, P, and K. Split applications work best to keep broccoli growing vigorously through harvest. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Side-dress an additional 0.25 lb N when the plants are about 12 inches tall. For side-dressing, select a high-N fertilizer such as 21-0-0 or 46-0-0.

Weed Control

Early season weed control is important for broccoli. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand removal, or use of a labeled garden herbicide. When tilling close to plants, tillage should be shallow in order to prevent damage to roots. Also, try to avoid damaging the large, brittle leaves of mature plants.

Irrigation

Drought stress has a marked effect on broccoli quality, making heads fibrous and strong flavored. It is important to provide consistent, timely irrigation. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common broccoli pests in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms and

cabbage loopers damage both the leaves and the heads. Cabbage worms often inhabit the heads and become evident only upon cooking. They may require an insecticidal product for good control. Early transplanting often allows harvest before cabbage worms and loopers become a problem. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are no consistent, serious diseases of broccoli in Idaho gardens.

Harvest

Harvest broccoli when the center head is 4–10 inches across. However, head size is not the critical factor in determining maturity. Harvest when heads reach maximum size but are still compact and dark green, as heads quickly lose quality once the buds start to separate and turn yellow. Harvest by cutting the stem 3 inches below the flower buds. Utilize both the stem and the head. After the first harvest, broccoli often produces small lateral heads. If the central head becomes overly mature, remove it to stimulate production of these side shoots.

Storage

Broccoli head quality deteriorates very quickly following harvest. Broccoli is rarely stored and should be prepared or processed immediately after harvest. If necessary, it can be held for a few days at near-freezing temperatures in a moist refrigerator.

Consumptive Yield

Compute household planting requirements as follows:

- 3–5 lb fresh broccoli per person
- 5–6 lb frozen broccoli per person
- Each foot of row will yield 0.75 lb

Plant 4–15 feet of row per person.

Nutritive Value

Broccoli is remarkably nutritious. It contains many phytonutrients, including thiocyanates, indoles, sulforaphane, isothiocyanates, and flavonoids, which help prevent prostate, colon, urinary tract, pancreatic, and breast cancers. Broccoli is an excellent source of vitamin C and vitamin K. It is a good source of thiamin, riboflavin, folate, vitamin E, vitamin B6, magnesium, manganese, iron, P, and K. One hundred grams (3.5 oz) of broccoli (head or bud clusters, stems, and leaves) contain 31 calories, 2.8 grams of protein, 0.4 gram of fat, 6.6 grams of carbohydrates, and 2.6 grams of dietary fiber. Broccoli heads contain about 89% water.

Brussels Sprouts

Brussels sprouts (*Brassica oleracea*) originated in Europe, principally in Brussels, Belgium. They are considered to be one of the "newer" vegetables, having been cultivated for only about 400 years. They were first described in the literature in 1587. By 1800, they were commonly grown in Belgium and France. Some people were growing Brussels sprouts in the United States by 1800, but they have never become widely popular in this country.

Brussels sprouts resemble small cabbages but require a longer growing season than cabbage. There are two major classes of Brussels sprouts, dwarf and tall. The dwarf types mature in fewer than 100 days and grow best in the cooler regions of Idaho. The tall types require up to 100 days to mature and grow best in the cooler regions of Idaho.

Growing Suggestions

Brussels sprouts are best planted as transplants. Transplanting makes weed control easier and reduces seedling disease and insect problems. Brussels sprouts are easy to transplant, as long as the seedlings are hardened off before being placed outside in the garden.

Late in the season, tall plants may become susceptible to damage from wind. Prevent plants from tipping over by installing support stakes.

Soil Type and Soil Preparation

This vegetable is adaptable to various soil types, as long as the soil is fertile, has good texture, and is moist. Brussels sprouts quality is enhanced by incorporating large amounts of organic matter.

Planting

If producing your own transplants, sow seeds in containers 4–6 weeks before transplanting in the garden. Otherwise, purchase transplants that are stocky, healthy, and not too large (stems the diameter

of a pencil). Place them in the garden 2–4 weeks before average last frost. Protect them from wind and hard frost for the first 1 or 2 weeks.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Brussels sprouts require high levels of fertility. Split applications of N work best to keep Brussels sprouts growing vigorously through final harvest. A preplant fertilizer application of 0.2 lb N for each 100 square feet is recommended. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. When plants are about one-third their final height, side-dress with an additional 0.2 lb N per 100 square feet. For side-dressing, select a high-N fertilizer such as 21-0-0 or 46-0-0.

Weed Control

Early season weed control is important for Brussels sprouts. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. As Brussels sprouts approach maturity, tillage close to plants should be shallow in order to prevent damage to roots. Also, it is important not to damage the large, brittle leaves of mature plants.

Irrigation

Good flavor and tenderness of Brussels sprouts depend on proper irrigation and consistent soil moisture. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 4 or 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common pests of Brussels sprouts in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms and loopers damage leaves, but are a serious problem only if they partially defoliate the plants. They can be removed by hand or may require an insecticidal product for control. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

Serious diseases of Brussels sprouts in Idaho gardens are rare.

Harvest

As the sprouts on the main stem begin to enlarge, remove the lower leaves of the plant. Harvest sprouts as they become solid and about 1–2 inches in diameter. The lowest sprouts will mature first. To speed up sprout maturity, pinch off the tip of each plant in late August or early September; however, this may reduce the total yield of the plant by as much as one-third. Brussels sprouts can withstand cold fall temperatures. The best-tasting sprouts are those that mature after the first fall frost.

Storage

When nighttime temperatures drop to 20°F on a regular basis, dig up the plants with a little soil remaining around the roots. Put them into a deep cold frame or in an unheated dark garage. They will continue to grow until all the sprouts mature.

Harvested Brussels sprouts can be stored for 2–3 weeks in a refrigerator at a temperature near freezing and with high humidity. They should not be stored with apples or other fruits because they may become bitter due to the presence of a gaseous compound called ethylene.

Consumptive Yield

Compute household planting requirements as follows:

- 1.5–4 lb fresh Brussels sprouts per person
- 4–6 lb canned or frozen Brussels sprouts per person
- Each foot of row will yield 0.5 lb

Plant 3–20 feet of row per person.

Nutritive Value

Brussels sprouts are an outstanding source of vitamin K, which is linked to bone health. They are also an excellent source of vitamin C and a good source of thiamin, folate, riboflavin, vitamin E, vitamin B6, iron, magnesium, manganese, P, and K. One hundred grams (3.5 oz) of Brussels sprouts provide 3.4 grams of protein, 0.3 gram of fat, 9 grams of carbohydrates, 43 calories, and 3.8 grams of dietary fiber. Fresh Brussels sprouts are 86% water.

Cabbage

The wild relatives of the cabbage plant are native to the Mediterranean area of Europe. These nonheading types of cabbage were cultivated for thousands of years before people began to prefer the smaller, tender leaves packed more closely in the center of certain plants. Initially, people gravitated toward plants with large, succulent leaves. They chose these plants as their source of seed for the next year. Kale was developed by the fifth century BC. Later, selection began for small, tender leaves, and over time plants began to emerge that had cluster or "head" formation. By the first century AD, cultivated cabbage (*Brassica oleracea*) looked much like the plants we grow today.

Cabbage cultivars vary widely. Maturity times vary and heads may be globular or flat; smooth or savoy; and green, red, or purple. Some cultivars produce heads that store for many months under proper conditions. Choose cultivars based on personal preferences and growing conditions.

Growing Suggestions

Cabbage can be either transplanted or direct seeded. Transplanting is best in short-season areas. Also, transplanting makes weed control easier and reduces seedling disease and insect problems. Cabbage is easy to transplant, as long as the seedlings are hardened off before being placed outside in the garden.

To achieve best quality, cabbage must be supplied with consistent growing conditions. Any fluctuation in rate of growth, caused by stress, nutrient deficiencies, or lack of water, can cause the heads to split.

Soil Type and Soil Preparation

Cabbage is adaptable to various soil types, as long as the soil is fertile, has good texture, and is moist. Begin seedbed preparation when the soil has sufficient moisture to form a ball that crumbles into medium-size fragments under finger pressure. Cabbage quality is enhanced by working in organic matter.

Planting

If direct seeding, plant extra seeds and thin to a final stand. Plant cabbage 3–5 weeks prior to average last frost or as soon as the soil is dry enough to be worked.

Transplants can be purchased or grown from seed. If producing your own transplants, sow seeds into containers 4–6 weeks before transplanting to the garden. Otherwise, purchase transplants that are stocky, healthy, and not too large. (Stems should be the diameter of a pencil.) Large cabbage transplants may bolt (produce seedstalks instead of heads) if subjected to several weeks of 40°F–50°F weather. Transplant to the garden 2–4 weeks before average last frost.

Planting specifications:

- Seed spacing: 1.25–1.5 inches
- Final spacing: 1–2 feet
- Ounces of seed per foot: 0.01
- Row width: 24–30 inches
- Seed depth: 0.25–0.5 inch
- Germination: 4–10 days

Transplanting specifications:

- Final spacing: 18–24 inches apart

Fertilizer

Cabbage is a heavy nutrient user and needs a good supply of most nutrients, especially N, P, and K. Split applications work best to keep cabbage growing vigorously through harvest. Apply 0.25 lb N (in combination with P and K) per 100 square feet before planting. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Side-dress an additional 0.25 lb N, using a 21-0-0, 46-0-0, or similar high-N fertilizer, when the plants show signs of heading.

Weed Control

Early season weed control is important. Once established, plants compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once plants reach full size, tillage activities close to plants should be shallow in order to prevent damage to roots. Also, avoid damage to the large, brittle leaves of mature plants.

Irrigation

Head size and tenderness depend on proper irrigation and consistent soil moisture. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common pests of cabbage in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water, although they may crawl under the outer leaves of the head, where they are difficult to reach. Heavy infestations may require use of a labeled insecticide. Cabbage worms and loopers usually do the most damage to the outer leaves of the head and are a serious problem only if they consume large portions of the outermost layer. They can be removed by hand or may require an insecticidal product for control. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are few, if any, serious diseases of cabbage in Idaho gardens.

Harvest

Cabbage is ready to harvest 50–65 days after transplanting. The heads should be solid, but must be picked before they crack. Soft heads have poor quality. Heads may split during hot weather if the water supply fluctuates.

Reducing irrigation or twisting the mature heads part of the way around to sever half the roots will allow mature cabbage to stay in the garden longer without losing quality. Plants harvested early in the summer and left with as many leaves as possible often develop small heads where the leaves meet the stem. These heads are edible and should be picked when firm.

Cabbage can withstand very light frosts before harvest. However, temperatures below 30°F may result in injury that will eventually cause the head to break down.

Storage

For storage, place mature cabbage heads in a pit, trench, outdoor cellar, or cool storage room. The temperature should be as near 32°F as possible and definitely 40°F or below. Humidity should be high. Stored cabbages will last well into winter.

Consumptive Yield

Compute household planting requirements as follows:

- 4–5 lb fresh cabbage per person
- 6–12 lb processed cabbage per person
- Each foot of row will yield 0.8 lb

Plant 5–21 feet of row per person.

Nutritive Value

Cabbage contains thiocyanates, indoles, sulforaphane, isothiocyanates, and flavonoids, which help prevent cancer and lower "bad cholesterol." It is an excellent source of vitamin C and vitamin K, as well as a good source of thiamin, vitamin B6, folate, iron, and manganese. One hundred grams (3.5 oz) of cabbage supply 1.3 grams of protein, 0.1 gram of fat, 5.8 grams of carbohydrates, 25 calories, and 3.8 grams of dietary fiber. Fresh cabbage consists of 92% water.

Cantaloupes

Evidence exists that cantaloupes (*Cucumis melo*) were cultivated from Egypt to Iran and northern India as early as 2400 BC. Dried and roasted melon seeds have been a favorite throughout the Middle East and China for several thousand years. During the fifteenth century, Arabs brought melon seeds to southern Spain, where the fruit became popular. From there, Columbus took them on his second voyage to the New World and they were planted in Haiti. Cantaloupes were soon being grown in Central and South America, where the native populations enjoyed the new fruit. By the 1600s, cantaloupes were being grown in parts of North America. They didn't become a popular crop in the United States, however, until after the Civil War.

Most cantaloupe cultivars are suitable for production in the south-central and southwestern regions of Idaho. In all other areas, it is important to select early maturing cultivars. In short-season areas, early cultivars of standard netted muskmelons may mature to a quality harvestable state. Most crenshaw, cassava, honeydew, or Christmas-type melons require a longer season than is usually available.

Growing Suggestions

Cantaloupe plants have separate male and female flowers on the same vine and are cross-pollinated. For this reason, they need insects to pollinate the flowers. It is important to protect pollinators in the garden when growing cantaloupes.

Cantaloupes require full sun all day long to produce the sweetest fruit. Any shade will not only result in inferior flavor, but may delay maturity, making production in marginal climates even more difficult.

Cantaloupes are a warm-season crop. It is critical to be patient in waiting for warm, late-spring weather before planting them in the garden. It helps to provide warm growing conditions by planting next to a south-facing structure, planting on black plastic, and/or using row covers.

Soil Type and Soil Preparation

Cantaloupes are adapted to most soils, but grow best in a fertile, mellow soil with large amounts of compost. During tillage, incorporate organic matter, if needed. Cantaloupes will grow faster and mature earlier in sandy soils.

Planting

Cantaloupes can be either direct seeded or transplanted. Direct seeding usually results in healthier, stronger plants. Transplanting often provides the advantage of slightly earlier maturity. Direct seed 1–2 weeks after average last frost and when daytime maximum soil temperatures are near 70°F.

Transplanting cantaloupes into the garden requires special attention to details. Use transplants that are healthy and at the right stage of growth. Transplants that are too old, etiolated ("spindly"), slow-growing, or have been stressed at any time for water or nutrients seldom produce a vigorous plant. A root-hardening response common to this family of plants slows or prevents new growth on less-than-ideal transplants. Acceptable transplants have only one or two true leaves (don't count cotyledons), are succulent and growing rapidly, have dark green color, and are short and compact.

Timing of transplanting is usually 2–3 weeks after average last frost and only when the forecast is for mild weather. Once a healthy transplant has been placed in the garden, it must be protected from intense sunlight, wind, and near-freezing or freezing temperatures.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3 plants
- Ounces of seed per foot: 0.05
- Row width: 4–6 feet
- Seed depth: 1 inch
- Germination: 5–14 days

*Hill spacing for transplants is the same as for seed.

Fertilizer

Cantaloupes are heavy feeders and respond positively to adequate levels of N, P, and K. Split applications work best to keep cantaloupes growing vigorously throughout the season. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Side-dress an additional 0.3 lb N (21-0-0, 46-0-0, or similar formulation) at the time the plants begin to form running vines.

Weed Control

Cantaloupes do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

Cantaloupes require average amounts of water as compared to other crops. They produce the sweetest melons if not overirrigated during the latter part of the season. Once plants are established and growing, applications of 1.5–2 inches of water every 5 or 6 days are usually adequate. On very sandy soils, you may need to supply water more frequently.

Insects

Cutworms are a common pest of cantaloupes in Idaho. They emerge from the soil at night and cut down newly emerged seedlings or transplants. Consistent problems with cutworms may require application of a labeled soil insecticide. Spider mites occasionally become problematic. They are best controlled by using sprinkler irrigation because they tend to avoid leaves that are frequently wet. Occasionally, an application of a miticide may be necessary.

Diseases

Repeated production of watermelons, cucumbers, cantaloupes, and squash can result in the buildup of

a soilborne disease called fusarium wilt. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Crop rotations of at least four-year intervals provide partial control. Cantaloupes are also very susceptible to root rots that result from poor soil drainage or overirrigation.

A few viral diseases occasionally appear on cantaloupes. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing or stunting. Plants showing these symptoms should be removed to prevent them from competing with healthy plants.

Powdery mildew, identified by white, powdery fungal growth on the upper leaf surface, often appears in Idaho gardens. No control is necessary if it appears during the last month of the season because it will do little or no damage to the crop. If it appears earlier, it may be necessary to apply a labeled garden fungicide.

Fruit rots can occur if melons sit on damp soil for extended periods of time. Prevent this problem by irrigating properly and by planting on plastic mulch or suspending the developing fruit above the soil.

Harvest

Cantaloupes must ripen on the vine for maximum quality. Ripe netted cantaloupes form an abscission layer where the stem meets the fruit, allowing the fruit to separate from the vine when it is ripe. When the stem is nearly loose, the cantaloupe is said to be at the full slip stage and is ready to be harvested. Slight softening of the blossom end, a change in the background color of the melon from green to yellow or tan, and a strong cantaloupe smell are additional indications of ripeness.

Storage

Cantaloupe fruits can be held for a few days at room temperature. Held for too long, they quickly soften and become susceptible to fruit rots.

Consumptive Yield

Compute household planting requirements as follows:

- 8–10 lb fresh cantaloupe per person
- Each foot of row will yield 1 lb

Plant 8–10 feet of row per person.

Nutritive Value

Cantaloupes are very high in vitamin A, which is a powerful antioxidant, protects vision, and helps maintain healthy mucus membranes and skin. They are also an excellent source of vitamin C and a good source of niacin and vitamin B6. One hundred grams (3.5 oz) of cantaloupe contain 1.8 grams of protein, 0.2 gram of fat, 8.2 grams of carbohydrates, 34 calories, and 0.9 gram of dietary fiber. Fresh cantaloupe fruits are 90% water.

Carrots

The use of carrot roots (*Daucus carota*) as food began about 5,000 years ago in the area now known as Afghanistan. Drawings found in Egyptian pyramids from about 2000 BC. show what seem to be purple carrots. Early Egyptian writings discuss various medical treatments using carrots and carrot seeds. By the tenth century, Arab merchants traveling throughout Arabia, Asia, and Africa brought home the seeds of purple carrots. Other early carrot cultivars consisted of a range of colors such as purple, white, light yellow, green, red, and almost black.

Purple and yellow varieties are believed to have been brought to southern Europe in the twelfth century by Moorish invaders. By the thirteenth century, carrots were being grown in German and French farms and gardens. Flemish refugees brought various colors of carrots to England in the fifteenth century. It wasn't until the 1500s that Dutch plant breeders used mutant yellow carrot seeds to develop an orange cultivar. With continued improvements, the orange carrot was made sweeter and its popularity spread.

Soil Type and Soil Preparation

Carrots grow best in loose loamy, sandy, or organic soils. Heavy clay soils can cause misshapen roots, but this problem can be improved by the addition of organic matter. For an ideal seedbed, create a 12-inch-deep mixture consisting of one-fifth garden soil, two-fifths sand, and two-fifths compost or peat moss. Spring application of manure to carrots often results in branched, short, or malformed roots. If you apply manure, it is best to do so in the fall. Applications in the spring must be light, using only well-aged manure. Soil tillage must be deep and

create a mellow seedbed. Avoid working overly wet soil, which may become compacted and cloddy. Before planting, rake the soil surface to create a smooth, firm surface.

Planting

Plant carrots up to 2 weeks prior to the average last killing frost and when daytime soil temperatures approach 50°F. A salt or pepper shaker can be used to scatter seeds in the row. In small gardens, carrots can be grown in banded rows or groupings in raised beds.

Because carrots require shallow planting, the soil often dries out and crusts, making it difficult for seedlings to emerge. Keeping the soil moist after planting is critical. It may be necessary to irrigate lightly several times a day until seedlings emerge. Other methods for maintaining soil moisture and preventing crusting include covering seeds with a light layer of compost, (sifted) grass clippings, sawdust, or vermiculite. Clear plastic or damp burlap placed over the seedbed will also speed germination by warming the soil, preventing crusting, and keeping the soil moist. Remove the cover as soon as the seedlings emerge.

Coplanting carrots and radishes often helps carrots overcome soil-crusting issues and provides a good stand. Once the radishes are harvested (pull carefully to avoid damaging the carrots), the carrots will be well spaced and off to a good start.

As the carrots grow, thin them to 1–2 inches apart in the row. In group plantings, thin to provide 3–4 square inches per plant.

Planting specifications:

- Seed spacing: 0.5–0.75 inch
- Final spacing: 1–2 inches
- Ounces of seed per foot: 0.02
- Row width: 15–24 inches
- Seed depth: 0.25–0.5 inch
- Germination: 10–17 days

Fertilizer

Carrots require only moderate levels of fertilizer to produce an acceptable crop. All fertilizer applications for carrots can be made during soil preparation. A 10-10-10 or similar fertilizer formulation is usually appropriate. The equivalent of 0.25–0.3 lb N (in combination with P and K) per 100 square feet will provide adequate levels of nutrients.

Weed Control

Carrots require early season weed control, but compete well with weeds once full size. Cultivation or use of a labeled garden herbicide can limit weed populations.

Irrigation

Shallow planting and problems with soil crusting mean that carrots may need several light irrigations to ensure good seedling emergence. Once emerged, any irrigation regime that maintains consistent soil moisture is adequate. Carrots tolerate a wide range of soil moisture conditions, as long as they do not get dry enough to cause wilting. Application of 1.5–2 inches of water every 5 or 6 days will work on most soils.

Insects and Other Pests

In Idaho, carrots have few serious insect problems, other than occasional soil pests such as wireworms or carrot rust flies. Carrot rust fly larvae tunnel into and damage the roots. If this is a consistent problem, remove all carrot residue from the garden after harvest and avoid the practice of overwintering carrots in the ground.

Root-knot nematodes (microscopic wormlike creatures) can be a serious pest of carrots. They cause the roots to be bumpy and deformed, with a proliferation of tiny feeder roots. Nematodes are very difficult to manage or control. The best advice is to avoid growing a garden in infested soils. If this is not feasible, crop rotation will help minimize damage.

Diseases

Powdery mildew, identified by a white, powdery fungal growth on the upper leaf surface, is an occasional problem with carrots in Idaho gardens, but it seldom requires control. Although not common, aster yellows occasionally becomes problematic. It is caused by a bacteria-like organism. Infected plants are stunted and yellow and the roots become “hairy” due to the growth of many secondary roots. There is no cure for this disease. If infected plants are found, it is best to remove and destroy them to prevent it from spreading to healthy plants.

Harvest

Carrots can be harvested as soon as the roots are the size of a little finger. Beginning harvest early allows for a long harvest window. The highest-quality roots are harvested after fall frost when the carrots become sweeter.

Storage

Carrots can be stored throughout the fall and winter in a pit, storage cellar, refrigerator, or covered row. Once out of the soil, carrots store best if the tops are removed. Storage temperature should be as near 32°F as possible. Maintain high humidity.

Consumptive Yield

Compute household planting requirements as follows:

- 5–10 lb fresh carrots per person
- 10–25 lb canned or frozen carrots per person
- Each foot of row will yield 1 lb

Plant 5–35 feet of row per person.

Nutritive Value

Carrots contain the antioxidant falcarinol, which may have anticancer properties. Carrots are well known as an excellent source of vitamin A. They are also a good source of niacin, thiamin, vitamin B6, folate, vitamin C, vitamin K, manganese, P, and K. One hundred grams (3.5 oz) of raw carrots provide 0.9 gram of protein, 0.2 gram of fat, 9.6 grams of carbohydrates, 41 calories, and 2.8 grams of dietary fiber. Fresh carrots are 88% water.

Cauliflower

Cauliflower (*Brassica oleracea*) probably originated in Asia Minor in the fifteenth century, but was used almost exclusively in Italy until the sixteenth. At that time it was introduced into France and eventually became a part of diets throughout Europe. Cauliflower came into common use about a century before broccoli, but wasn't grown in North America until the late 1600s.

There are many outstanding cultivars of cauliflower available for garden production. Newer hybrid cultivars include those that are **self-blanching**, meaning they produce leaves that are folded over the head to keep curds white, flavorful, and attractive.

Growing Suggestions

Cauliflower is considered the most delicate member of the cabbage family. It can be difficult to grow because it requires cool temperatures, constant moisture, and high levels of fertility. In hot weather, cauliflower will not head up well and it is less tolerant of cold fall temperatures than cabbage.

Cauliflower is typically transplanted rather than grown from seed. There are many advantages to using transplants, including simpler weed control, fewer seedling disease and insect problems, and improved earliness. Early cauliflower usually has better quality because it is harvested before the arrival of hot summer temperatures. Cauliflower plants are easy to transplant, as long as the seedlings are hardened off before being placed in the garden.

If growing a cultivar that is not self-blanching, it is essential to protect developing curds from sunlight to maintain white color and good eating quality. The most common method is to tie the largest inside leaves over the heads. Large rubber bands work well to secure the blanching leaves.

Soil Type and Soil Preparation

Cauliflower grows well in most soils, from sand to clay. It does well in Idaho soils that have been modified with extra organic matter. Soil preparation should include the addition of organic matter in the form of manure or compost.

Planting

Transplanting is the best way to establish cauliflower in Idaho. Transplant cauliflower 2–3 weeks before average last spring frost. At the time of planting, transplants should not be too large. They should be stocky, have a stem about the diameter of a pencil, and be dark green and vigorous. Overly large or weak transplants will not produce large, quality curds.

To produce your own transplants, sow cauliflower seeds indoors 5–7 weeks before the expected transplanting date. Before setting the transplants into the garden, harden them off by setting them outside for increasing periods of time during the last 1 or 2 weeks of growth.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Cauliflower is a heavy feeder and responds positively to adequate levels of N, P, and K. Split applications of N work best to keep cauliflower

growing vigorously through harvest. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar ratios) is usually appropriate for this preplant application. Side-dress an additional 0.25 lb N (21-0-0, 46-0-0, or similar product) when the curds begin to develop.

Weed Control

Early season weed control is important for cauliflower. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent root damage. Also, try to avoid damage to the large, brittle leaves of mature plants.

Irrigation

Improper irrigation detracts from cauliflower curd quality, making curds fibrous and strong flavored. It is important to provide consistent, timely irrigation. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common cauliflower pests in Idaho include aphids, cabbage worms, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms damage both the leaves and the curds. They often inhabit the curds and become evident only upon cooking. They may require an insecticidal product for good control. Early planting often allows harvest before cabbage worms become a problem. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are few or no serious diseases of cauliflower in Idaho gardens.

Harvest

Harvest cauliflower when the curd is 4–8 inches across, bright white, and compact. Once the curd becomes loose, called **ricing**, quality quickly declines.

Storage

Cauliflower can be stored for a longer period than broccoli, up to a week or more if held at near-freezing temperatures and high humidity. Quality for freezing is best if processing occurs soon after harvest.

Consumptive Yield

Compute household planting requirements as follows:

- 3–5 lb fresh cauliflower per person
- 8–12 lb frozen cauliflower per person
- Each foot of row will yield 1 lb

Plant 3–17 feet of row per person.

Nutritive Value

Cauliflower is a nutritious food. Along with many of the brassica crops, it contains diindolylmethane, which serves to enhance the immune system. Cauliflower is an excellent source of vitamin C and a good source of folate, vitamin B5, vitamin B6, vitamin K, iron, manganese, P, and K. One hundred grams (3.5 oz) of cauliflower curds contain 1.9 grams of protein, 0.3 gram of fat, 5 grams of carbohydrates, and 25 calories. Fresh cauliflower curds are 92% water.

Cucumbers

It is believed that cucumbers (*Cucumis sativus*) are native to India and likely have been cultivated in western Asia for more than 3,000 years. The Romans probably introduced this vegetable to Europe. Agricultural records show that the French were cultivating cucumbers in the ninth century, and by the fourteenth century they were being grown in English gardens and farms. Cucumbers didn't arrive in North America until Columbus brought them in the late fifteenth century.

Growing Suggestions

Cucumbers can be planted with cantaloupes, watermelons, and squash without fear of cross-pollination. The flavor of cucumbers is not affected by the pollen from these related crops.

Cucumber plants have separate male and female flowers on the same vine and are cross-pollinated. For this reason, they need insects to pollinate the

flowers and produce fruit. It is important to protect pollinators when growing cucumbers.

Cucumbers do best where they will receive at least 8 hours of sunlight daily.

It is essential to pick fruits every day or every other day to maintain plant productivity. Once cucumber fruits reach mature size with fully developed seeds, they send a hormonal signal to the plant to stop production of new fruits.

Soil Type and Soil Preparation

Cucumbers are adapted to most soils, but grow best in a fertile, mellow soil with large amounts of compost. During tillage, incorporate organic matter, if needed. Cucumbers grow faster and mature earlier in sandy soils.

Planting

Cucumbers can be either direct seeded or transplanted. Direct seeding usually results in healthier, stronger plants. Transplanting often provides the advantage of earlier maturity. Direct seed 1–2 weeks after average last frost and only when daytime soil temperatures are near 70°F.

If transplanting, use transplants that are healthy and at the right stage of growth. Transplants that are too old, etiolated, or slow-growing, and those that have been stressed at any time for water or nutrients, seldom produce a vigorous plant.

Acceptable transplants have only one or two true leaves (don't count cotyledons), grow rapidly, and are succulent, dark green, short, and compact. Transplant 2–3 weeks after last average frost and only if the forecast predicts mild weather. Once a healthy transplant has been placed in the garden, it must be protected from intense sunlight, wind, and near-freezing or freezing temperatures.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3 plants
- Ounces of seed per foot: 0.05
- Row width: 4–6 feet
- Seed depth: 1 inch
- Germination: 6–10 days

*Hill spacing for transplants is the same as for seed.

Fertilizer

Cucumbers respond well to adequate levels of soil nutrients. Split applications of N work best to keep cucumbers growing vigorously throughout the season. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar nutrient ratios) is usually appropriate. Side-dress an additional 0.3 lb N (21-0-0, 46-0-0, or similar product) at the time the plants begin to form running vines.

Weed Control

Cucumbers do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

If plants are stressed for water, cucumber fruits become malformed and often develop a bitter flavor. Thus, it is important to supply consistent irrigation. Once plants are established, application of 1.5–2 inches of water every 5 or 6 days is usually adequate.

Insects

Cutworms are a common pest of cucumbers in Idaho. They emerge from the soil at night and cut down newly emerged seedlings. Repeated problems with cutworms may require application of a labeled soil insecticide prior to soil preparation.

Diseases

Production of watermelons, cucumbers, cantaloupes, and squash in the same site over multiple years can result in the buildup of a soilborne disease called **fusarium wilt**. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Partial prevention is possible by practicing crop rotation with at least four-year intervals between these crops. Cucumbers are also very susceptible to root rots if overirrigated or grown where there is poor soil drainage.

A few viral diseases occasionally occur on cucumbers. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing

or stunting. Plants showing these symptoms should be removed to prevent them from competing with healthy plants.

Powdery mildew, identified by white, powdery fungal growth on the upper leaf surface, often appears in Idaho gardens. No control is necessary if it appears during the last month of the season because it will do little or no damage to the crop. If it appears earlier, it may be necessary to apply a labeled garden fungicide.

Harvest

Harvest cucumbers any time after they have reached the desired size, but be sure to harvest before they turn yellow and the seeds become hard. For slicing, fruits should be 6–10 inches long. For pickles, harvest when fruits are 2.5–6 inches long. Cucumbers are of the highest quality when they are dark green, firm, and crisp.

Storage

If refrigerated, cucumbers can be held for several days. Sometimes seeds continue to develop in storage, reducing quality.

Consumptive Yield

Compute household planting requirements as follows:

- 2.5–4 lb fresh cucumbers per person
- Each foot of row will yield 0.8 lb

Plant 3–5 feet of row per person. Add additional row space for pickles as experience dictates.

Nutritive Value

Cucumbers have a mild diuretic effect, which helps reduce weight and blood pressure. Due to their very high water content (95%), cucumbers rank as a good source of only a few nutrients, including vitamin A and vitamin K. One hundred grams (3.5 oz) of cucumbers with skins contain 0.7 gram of protein, 0.1 gram of fat, 3.6 grams of carbohydrates, 15 calories, and 0.5 gram of dietary fiber.

Eggplant

Eggplants (*Solanum melongena*) are native to India. They were also cultivated in southern and eastern Asia long before historical records were kept. The first known description of eggplant was found in an ancient Chinese agricultural record written in 544 AD. All of the original eggplant names are of Arabic and North African origins, indicating that Arab cultures were primarily responsible for introducing eggplants to the Mediterranean region.

Most of the historically important varieties produced fruits that resembled goose or chicken eggs, were relatively small, and were white or light yellow.

Eggplants are in the Solanaceae family and many people originally believed the plant was extremely poisonous. Over time, people learned that it was not only safe but a wonderful addition to many recipes.

Eggplant fruits vary greatly in size, shape, and color. They can be purple, green, white, or even orange. Some cultivars have mixed colors or color gradients. Size varies from two-pound fruits to small, egg-size fruits. Some cultivars produce large, oval fruits, while others, such as the Chinese cultivars, produce fruits that are shaped like cucumbers. In India, miniature cultivars are quite popular.

Growing Suggestions

Eggplants are best adapted to Idaho's warmest regions. However, they can be grown in some of the shorter-season areas if provided with proper conditions. They benefit from full sun, a warm southern exposure, cold weather protection, black plastic mulch, and possibly row covers.

Soil Type and Soil Preparation

Eggplants grow best in a rich soil with plenty of organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps eggplants develop a healthy root system.

Planting

In Idaho, eggplants are almost always grown from transplants. Transplanting should occur 2–3 weeks after average last frost and after warm weather is the rule. At transplanting, the plants should be stocky and only 4–6 inches tall in order to minimize transplant shock.

It is feasible to produce your own transplants of eggplant. Doing so allows production of unusual va-

rieties. Sow seeds in containers 10 weeks before the intended transplant date. The young plants tend to be very sensitive to transplant shock; therefore, it is best to plant two or three seeds in individual pots and thin to one plant by clipping off the weakest plants.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–36 inches

Fertilizer

Eggplants have a fairly high demand for nutrients over a long growing season. They do best with a balanced fertilizer program and respond to adequate levels of P and K. Add fertilizer in two separate applications. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate for preplant applications. Side-dress an additional 0.25 lb N when the plants are 12 inches high. For side-dressing, select a high-N source such as 21-0-0, 46-0-0, or product with similar high N formulation.

Weed Control

Early season weed control is important for eggplant production. Weeds can be controlled through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once rapid growth begins, tillage close to plants should be shallow in order to prevent root damage. Once plants are tall, they often suppress weeds through competition and shading.

Irrigation

Once established, eggplants can get by on less water than many other vegetable crops. They develop an extensive fibrous root system. However, if they become severely stressed, fruit set will be curbed. Irrigate eggplants with 1.5–2 inches of water every 5–7 days.

Insects

Eggplants grown in Idaho can have problems with leaf-feeding insects. Colorado potato beetles and tomato hornworms can cause extensive defoliation. They can be controlled with an insecticide or by picking the larvae from the plants by hand. Aphids are an occasional problem and can be controlled by knocking them from the plants with a hard stream of water.

Diseases

Leaf spot diseases are common to eggplants in moister climates, but are seldom a problem in Idaho. Soilborne diseases such as verticillium wilt make plants yellow and weak. Control these diseases by rotating eggplants and other solanaceous crops to different places in the garden each year.

Harvest

Eggplants can be harvested anytime after the fruits reach egg size. The quality of young fruit is better than that of older fruit. Be sure to harvest before the fruit reaches full maturity and the seeds harden. Leave a short stem on the fruit when harvesting. The stems are woody, so harvest with pruning shears. Keeping the fruits picked will stimulate additional production. Three or four weeks before the average first killing frost, clip or pinch off any remaining blossoms to encourage the plant to finish maturing the existing fruits.

Storage

Eggplant fruits cannot be refrigerated without suffering cold injury. Storage life at room temperature is limited to a few days.

Consumptive Yield

Compute household planting requirements as follows:

- 3–5 lb fresh eggplant per person
- 2–3 lb canned or frozen eggplant per person
- Each foot of row will yield 1 lb

Plant 3–8 feet of row per person.

Nutritive Value

Eggplants contain a lower nutrient content than many other vegetables, but are still an important source of some vitamins and minerals. Research in Brazil has shown eggplants to be effective in treating high blood cholesterol. Fruits with purple skin also contain some anthocyanins with antioxidant activity. Eggplants are a good source of vitamin B5, vitamin B6, folate, and manganese. One hundred grams (3.5 oz) of raw eggplant contain 1 gram of protein, 0.2 gram of fat, 5.7 grams of carbohydrates, 24 calories, and 3.4 grams of dietary fiber. Fresh eggplant fruits contain 92% water.

Kohlrabi

The edible portion of kohlrabi (*Brassica oleracea*) is an aboveground enlarged stem that resembles a mild turnip in shape and flavor. An excellent raw addition to relish dishes, it also may be boiled, stuffed, or baked. Historians don't agree on its origins.

Historical records indicate that in the first century AD, Pliny the Elder talked about what he called a "Corinthian turnip." Based on the description of this plant's growing habits, most historians agree that he must have been referring to kohlrabi. Apicius, a Roman citizen, wrote an early cookbook on Roman cooking and dining and includes this vegetable as an ingredient in some of his recipes.

By the 1600s, kohlrabi was being grown in northern India, where it became an important part of local diets. It is now common in China and Africa. In the United States, it continues to be a lesser-known vegetable, but seems to be gaining in popularity. Cultivars vary in color, including white, green, and purple.

Growing Suggestions

Growing kohlrabi is similar to growing many of the other cole crops such as broccoli, kale, and cauliflower. Kohlrabi develops best quality when grown in the cool weather of early spring or late fall.

Soil Type and Soil Preparation

Kohlrabi grows in most soils, from sand to clay. Begin seedbed preparation early, but only when the soil has dried sufficiently to form a ball that crumbles into medium-size fragments with finger pressure. Kohlrabi quality will be enhanced by working in large amounts of organic matter.

Planting

Kohlrabi can be seeded directly into the soil or transplanted. To grow transplants, sow kohlrabi seeds into containers 6 weeks before the desired transplant date.

Planting specifications:

- Seed spacing: 1–1.5 inches
- Final spacing: 12–18 inches*
- Ounces of seed per foot: 0.01
- Row width: 18–24 inches
- Seed depth: 0.5 inch
- Germination: 3–10 days

*Transplant spacing is the same as for final spacing of direct-seeded kohlrabi.

Fertilizer

Kohlrabi requires only moderate amounts of fertilizer due to its short production period. Fertilizer can be applied during soil preparation. A 10-10-10 or similar fertilizer formulation is appropriate. Add the equivalent of 0.25–0.35 lb N (in combination with P and K) per 100 square feet.

Weed Control

Season-long control of weeds in kohlrabi is essential for maximizing production and quality. Kohlrabi does not compete well with weeds. Hand pulling, cultivation, or use of a labeled garden herbicide will control or eliminate most annual weeds.

Irrigation

Once established, kohlrabi will do fine with any irrigation regime that maintains reasonable soil moisture. For most soils, apply 1–1.5 inches of water every 3–5 days. If the soil is allowed to dry out, kohlrabi will develop a strong flavor and woody texture.

Insects

Common pests of kohlrabi in Idaho include aphids and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cutworms often kill seedlings or new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

Diseases of kohlrabi in Idaho gardens seldom require control measures.

Harvest

Kohlrabi should be ready to harvest 50–60 days after transplanting. It has the best flavor when it is 2–4 inches in size and the flesh is still tender. The leaves of the young plant may be used like spinach.

Storage

If kept refrigerated at near-freezing temperatures and high humidity, kohlrabi can be stored for several weeks.

Consumptive Yield

Compute household planting requirements as follows:

- 2–4 lb fresh kohlrabi per person
- 4–8 lb canned or frozen kohlrabi per person
- Each foot of row will yield 0.75 lb

Plant 3–16 feet of row per person.

Nutritive Value

A large serving of kohlrabi will supply your daily requirement for vitamin C. Kohlrabi is also a good source of vitamin B6, iron, P, K, and manganese. One hundred grams (3.5 oz) of kohlrabi contain 1.7 grams of protein, 0.1 gram of fat, 6.2 grams of carbohydrates, 27 calories, and 3.6 grams of dietary fiber. Fresh kohlrabi is 91% water.

Lettuce

Lettuce (*Lactuca sativa*) is by far the most popular salad plant. Various types of lettuce have been cultivated in many parts of the world since ancient times. Modern cultivars were very likely derived from wild lettuce. Wild lettuce now grows throughout the world, but it probably originated in Asia Minor, Iran, and Turkistan.

Herodotus described lettuce being served on the tables of Persian kings as far back as 600 BC. One to two hundred years later, Greek writers described the virtues of lettuce. Roman gardeners were growing and improving this popular vegetable by the beginning of the Christian era. Their writings show that they had developed at least a dozen cultivars.

Most of the original cultivars of lettuce were leafy types. Head-forming types were developed much later, but seem to have been well developed in Europe by the sixteenth century. Romaine lettuce was first described in the early 1600s. This type was fairly common in Italy and a few other areas of Europe. Columbus brought lettuce to the New World in 1494. After that, it was slowly introduced to many parts of North and South America.

Lettuce is sensitive to high temperatures. Summer heat will cause most types to **bolt** (go to seed) and develop bitter flavor. Hot Idaho summers make it especially difficult to produce quality head lettuce. Selection of heat-resistant cultivars is critical to success. Leaf, butterhead, Romaine, and some Batavia lettuce cultivars are less affected by heat, although bolting still occurs more quickly in warm weather.

Growing Suggestions

Lettuce can grow well with some shade. When the weather is especially warm, lettuce quality is actually better if plants are shaded in the afternoon or grown under a shade cloth.

Soil Type and Soil Preparation

Lettuce will grow in almost any type of soil. For production of the best-quality leaves, the soil must be fertile and have adequate organic matter. Lettuce is usually planted very early in the spring. Consequently, it is important to make sure the soil is not too wet when tilling. The soil should be damp but not wet.

Planting

Lettuce seeds are typically planted directly in the garden, but they may be sown indoors or in cold frames for transplanting. Lettuce is quite cold-tolerant and can be planted early in the spring (3–4 weeks before the average last killing frost) or as soon as soils are dry enough to be worked.

Succession planting can create a constant supply of lettuce throughout the summer. Plant additional seeds when plants of the previous crop reach about 1 inch in height. Plant beginning in early spring and ending a few weeks before average first frost.

Planting specifications:

- Seed spacing: 1.5–3 inches
- Final spacing (leaf): 6–8 inches
- Final spacing (head): 6–12 inches
- Row width: 18–24 inches
- Seed depth: 0.25–0.5 inch
- Germination: 4–8 days

Fertilizer

Lettuce has a very high demand for N, but has a short production cycle. Consequently, a single application of fertilizer at planting time is usually adequate. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually suitable. Apply the equivalent of 0.3 lb N (in combination with P and K) per 100 square

feet during soil preparation. If using succession planting, apply fertilizer at the time of each new planting. Alternatively, if the seedbed was fertilized with the rest of the garden in the spring, add an additional small amount of N with each planting.

If soil tests indicate adequate levels of P and K, consider using a high-N fertilizer such as 21-0-0 or 46-0-0. Adjust the application rate to account for the percentage of N in the product.

Weed Control

Season-long weed control is essential for lettuce. Hand pulling, cultivation, or application of a labeled garden herbicide are effective control options. Cultivation should be shallow because lettuce has a shallow and limited root system. Deep cultivation close to the plants will destroy much of the root system and can reduce yield and quality.

Irrigation

Because of the shallow root system, lettuce should be watered frequently in order to support rapid leaf development. Inadequate water supply will lead to poor growth and bitter flavor. On most soil types, apply 1.25–1.5 inches of water every 4 or 5 days. On sandy soils, apply smaller amounts, but more frequently.

If possible, avoid overhead sprinkler irrigation on lettuce. Wetting the leaves often causes leaf scorch and encourages leaf diseases. These problems reduce quality and shorten the productive life of the plants.

Insects

Insect problems on lettuce rarely require control measures. However, many insects feed on lettuce, including aphids, leaf miners, flea beetles, loopers, cucumber beetles, cutworms, armyworms, and slugs. If infestations are severe, several organic or traditional control measures are effective.

Diseases

The short productive life span of lettuce generally precludes serious disease problems. In Idaho, white mold and stem rots may be problematic. To prevent these diseases, avoid overwatering and, if possible, avoid using overhead sprinklers.

Harvest

Leaves of plants pulled during thinning can be used for early salads. Harvest of leaf lettuce can begin as soon as leaves are large enough to eat. Leaf lettuce can be harvested multiple times, so it is important to avoid damage to the crown and new leaves when harvesting older leaves.

Head lettuce is ready to harvest when the heads are solid and of adequate size. Butterhead lettuce can be harvested as soon as the heads form. Head lettuce and butterhead lettuce are usually harvested only once.

Storage

Lettuce is not usually stored. However, if kept refrigerated in a plastic bag, it can be held for several days.

Consumptive Yield

Compute household planting requirements as follows:

- 4–5 lb fresh lettuce per person
- Each foot of row will yield 0.5 lb

Plant 8–10 feet of row per person.

Nutritive Value

Lettuce is not considered a nutrient-rich food; however, it does contain significant amounts of several vitamins and minerals. It is an excellent source of vitamin K and vitamin A. It is also a good source of vitamin C, thiamin, riboflavin, folate, vitamin B6, iron, and manganese. One hundred grams (3.5 oz) of fresh leaf lettuce contain 15 calories, 1.4 grams of protein, 0.2 gram of fat, and 2.9 grams of carbohydrates. Fresh lettuce is 95% water.

Onions

Onions (*Allium cepa*) were grown in Chinese gardens as early as 5000 BC. In Egypt, the use of onions can be traced back to about 3500 BC. Studies show that the Sumerians were growing onions as long ago as 2500 BC.

Ancient Egyptians worshipped the onion. They believed that its round shape and concentric rings represented eternal life. In Egyptian burials, onion slices were placed over the eye sockets. It was believed the strong scent of onions would bring the dead back to life.

Roman gladiators often received onion massages in the belief that the onion juice would firm up their muscles. During the Middle Ages, onions were often

used for barter or given as gifts. Doctors prescribed onions to improve bowel function and to provide relief for headaches, hair loss, and even snake bites.

In 1492, Christopher Columbus introduced onions to the New World. They have since become one of the most popular vegetables around the world.

The length of summer days provides a trigger for onions to grow bulbs. There are onions that bulb best where summer days are short (low latitudes), moderate (medium latitudes), or long (high latitudes). It is very important to choose moderate- to long-day cultivars for Idaho's medium to high latitude.

Growing Suggestions

Planting onion sets (small bulbs) is a very convenient and dependable way to grow onions in the garden. However, not all onion cultivars respond well to the process of set production, namely partial growth, harvest, and storage at the immature stage. Onions available for planting as sets are usually the pungent, flattish Spanish onions. The large, round, mild "Walla Walla" type onions are not available as sets and therefore must be planted using seeds or transplants.

Soil Type and Soil Preperation

Onions grow well in a wide range of soils and climates, but they develop best in a loose, crumbly soil with high fertility. They can be planted very early, as soon as the soil is dry enough to till. Begin seedbed preparation when the soil has sufficient moisture to form a ball that will crumble with finger pressure into medium-size fragments. Onions benefit from consistent addition of organic matter, regardless of soil type.

Planting

Onion seed may be sown indoors for transplanting later or direct seeded into the garden or onions may be planted from sets. In short-season areas of Idaho, it is best to utilize transplants or sets.

When growing onion transplants indoors, sow the seeds about 8 weeks before the average last killing-frost date. Seeds are small, so plant them only about 0.25 inch deep and about 0.5 inch apart in a tray. If the plants get tall enough that they begin to tip over, trim them with a pair of scissors to about 3 inches tall. Trimming can be done more than once. Onion seedlings are not as frost-tolerant as are sets. Place them in the garden about a week after the average last frost date. They will transplant better if hardened off.

Onions that are direct seeded into the garden do not go through the shock of being uprooted and replanted. This method minimizes stress and disease potential and results in plants that are less likely to bolt. It also produces onions that will store better.

If using onion sets, sort them into two sizes: sets smaller than 0.75 inch and those that are larger. Use the larger sets for green onions because they frequently form seed stalks instead of a bulb. Plant these sets 1–2 inches apart.

Planting specifications:

- Seed spacing: 0.75–1.25 inches
- Final spacing: 3–4 inches
- Ounces of seed per foot: 0.2
- Row width: 12–14 inches
- Seed depth: 0.5 inch
- Sets depth: 2–3 inches
- Germination: 7–12 days

Fertilizer

Onions are considered to be high users of nutrients, due more to their shallow root system than to their actual nutrient needs. Onions use nutrients over a long period, so apply fertilizer two times. The first application can be made during soil preparation. The second is typically made no later than mid-July. If fertilizer is added later, the plant may revert to leaf growth at the expense of bulb growth.

Onions do best with a balanced fertilizer program and benefit from fairly high levels of P. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet before planting. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually suitable. Side-dress an additional 0.25 lb N by mid-July. For side-dressing, it is appropriate to use a high-N product such as 21-0-0 or 46-0-0.

Weed Control

Direct-seeded onions emerge more slowly than most weed competitors. It is important to avoid damaging or killing emerging seedlings during early weed-control activities. Carefully mark the planting location, in case weeding is needed before crop emergence. Hand weeding is best for removing early weeds.

Onions provide little or no competition for weeds and require season-long, intensive weed control. Weeds can be controlled by hand-pulling, cultivation, or use of a labeled garden herbicide. Onions have very weak, shallow roots, so cultivation should be shallow.

Irrigation

Their shallow root system and relatively high demand for water mean that onions should be watered fairly lightly and frequently. On most soil types, apply 1–1.5 inches of water every 3 or 4 days. On sandy soils, irrigation may be required even more frequently. Frequent watering becomes less critical toward the end of the season.

Insects

Many insects can cause severe damage to onions, including onion thrips, onion maggots, pea leafminers, and wireworms. A severe outbreak of onion thrips may require the use of a labeled insecticide. Onion maggots and wireworms can destroy the bulbs, and control can be difficult. Crop rotation may help, especially in preventing maggot damage. Application of a granular insecticide at planting can be helpful if the site has a history of problems with these pests.

Diseases

In Idaho, onions are potentially subject to a number of serious diseases. Plate rot, pink rot, and neck rot are soil-borne fungal diseases that infect onions while growing in the garden. If unlucky enough to have one of these diseases in the garden, there is very little a gardener can do, other than employ crop rotation. These diseases infect the bulbs during growth, but often do not create serious problems until onions are in storage. Inspect onions at harvest. If there is any sign of disease on the root surface or neck tissue of the bulbs, use these onions immediately rather than trying to store them. Foliar diseases, such as powdery mildew and downy mildew, although sometimes visible, usually do minimal damage to onions.

Harvest

Green onions can be harvested at any stage of growth, either before or after bulbing is initiated. Simply pull the onions from the ground by hand to avoid disturbing nearby plants.

Proper harvest of mature onions is more complex. Softening of the neck tissues allows the leaves to fall over (known as top break), indicating maturity. Once half or more of the onions break, the crop is ready to pull and cure. Curing is essential if onions are to be stored. Cure onions by leaving them on the soil surface or other dry place until tops and outer scales are completely dry. Drying can take up to a week. Do not allow the onions to be rained on during curing. After the bulbs are cured, remove the dried tops.

Storage

The pungent Spanish-type onions generally store better than the large sweet onions. Onions store best refrigerated at near 32°F. However, they are damaged by temperatures below 30°F, so it is important to carefully control storage conditions. Onions do best with only moderate levels of humidity in storage. Cold, relatively dry conditions are often difficult to find in home storage facilities, but a dry cellar or attic may suffice. Under proper conditions, onions can be stored for 6 months or longer.

Consumptive Yield

Compute household planting requirements as follows:

- 3–5 lb fresh onions per person
- 15–20 lb dried or stored onions per person
- Each foot of row will yield 0.75 lb

Plant 4–33 feet of row per person.

Nutritive Value

Due to the presence of the compound allacin and the trace mineral chromium, onions help moderate the symptoms of diabetes. They are an excellent source of vitamin A and a good source of vitamin B6, vitamin C, and manganese. One hundred grams (3.5 oz) of fresh chopped onions contain about 40 calories, 0.1 gram of fat, 9.3 grams of carbohydrates, 1.1 grams of protein, and 1.7 grams of dietary fiber. Fresh onions are 89% water.

Peas

Field peas were among the first crops cultivated by humans. Archaeologists and historians think the garden pea (*Pisum sativum*) may have originated in China or Egypt. Peas found in what is called "Spirit Cave," located between Myanmar (Burma) and Thailand, have been carbon dated to 9750 BC. These peas were

probably growing wild and were gathered rather than cultivated. Peas have also been found in archaeological digs in northwestern Iraq that date back as far as 7000 BC. In Switzerland, peas were found that date to about 3000 BC.

Peas were not widely eaten in early history. The Romans seemed to prefer the taste of chickpeas over that of garden peas. During the Middle Ages, peas were sometimes dried and kept for use in times of famine.

When explorers prepared to sail to the American continent, they took along dried peas. Peas were easy to store and kept for long periods of time. A list published in 1635 showing supplies needed for one colonist for one year listed "one bushell of pease." Europeans didn't start eating fresh peas until the late seventeenth century.

Peas are classified as smooth or wrinkled according to how the seed looks when dry. The wrinkled seed types are normally the sweetest.

Growing Suggestions

Obtaining a good stand of peas can be one of the most challenging problems associated with growing this crop. Peas are very susceptible to a number of rot organisms that kill the seedlings before or just after emergence. See subsection "Diseases" for managing this problem.

Early planting is essential because peas do not set pods in extreme summer heat. It is important that the crop be ready to harvest by the time it gets hot. Luckily, peas are cold-tolerant and can be planted up to 5 weeks before the average last spring frost.

Soil Type and Soil Preparation

Peas will grow in any well-drained garden soil. They do best in soils that do not crust. They require only routine soil preparation.

Planting

Plant peas as soon as the ground can be worked in the spring, usually 3–5 weeks before the average last spring frost. Maximum daytime soil temperature at the time of planting should approach 50°F.

Peas can be planted in a variety of row designs. Some gardeners plant peas in a block with seeds planted on a grid about 2 inches apart in each direction. Peas planted in this way will support one another without the use of a trellis. Others plant a double row of peas about 6 inches apart, with the seeds placed 2 inches apart in the rows. When planting single or double rows, it may be desirable to install a trellis for the peas to climb.

Planting specifications (single row):

- Seed spacing: 1.5–1.75 inches
- Final spacing: 3–4 inches
- Ounces of seed per foot: 0.16
- Row width: 18–30 inches
- Seed depth: 1.5–2 inches
- Germination: 6–15 days

Fertilizer

Take care when fertilizing peas. Peas are a legume and are able to produce much of their own N. Excess N can cause the plants to produce large vines, but fewer peas. Although peas require minimal applications of N, levels of P, K, and other nutrients must be adequate to ensure productivity. Apply fertilizer during soil preparation. A 5-10-10 or similar fertilizer formulation that is low in N and high in other nutrients is best for peas. The equivalent of 0.1–0.2 lb N (in combination with P and K) per 100 square feet will provide adequate nutrients.

Weed Control

Season-long weed control is important for peas because they are only moderately competitive with weeds. Achieve control through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Be careful when cultivating close to pea plants to avoid damaging the root systems.

Irrigation

Peas have a shallow root system and little tolerance of drought stress. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Many insects feed on peas, but few become problematic. Pea aphids may occasionally reach population levels that require control. Washing them off the plants with a hard stream of water usually provides adequate control. In some parts of Idaho, pea weevils are problematic. Larvae penetrate the pods and feed on the developing seeds. A timely insecticide application to control the adults before egg laying may be required.

Diseases

Seed and root rots impact emergence of peas. These problems are managed by planting in warm soil (above 50°F), planting after soil dries partially, and delaying irrigation until after emergence. White mold occasionally damages pods that touch the ground. Staking the vines and allowing the soil surface to dry between irrigations usually eliminates this problem. Peas are also susceptible to a number of viruses. These diseases are usually kept in check by buying certified seed from a reputable source.

Harvest

Pick peas during the cool part of the day so they remain crisp. Harvest garden peas when pods are nearly full, but before pods begin to wrinkle. If allowed to mature too long, peas become starchy and lose their sweetness. Peas also become starchy if left to sit at room temperature after harvest. As little as 4 hours is enough time to significantly reduce quality.

Harvest edible pod peas while the pods are still flat and the peas are hardly discernible. Pick these peas every other day to prevent overmaturity.

Storage

In order to maximize quality, do not store peas. They should be consumed, frozen, or canned immediately. If immediate use is not possible, peas can be stored in the pod for a few days at high humidity and a temperature near 32°F.

Consumptive Yield

Compute household planting requirements as follows:

- 4 lb fresh peas per person
- 10 lb canned or frozen peas per person
- Each foot of row will yield 0.3 lb

Plant 13–46 feet of row per person.

Nutritive Value

Peas contain significant quantities of many nutrients, including some that are difficult to obtain from other vegetables. They are an excellent source of niacin, vitamin C, and potassium. They are also a good source of vitamin K, riboflavin, thiamin, vitamin B6, folate, iron, P, magnesium, manganese, and zinc. One hundred grams (3.5 oz) of peas contain 81 calories, 0.4 gram of fat, 14.5 grams of carbohydrates, 5.4 grams of protein, and 5.1 grams of dietary fiber. Fresh peas are 79% water.

Peppers

Peppers (*Capsicum annuum*) belong to the Solanaceae family, as do tomatoes and potatoes. Christopher Columbus found these plants growing in the New World and brought them back to Europe. He named them peppers because he mistakenly believed they were related to the plants that yielded the highly prized peppercorn.

Peppers are native to Mexico, Central America, and northern South America. Historians believe that chili peppers were probably the first plants to be domesticated in Central America. Evidence suggests they were consumed as early as 7500 BC. It is believed that other groups of people in North and South America developed domesticated varieties for cultivation. After Columbus brought peppers back to Spain, they slowly spread to other European and Asian countries. The impact of bringing the pepper plant to other parts of the world has been phenomenal. It has become one of the most important and widespread vegetable crops worldwide.

Extremely hot and pungent cultivars are often grown in South Asia. These types were introduced into these areas by Portuguese and Spanish explorers, probably in the sixteenth century.

Most peppers are categorized as either sweet or hot, depending on how much pungent capsaicin they contain. They range from very mild and sweet to so hot they are almost inedible. A rating system called the Scoville scale has been developed for quantifying the "heat" in various peppers. For example, bell peppers are rated at 0 Scoville units because they have no detectable "hotness." Jalapeño peppers rate between 2,500 and 6,000 Scoville units. Cayenne peppers rate between 30,000 and 50,000 Scoville units and habañero peppers rate between 100,000 and 500,000 Scoville units. The hottest pepper on record, derived from the ghost peppers of India, was measured at 2.3 million Scoville units.

Growing Suggestions

Peppers grow best in very warm climates. In short-season areas of Idaho, production is enhanced by planting on the south side of a structure, planting on black plastic, or using row covers.

Soil Type and Soil Preparation

Peppers can be grown in most types of soil, as long as the soil is well drained. Pepper fruits will mature more quickly when grown on lighter soils. Peppers grow best when supplied with sufficient organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps pepper plants develop a healthy root system.

Planting

In Idaho, peppers are almost always grown from transplants, partially because of the need to speed maturity and secondarily to overcome germination problems. Purchase healthy transplants or grow your own by sowing pepper seeds indoors or in the greenhouse 6–8 weeks before the intended transplant date. Transplants should be stocky and from 4–6 inches tall. Newly transplanted pepper plants require protection from frost, wind, and intense sun.

Transplanting specifications:

- Final spacing: 15–18 inches
- Row width: 24–36 inches

Fertilizer

Peppers do best with a balanced fertilizer program and respond to adequate levels of P and K. They have a fairly high demand for nutrients over a long growing season. Add fertilizer in two separate applications. Apply 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually appropriate. Side-dress an additional 0.3 lb N when the plants begin flowering and setting fruit. The product selected for side-dressing should be high in N, e.g., 21-0-0 or 46-0-0.

Weed Control

Season-long weed control is important for pepper production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once rapid growth begins, tillage activities close to plants should be shallow in order to prevent root damage.

Irrigation

Peppers require moderate amounts of water on a consistent schedule. If allowed to wilt, production will decline and fruit will lose quality. Irrigate peppers with 1.5–2 inches of water every 5–7 days.

Insects

Other than spider mites, there are no major insect pests of peppers in Idaho gardens. Mites can be controlled by using overhead irrigation or occasionally wetting the leaves.

Diseases

Virus diseases are common in peppers. Plants that become unthrifty and have malformed and mosaic color patterns in the leaves are likely infected. Remove these plants to prevent them from competing with healthy plants. Verticillium wilt, a soil disease that causes plants to wilt, become yellow, and lose leaves, is also common in many places in Idaho. This disease is partially controlled through crop rotation.

Harvest

Peppers can be harvested at any time after they are large enough to use. Bell types usually are harvested when they are 3–4 inches long. Hot peppers grown for salsas and sauces can be picked when they reach the desired size and color. When picking peppers, cut them from the plant rather than pulling them. If the end cap is pulled off, the fruit will quickly rot.

It is important to harvest peppers on a consistent schedule. Allowing fruit to hang on the plant until completely mature will delay the setting of additional fruit. Hot peppers grown for drying are the exception. Leave them on the plant until they are wrinkled and partially dry. After harvest, place them in a sunny, hot place to complete the drying process.

Storage

Peppers can develop cold injury symptoms in a refrigerator. They are best stored in an unheated basement or storage room at 45°F–50°F. If conditions are good, they may keep for up to 2 weeks, although they will probably lose moisture and become wrinkled. An alternative is to slice and/or dice peppers and then dry them in an oven or dehydrator. They can then be stored in a glass jar. When dried properly, these peppers should remain flavorful for about 1 year.

Consumptive Yield

The amount of peppers required to supply household needs varies widely, due to differences in types of pepper, intended use, and processing methods. Experience will dictate how many to plant.

Nutritive Value

Peppers are used mostly as a seasoning rather than a staple food. However, sweet peppers are often eaten in quantity and become important nutritionally. They are a good source of B-complex vitamins. Peppers are one of the best sources of vitamin C among vegetable crops. They are also a good source of vitamin K and manganese. One hundred grams (3.5 oz) of raw sweet, green peppers contain 20 calories, 0.2 gram of fat, 0.9 gram of protein, 4.6 grams of carbohydrates, and 1.7 grams of dietary fiber. Peppers contain 94% water.

Potatoes

Potatoes (*Solanum tuberosum*) were critical to the development of the Andean cultures in South America. For thousands of years, they have provided a consistent, nutritious food source for these mountain-dwelling peoples. Potatoes were of such importance that they became deeply ingrained into every facet of society, including religion.

Andean potato varieties, still critical to food supplies in much of South America, are quite different from those grown in the United States and Europe. Tubers are typically small and come in a variety of colors and shapes. Occasionally, these native varieties are available for planting in gardens. It can be enjoyable to grow, prepare, and eat these interesting potatoes.

There are many cultivars of potatoes available. The type of potato often dictates product quality. Red potatoes are often harvested early and are good for boiling and making hash browns. White potatoes are good boiled and sometimes make great potato chips. Russet potatoes are usually great for baking or making french fries. In Idaho, many people prefer Russet Burbank potatoes. This cultivar is often difficult to grow in the garden. It must be consistently supplied with large amounts of water and fertilizer to perform well. If these conditions cannot be provided, choose another cultivar.

Growing Suggestions

The single most important tip for growing potatoes is to always buy new, certified seed potatoes. Potatoes are propagated by planting the current crop using tubers from last year's crop. This practice means that any diseases present in the last crop will be transferred to the new crop. Using certified seed potatoes ensures that such diseases are minimized. Never plant potatoes sold in the grocery store for food. These potatoes are often treated with antisprouting compounds that prevent normal growth.

Soil Type and Soil Preparation

The largest, smoothest potatoes are produced in loamy or sandy soils. Clay soils often result in malformed tubers. Heavy soils can be improved with the application of large amounts of compost or manure.

Potatoes need soil that is loose and deeply tilled. Tubers will not develop properly in packed or hard soil. Till soil to a depth of at least 10 inches. Avoid tilling soil that is too wet.

Planting

Be sure to purchase and plant certified seed potatoes. Cut seed potatoes into pieces that weigh 2–3 ounces (about 2 inches long and 1–1.5 inches wide).

Potatoes can be planted about 2 weeks prior to average last spring frost or even slightly earlier if you don't mind a little frost damage to the newly emerged sprouts. Early planting is important if you want an early harvest of new, summer potatoes. Soil temperature is important for healthy sprout development and should be approaching 50°F at the time of planting. As the plants start to emerge, mound a few inches of loose soil around them to ensure that the developing tubers remain covered with soil.

Planting specifications:

- Seed-piece spacing: 1 foot
- Final spacing: 1 foot
- Ounces of seed tubers per foot: 2–3
- Row width: 30–36 inches
- Seed depth: 5 inches
- Emergence: 18–25 days

Fertilizer

Potatoes are considered to be heavy users of nutrients. In reality, they can grow with limited fertility, but they produce the largest tubers and highest yield with adequate nutrition. Potatoes respond positively to adequate levels of N, P, and K.

Potatoes do best with split applications of fertilizer. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation is usually adequate. Side-dress an additional 0.25 lb N when the plants are about 12 inches tall. It is appropriate to use a product containing P and K for side-dressing.

Weed Control

Early season weed control is important for potatoes. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Hilling soil around the plants is helpful. Once mature, plants compete well with weeds.

Irrigation

Consistent irrigation is important for producing smooth, high-quality potato tubers. To keep the seed pieces healthy, delay irrigation until after the sprouts emerge, if possible. Once emerged, plants require relatively frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently. As plants mature, irrigation can be less frequent.

Insects

Colorado potato beetles are the most damaging insect pest of potatoes. The bright orange larvae of this insect can completely defoliate plants within a few days. In a small garden, the larvae can be removed by hand and destroyed. With large numbers of plants, control may require the use of an approved standard or organic insecticide.

Diseases

Potatoes are prone to a number of very serious diseases. A variety of viral diseases can appear at any time during the growing season. Removal of infected plants is the only defense against further spread. Plants showing leaf mottling or serious malformation should be removed and destroyed.

A soil fungal disease called verticillium wilt causes plants to become weak, turn yellow, and develop burned leaf edges. This disease is very common in southern Idaho. Other than planting resistant cultivars, the only ways to manage this disease are to avoid planting in infected soil and to pull and destroy infected plants. Crop rotation will help minimize symptoms.

Both early and late blight cause leaf spotting and leaf drop on potatoes. Under the right conditions (cool, cloudy, rainy), these diseases can rapidly kill plants and may rot the tubers. These diseases can be controlled with multiple applications of a labeled garden fungicide, beginning immediately after symptoms are detected.

Harvest

Tuber harvest can begin as soon as potatoes are large enough to eat. Immature tubers tend to lose their skin during handling and should be consumed shortly after harvest. If potatoes are intended for storage, let them grow into the cool weather of fall. Then kill or remove the vines and leave the tubers in the ground to mature for about 3 weeks. Finally, harvest tubers carefully to avoid damage.

Storage

Potatoes can be stored for 6 months or longer if provided with the right conditions. They need temperatures of 40°F–45°F and humidity over 95%. Supplying these conditions may require a root cellar or a refrigerator dedicated to produce storage. Potatoes must be kept in the dark to prevent greening and bitterness.

There is a direct relationship between storage temperature and frying quality of potatoes. If potatoes are to be used for making chips or fries, they must be stored at a warmer temperature than if they are to be baked or boiled. When fried, potatoes stored at temperatures below 45°F turn brown and taste burned.

Consumptive Yield

Compute household planting requirements as follows:

- 60 lb fresh and stored potatoes per person
- Each foot of row will yield 2 lb

Plant 30 feet of row per person. (If no storage is planned, 5 feet of row per person is adequate.)

Nutritive Value

Potatoes are one of the few vegetables to be considered a complete food. They provide most of the essential nutrients needed by humans, including a high-quality protein. Potato tubers are also a good source of vitamin B6 and contain valuable amounts of vitamin C, thiamin, niacin, K, P, iron, magnesium,

and manganese. Potatoes with yellow flesh also provide vitamin A. One hundred grams (3.5 oz) of fresh potatoes contain 2.1 grams of protein, 0.1 gram of fat, 18 grams of carbohydrates, 79 calories, and 1.3 grams of dietary fiber. Fresh potatoes consist of 79% water.

Pumpkins and Winter Squash

Pumpkin and winter squash (*Cucurbita* spp.) are botanically identical and are grown in a similar manner. Pumpkins are used primarily for decorations, although pumpkin pie is the final fate of many pumpkins. Winter squash are used primarily for food, including pie.

Pumpkins and winter squash are believed to have originated in the region between northern South America and the southwestern United States. Seeds from closely related plants dating back to 7000–5500 BC. have been found in Mexico. Native Americans used pumpkins and squash as a dietary staple several centuries before the Pilgrims landed.

Very early explorers took pumpkins back to Europe. The Greeks named the fruits "pepon," which meant "large melon." The French changed the pronunciation to "pompon." The English later changed "pompon" to "pumpion" and Shakespeare mentioned the "pumpion" in his *Merry Wives of Windsor*. American colonists changed the name from "pumpion" to "pumpkin."

Winter squash and pumpkin cultivars are derived from three separate cucurbit species. The three species do not freely intercross. However, all three produce fruits that are consumed in their mature phase or used for fall decorations. Winter squash cultivars come in an amazing array of sizes, shapes, and colors. Pumpkins and most winter squash fruits have yellow or orange flesh, although a few have white flesh. Most winter squash and pumpkin cultivars are vining or semivining and grow to be very large, sprawling plants.

Growing Suggestions

Pumpkins and winter squash grow best in a warm site with full sun. Warm soil is essential to good seed germination and emergence. Using transplants can speed production.

Soil Type and Soil Preparation

Pumpkins and winter squash will grow in almost any well-drained soil, but prefer sandy or loamy soils. They are most productive on fertile soils with adequate levels of organic matter. Prior to planting, amend soils to enhance fertility, organic matter content, and drainage. Till soil as deeply as feasible to create a deep, mellow seedbed. Mounding or hilling the soil can improve drainage and increase soil temperatures.

Installing black plastic mulch prior to planting can warm the microclimate around plants, speeding harvest and improving productivity. Plastic mulches also help control weeds, thereby reducing the need for herbicides and cultivation.

Planting

Pumpkin and squash seedlings are extremely susceptible to frost. They should not be direct seeded in the garden until about 1–2 weeks after average last frost. Daytime soil temperatures at planting time should consistently be above 65°F.

Transplant pumpkin and squash plants to the garden 2–3 weeks after average last frost. Transplants should be small (one or two true leaves), dark green, and growing vigorously. Protect them during the first week from wind, direct sun, and cold.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 5–6 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.05
- Row width: 6–10 feet
- Seed depth: 1 inch
- Germination: 5–14 days

*Hill spacing for transplants is the same as for seed.

Fertilizer

Pumpkins and winter squash need fairly high levels of N, P, and K and do best with a balanced fertilizer program. They are fairly high users of nutrients over a long period of the season, so apply fertilizer twice. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually adequate.

Side-dress an additional 0.25 lb N before flowering. N is the most important nutrient for the side-dress fertilizer application, so a product made up primarily of N (e.g., 21-0-0 or 46-0-0) will work fine.

Weed Control

Early season weed control is important for pumpkin and squash production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Tillage activities close to plants should be shallow in order to prevent damage to feeder roots. Weed control becomes less essential later in the season.

Irrigation

Due to their requirement for warm temperatures at planting time, pumpkin and squash seeds may need one or two light irrigations to ensure good seedling emergence. Once established, these crops do best with infrequent, deep irrigation. On clay or loam soils, apply 1.5–2 inches of water every 5 or 6 days. On sandy soils, apply smaller amounts, but more frequently. If plants are allowed to wilt, fruit shape and eating quality will be negatively affected.

Insects

Several species of aphids and squash bugs can become problematic on pumpkins and winter squash. Control aphids by using an insecticidal soap, spraying the affected parts of the plants with a hard stream of water or applying a registered insecticide. Pick squash bugs from the plants and destroy them or use an insecticide. Wireworms can damage roots, stems, or the fruit where it touches the ground. They are very difficult to control during the growing season. If problems with wireworms persist over several seasons, a preventive spring application of a soil insecticide may be necessary.

Diseases

Pumpkins and squash can be infected by a number of root rot diseases, viruses, and fungal leaf diseases. In Idaho, disease problems are generally minimal due to low humidity and short seasons. However, viruses and root rots occasionally reach levels that require control.

Virus symptoms include malformed or splotchy leaves or fruit. These diseases cannot be cured. They are usually controlled through removal and destruction of infected plants.

Root rots are nearly impossible to treat once symptoms appear. The best prevention is to avoid overwatering (or overly frequent watering). Also, avoid planting squash plants in low spots where water may accumulate.

Powdery mildew is a disease that often appears on winter squash and pumpkins, but is seldom an issue of concern. Symptoms include a white, powdery fungal growth on the upper leaf surface. No control is necessary if symptoms appear during the last month of the season. If symptoms appear earlier, it may be necessary to apply a labeled garden fungicide.

Harvest

Pick pumpkins and winter squash any time after full fruit color is expressed and the rinds are hard. Full maturation does not always occur until after frost kills the foliage. Mild frosts help speed maturation. Moderate to heavy frosts damage the fruit and shorten storage life, even if the fruit heals and returns to a normal appearance. Harvest fruits before they are exposed to temperatures below about 28°F.

Storage

If not completely ripe, store pumpkins and winter squash in a warm (room temperature or above) place for the first few weeks. Once full skin color has developed, they can be moved to long-term storage with temperatures around 50°F and moderate humidity. A cool basement is ideal. Under the right conditions, some types of winter squash will store for several months.

Consumptive Yield

Compute household planting requirements for squash as follows:

- 6–9 lb fresh and stored squash per person
- 6–9 lb processed squash per person
- Each foot of row will yield 1 lb

Plant 6–18 feet of row per person.

Most pumpkin cultivars produce 3–6 fruits per hill. If pumpkins are grown for decorative purposes, calculate the number of plants needed based on the number of fruits needed.

Nutritive Value

Pumpkins and winter squash vary widely in nutrition. Those with orange flesh are some of the best sources

of vitamin A among vegetable crops. Pumpkins and squash also are good sources of vitamin C, vitamin E, vitamin B6, folate, riboflavin, K, manganese, and iron. On average, 100 grams (3.5 oz) of fresh pumpkin or winter squash contain 1 gram of protein, 0.1 gram of fat, 8.6 grams of carbohydrates, 34 calories, and 1.5 grams of dietary fiber. Fresh pumpkins and winter squash are 90%–92% water.

Radishes

Radishes (*Raphanus sativus*) are grown for their colorful, sharp-tasting root and are usually the first spring-planted vegetable to be ready for harvest. They originated in western Asia and are a staple food in China and Japan. Radishes grown commonly in the United States produce roots that are small, spherical, and dark red. However, many types of radishes are available for planting in the home garden. They vary in shape from round to long and in color from red to white (or bicolored). The white Japanese daikon radish is becoming popular in many places.

Growing Suggestions

Radishes are best grown in spring or fall when temperatures are moderate. Summer heat results in inferior quality due to increased pungency (heat) and fibrousness (woodiness). Even when grown in optimal temperatures, radish roots remain at their best quality for only a few days. Luckily, it is possible to plant very early in the spring or late in the fall. It is possible to maintain a continuous supply of radishes during spring and early summer (or early to late fall) by succession planting. Plant a new crop of radishes when seedlings from the previous crop are fully emerged. Radishes can also be grown in a container.

Radishes make a great relay crop, meaning they can be harvested early to make way for a warm-season crop in the same location. Some of the crops that can be planted after radishes in Idaho include green beans, cucumbers, melons, pumpkins, and winter squash.

Soil Type and Soil Preparation

Radishes grow well in almost any well-drained soil. They emerge and mature faster in a sandy soil, but often develop the best root color and quality in heavier loam or clay soils. Work the soil to form a smooth, firm seedbed. Work the soil as early as feasible, but avoid working wet soils.

Planting

Radish seedlings are very frost-resistant, so seeds can be planted 3–5 weeks before average last frost. Sow seeds directly in the garden. Radishes are small seeded, so they should be planted shallow.

To make the most effective use of space, you can plant radishes in a bed row (a wide row, several plants across) or grouping. Give each radish 1–2 square inches of space. To ensure full productive potential, you can overplant radishes and thin to a final stand after emergence.

Radishes emerge very quickly — within 3–6 days depending on daytime temperature. They can produce edible roots in 20–30 days, making them one of the earliest vegetables to come from the spring garden.

Planting specifications (single row):

- Seed spacing: 0.5–0.75 inch
- Final spacing: 0.75–1 inch
- Ounces of seed per foot: 0.02
- Row width: 15–18 inches
- Seed depth: 0.5 inch
- Germination: 3–10 days

Fertilizer

Due to their very short production period, radishes require low to moderate levels of N fertilizer. For good root production, they do best with moderate to high levels of P and K. A 5-10-10 or similar fertilizer formulation is usually adequate. A single preplant application of 0.2 lb N (in combination with P and K) per 100 square feet will provide adequate nutrients.

Weed Control

Control of early weeds is essential for maximizing production and quality. Hand pulling and cultivation are usually adequate. Late-emerging weeds are not a concern with radishes due to their short production cycle.

Irrigation

Due to their requirement for shallow planting, radishes may need one or two light irrigations after seeding to ensure good seedling emergence. Once emerged, they do best with frequent, light irrigations that maintain soil moisture at a fairly high level. If soil is allowed to dry out, roots become pungent and woody.

Insects

Spring-planted radishes have very few insect pests, in part due to natural resistance, but also because their early season growth allows them to avoid many problematic pests. Flea beetles sometimes feed on the leaves, creating small, round holes. This damage generally does not affect growth or productivity.

Diseases

Disease control is rarely required for radishes in Idaho gardens.

Harvest

Radishes can be harvested as soon as the roots reach edible size, typically 1 inch in diameter. Larger roots (2 inches or more) often display inferior quality. Once the plants bolt (the blossom stem begins to form), the roots quickly become inedible. Optimal harvest period for quality often lasts for only a few days, depending on temperature.

Storage

Under moist, refrigerated conditions, radish roots can be stored for up to a week. Storage in a perforated plastic bag will help retain quality. Remove the leaves before storage to prevent the roots from losing moisture and becoming rubbery.

Consumptive Yield

Compute household planting requirements as follows:

- 2–3 lb fresh radishes per person
- Each foot of row will yield 0.67 lb

Plant 3–5 feet of row per person.

Nutritive Value

Radishes contain flavonoid antioxidants, which help lower the risk of cancers. They are a good source of vitamin C, folate, vitamin B6, and K. One hundred grams (3.5 oz) of radishes contain 0.7 gram of protein, 0.1 gram of fat, 3.4 grams of carbohydrates, 16 calories, and 1.6 grams of dietary fiber. Fresh radishes are 95% water.

Summer Squash

All species of squash (*Cucurbita pepo*) and closely related pumpkins and gourds have their origins in the New World, specifically northeastern South America, Mexico, and the southwestern United States. Summer squash are grown for their immature fruits, which come in a variety of sizes, shapes, and colors. Most fruits have white flesh, although a few cultivars are yellow. Plants of most modern cultivars of summer squash have a compact, bush growth habit. However, some types are vining or semivining.

Growing Suggestions

Summer squash grow best in a warm site with full sun. Warm soil is essential to good seed germination and emergence. Squash can be transplanted to speed production.

Soil Type and Soil Preparation

Summer squash will grow in almost any well-drained soil, but prefer sandy or loamy soils. They produce best on fertile soils with adequate levels of organic matter. Before planting, amend the soil to enhance fertility, organic matter content, and drainage. Till soil as deeply as feasible to create a deep, mellow seedbed. You can improve drainage and increase soil temperatures by mounding or hilling the soil.

Installing black plastic mulch prior to planting can warm the microclimate around squash plants, thereby speeding harvest and improving productivity. Plastic mulches also enhance weed control, reducing the need for herbicides and cultivation.

Planting

It is critical that squash transplants be small (one or two true leaves), dark green, and growing vigorously. Squash seedlings are extremely susceptible to frost. If seeding directly into the garden, delay planting until about 1 or 2 weeks after average last spring frost. Daytime soil temperatures should consistently be above 65°F. If using transplants, protect them during the first week from wind, direct sun, and cold. If protection is not available, do not transplant squash to the garden until at least 2 weeks after average last spring frost.

Planting specifications (bush type):

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.5
- Row width: 5–6 feet
- Seed depth: 1 inch
- Germination: 5–12 days

*Hill spacing for transplants is the same as for seed. For vining types, space hills 5–6 feet apart in rows 8–10 feet apart.

Fertilizer

Summer squash are fairly high users of nutrients and do best with a balanced fertilizer program. They need fairly high levels of N, P, and K. They use nutrients over a long period, so apply fertilizer twice. Apply 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually adequate. Side-dress an additional 0.25 lb N before flowering. N is the most important nutrient for the side-dress fertilizer application, so a product containing primarily N is adequate (e.g., 21-0-0 or 46-0-0).

Weed Control

Early season weed control is important for squash production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Tillage activities close to plants should be shallow in order to prevent damage to feeder roots. Late-season weed control is less essential.

Irrigation

Due to their requirement for warm temperatures at planting time, summer squash seeds may need one or two light irrigations to ensure good seedling emergence. Once established, squash do best with infrequent, deep irrigations. On clay or loam soils, apply 1.5–2 inches of water every 5 or 6 days. On sandy soils, apply smaller amounts, but more frequently. If plants are allowed to wilt, fruit shape and eating quality will be negatively affected.

Insects

Squash bugs and several species of aphids can become problematic on summer squash. Control aphids by using an insecticidal soap, spraying the affected parts of the plants with a hard stream of water, or applying a registered insecticide. Pick squash bugs from the plants and destroy them or use an insecticide. Wireworms can damage roots, stems, or the fruit where it touches the ground. They are very difficult to control during the growing season. If problems with wireworms persist over several seasons, a preventive spring application of a soil insecticide may be required.

Diseases

Squash can be infected by a number of root rot diseases, viruses, and fungal leaf diseases. In Idaho, disease problems are generally minimal due to low humidity and short seasons. Root rots are nearly impossible to treat once symptoms appear, so prevention is the best strategy. Avoid overwatering (or overly frequent watering) and avoid planting squash in low spots where water may accumulate.

Harvest

Summer squash can be picked at nearly any stage of growth. For best quality, rinds and seed coats should be soft and pliable. In order to maintain plant productivity and maximize fruit quality, harvest squash every day. The presence of large fruit with mature seeds causes the plant to cease setting new fruit.

Storage

Summer squash quality declines very rapidly in storage. Squash generally are not stored or held in refrigeration for more than a day or two.

Consumptive Yield

Compute household planting requirements as follows:

- 6–9 lb fresh summer squash per person
- Each foot of row will yield 1.5 lb

Plant 4–6 feet of row per person. (Additional production may be needed if squash is frozen.)

Nutritive Value

Nutrition of summer squash is slightly different than that of winter squash due to differences in cultivars and harvest maturity. Summer squash tend to be a little higher in protein and lower in carbohydrates. They are a good source of vitamin C, riboflavin, vitamin B6, folate, K, manganese, and P. One hundred grams (3.5 oz) of summer squash contain 1.2 grams of protein, 0.2 gram of fat, 3.4 grams of carbohydrates, 16 calories, and 1.1 grams of dietary fiber. Fresh summer squash is 95% water.

Sweet Corn

Grain corn has been a staple crop among the native peoples of the New World for more than 5,000 years, especially in and around Mexico. Sweet corn (*Zea mays*), with its use of the crop before the kernels dry, is relatively new. Documented use of sweet corn as an important crop is limited to the past 200 years.

It is important to understand a little about the genetic nature of this crop. Sweet corn kernels express the genetic traits of both the female and male parent. Thus, the source of pollen affects kernel quality. There are three types of sweet corn: standard (su), sugary enhanced (se), and supersweet (sh2). When one type of sweet corn pollinates another, it negates the sweetening gene, resulting in starchy, poor-quality corn. There are two ways to deal with this issue. One is to plant only one cultivar of corn and make sure it is isolated by a few hundred feet from any other corn cultivars. The other is to determine the type of sweet corn being planted and make sure all other cultivars planted close by are of the same type. The class or type is usually indicated on the seed package. If not, it can usually be found by doing an internet search on the cultivar name.

In regions with short-season climates, it is important to plant cultivars that mature quickly. Generally, cultivars that are listed as maturing in 75 days or fewer are suitable.

Growing Suggestions

Sweet corn will grow well in almost any type of soil. It requires warm soil and air conditions during much of the growing season to produce a quality crop. Sweet corn must have full sun for the ears to develop normally.

Corn smut — a gray fungal growth that infects tassels and silks and looks like a puffball mushroom — is often seen in Idaho gardens. It is a systemic disease and will appear on other parts of the plant as well. It can be a serious problem if it infects a large number of ears. Do not leave infected plants as residue or the problem likely will return. Remove infected plants from the garden as soon as smut is visible. The fungus is edible and is often cooked and consumed as a delicacy in Mexico.

Harvest

Corn is usually ready to harvest when the silks are entirely brown and the husks are tight. Pull back the husk to reveal the top end of the cob and check whether the kernels are the mature color. Once ripe, it is important to pick sweet corn within a day or two to preserve quality.

Storage

Sweet corn quality declines very rapidly in storage. Ears are generally not stored or held in refrigeration for more than 2 or 3 days. For frozen or canned corn, process sweet corn immediately after harvest.

Consumptive Yield

Compute household planting requirements as follows:

- 3–5 lb fresh sweet corn per person
- 9–15 lb canned or frozen sweet corn per person
- Each foot of row will yield 0.3 lb

Plant 10–67 feet of row per person.

Nutritive Value

Due to its starchy kernels, sweet corn is higher in calories (86 per 100 grams) and carbohydrates (18.7 grams per 100 grams) than most other vegetables. It provides many of the essential amino acids important to human health. Sweet corn is a good source of vitamin C, vitamin B6, folate, thiamin, niacin, K, P, magnesium, iron, and manganese. One hundred grams (3.5 oz) of fresh sweet corn kernels consist of 3.3 grams of protein, 1.4 grams of fat, and 2 grams of dietary fiber. Fresh kernels are 76% water.

Swiss Chard

Swiss chard (*Beta vulgaris*) is derived from the same species as table beets, but does not grow an enlarged root. Instead, the leaves are used for potherbs and salads. The crop has been selected to produce large, fleshy leaves, sometimes with colored stems, veins, and midribs. Swiss chard originated in western Europe and the Mediterranean region. It is a very popular crop in much of northern Europe.

Growing Suggestions

Swiss chard will produce for a good portion of the summer if the leaves are frequently cut back or harvested. After old leaves are removed, the plant will produce tender, flavorful new leaves.

Soil Type and Soil Preparation

Swiss chard will grow in almost any type of soil. For production of the best-quality leaves, the soil must be fertile and have adequate organic matter. Swiss chard can be planted very early in the spring. Consequently, it is important to make sure the soil is not too wet when tilling. The soil should be damp but not wet. A ball of soil formed by squeezing in the hand should crumble easily under finger pressure.

Planting

Swiss chard can withstand moderate frost (down to 26°F) when the seedlings are small. Seed can be planted up to 2 weeks before last average frost. For best emergence, the daytime soil temperature should approach 50°F.

Planting specifications:

- Seed spacing: 1.25–2 inches
- Final spacing: 6–12 inches
- Ounces of seed per foot: 0.01
- Row width: 18–24 inches
- Seed depth: 1 inch
- Germination: 7–10 days

Fertilizer

Swiss chard has a fairly high demand for N in order to keep new growth vigorous and succulent. If you plan to harvest over a long period of the summer, apply fertilizer twice. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually appropriate. Side-dress an additional 0.25 lb N at first harvest. N is the most important nutrient for the side-dress fertilizer application, so a product made up primarily of N (21-0-0 or 46-0-0) is appropriate.

Weed Control

Season-long weed control is important for Swiss chard, as it does not compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots.

Irrigation

Swiss chard has a shallow root system and little tolerance of drought stress. Even short, sporadic water deficits will cause the leaves to become fibrous and tough. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Insects rarely become a serious problem on Swiss chard. Occasionally, aphids or other leaf-chewing insects (such as blister beetles, loopers, armyworms, spotted blister beetles, or leaf miners) cause sufficient damage to require control. Insecticidal soap or a range of organic or traditional insecticides will control most insects. The most difficult insects to control are leaf miners. They reside inside the leaves, where they are difficult to treat. The best strategy often is to remove and destroy damaged leaves and allow new leaves to grow in their place.

Diseases

There are few or no serious diseases of Swiss chard in Idaho. Occasionally, plants become infected with curly top, a virus. Remove and destroy malformed or mottled plants.

Harvest

Remove large, succulent leaves by cutting near the base with a sharp knife. Take care not to damage the new inner leaves.

Storage

Swiss chard is usually cooked or eaten immediately after harvest. It will retain adequate quality for 2 or 3 days under humid refrigerated conditions.

Consumptive Yield

Compute household planting requirements as follows:

- 1.5–3 lb fresh Swiss chard per person
- Each foot of row will yield 0.8 lb

Plant 2–4 feet of row per person.

Nutritive Value

For a succulent, leafy vegetable, Swiss chard is surprisingly high in nutrients. It is extremely high in vitamin K, which is purported to protect brain activity and has a role in treating Alzheimer's patients. Swiss chard is an excellent source of vitamins A and C and a good source of vitamin E, vitamin B6, riboflavin, K, magnesium, manganese, iron, P, and calcium. One hundred grams (3.5 oz) of freshly harvested Swiss chard contain 1.8 grams of protein, 0.2 gram of fat, 3.7 grams of carbohydrates, 19 calories, and 1.6 grams of dietary fiber. Fresh chard consists of 93% water.

Tomatoes

Tomatoes (*Lycopersicon lycopersicum*) are one of the most commonly grown crops in home gardens around the world. Almost any small space can be utilized to grow significant quantities

of this popular vegetable. Tomatoes originated in the tropical deserts of coastal Ecuador, Peru, and Chile. Archeological evidence suggests that they first found consistent use by humans in Mexico.

In short-season climates of northern and southeastern Idaho, the single most important production decision is choice of cultivar. Only the earliest cultivars should be used. (Remember, the word "early" in the name does not necessarily equal early in the garden.) The earliest cultivars usually produce fairly small fruit. Multiple varieties can be planted to provide both early fruit and larger, higher-quality fruit later in the season. In the warmer climate of southwestern Idaho, cultivar choice is less important, although early cultivars can still be used to bring tomatoes to the table sooner.

Tomatoes vary widely in growth habit. **Determinate** cultivars are very short, set fruit early, and tend to ripen the fruit over a short period of time. **Indeterminate** cultivars are viny and tall. They tend to set fruit continuously over the summer, mature a few fruit at a time, and reach maximum production very late in the summer. **Semideterminate** cultivars are intermediate between the two growth habit classes. Determinate cultivars tend to be more useful in short-season climates because of their earlier maturity. However, there are exceptions; some indeterminate cultivars, especially cherry tomatoes, set and mature their first fruit fairly early.

Tomato cultivars have been developed for specific uses. Tomatoes developed for fresh use have a good balance of sugars and acids to create a good flavor. The fruits have large cavities that are filled with gel and seeds to produce juiciness.

Processing or sauce tomatoes are starchy and have very thick walls, making them high in solids and low in water. They are much easier to cook down to a thickened processed product. Match the class of tomato to the intended use when choosing cultivars.

Heirloom tomato varieties are becoming very popular. These old varieties offer gardeners a wide array of unique production options. Heirloom plants are available in all maturity classes and growth habits. Fruits come in many sizes, colors, shapes, and flavors. Most heirloom varieties lack resistance to pests and disease, in comparison with modern hybrids, but offer other advantages.

Growing Suggestions

Both heat and sunlight markedly improve earliness in tomatoes. Planting tomatoes in full sunlight is critical to encouraging early fruit ripening. You can provide warmer growing conditions by planting next to a south-facing structure, planting on black plastic, or using row covers.

Tomatoes are very sensitive to fertilizer applications, especially N fertilizers. High levels of fertility dramatically delay fruit set and ripening. If your goal is early maturing fruit, maintain low levels of soil fertility. If a long season of production is desired (not possible in the short-season areas of Idaho), maintain higher levels of soil fertility.

Pruning tomato plants can enhance earliness and increase fruit size. Allow plants to grow unhindered until the first flush of fruits is set and increasing in size. At that time, begin removing all newly formed shoots from the plants.

Soil Type and Soil Preparation

Tomatoes can be grown in most types of soil, but do best in lighter, sandy loams and loamy sands. Not only will plants be healthier on lighter soils, but fruits will mature more quickly. Clay soils must be managed to avoid frequent saturation in order to prevent root, stem, and fruit rots.

Tomatoes do best in soil with sufficient organic matter. If soil is low in organic matter, amend it with compost or manure (the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps tomato plants develop a healthy root system.

Planting

Tomatoes are almost always transplanted rather than planted as seed. Transplanting enhances earliness, reduces problems with seedling diseases, and helps with weed control. Fortunately, tomatoes are very easy to transplant.

Unlike many other crops, tomatoes can be transplanted as very large plants. The larger the transplant, the quicker the plant will produce and mature fruit. Regardless of size, tomato transplants should be healthy, dark green, and growing vigorously. If transplants are tall or spindly, plant them deeply enough to leave only the leafy part of the stem exposed. Roots will form along the buried segment of stem.

Tomato transplants are damaged or killed by very light frost. Consequently, if planted early, they must be protected. A variety of season-extending products (hot caps, water sleeves, milk jugs, row covers, etc.) is available. If protection is provided, tomatoes can be transplanted shortly after the average last frost date. Otherwise, delay transplanting by about 2 weeks.

To grow unusual or heirloom varieties, you may need to produce your own transplants. Plant seed indoors 5–7 weeks before the projected transplant date. The most difficult aspect of producing transplants without a greenhouse is providing adequate light to keep the seedlings healthy and compact. It is best to provide both a window with southern exposure and artificial lighting.

Transplanting specifications:

- Final spacing (determinate): 18 inches
- Final spacing (indeterminate): 30 inches
- Row width (determinate): 36 inches
- Row width (indeterminate): 36–48 inches

Fertilizer

Tomatoes have a reputation as heavy users of nutrients. In climates with long, warm seasons, this is true. In short-season climates, the tendency for delayed maturity under conditions of high fertility makes it necessary to limit the amount of added fertilizer (specifically N).

Tomatoes respond positively to adequate levels of P and K. A 5-10-10 fertilizer formulation (or similar product with low N ratio) is usually best. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. In short-season climates, this application will be sufficient to bring the crop to harvest; additional fertilizer will serve only to delay maturity. In longer-season climates, enhance late-season production by side-dressing an additional 0.2 lb N at first harvest. A third application of 0.1 lb N in early August may be beneficial in places where production continues into September or later. N is the most important nutrient for the side-dress fertilizer applications, so a product made up primarily of N (21-0-0 or 46-0-0) is appropriate.

Weed Control

Early season weed control is important for tomatoes. Once established, plants compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots.

Irrigation

Young tomato plants have a relatively shallow root system and little tolerance of drought stress. Improper irrigation not only reduces productivity, it encourages the development of a fruit-destroying condition known as **blossom-end rot** (a black, leathery patch on the bottom of the fruit). Early in the season, optimal irrigation entails relatively frequent, small applications of water. On clay or loam soils, apply 1–1.5 inches of water every 3–5 days. On sandy soils, apply smaller amounts, but more frequently. As plants mature, irrigation can become less frequent, although the soil should remain evenly damp.

Insects

Only a few insects routinely affect tomatoes. The most damaging is the tomato hornworm. This large caterpillar can defoliate an entire plant within a day or two. Luckily, hornworms do not appear in large numbers and can usually be removed by hand and destroyed. Colorado potato beetles may damage leaves; they can also be controlled by hand removal or application of an approved insecticide. Spider mites occasionally become a problem in hot weather. They are best controlled by irrigating with overhead sprinklers or frequently spraying the plants with water.

Diseases

Tomatoes are prone to a number of very serious diseases. Curly top is a virus that appears frequently in Idaho gardens. This virus causes the youngest leaves on the plant to curl and become malformed. It does not spread from one plant to another, so it can be ignored if not serious. If it affects productivity, remove diseased plants so they do not compete with healthy plants.

A soil fungal disease called verticillium wilt often causes plants to become weak, turn yellow, and develop burned leaf edges. This disease is very common in southern Idaho. Other than planting resistant cultivars (usually designated with a “V” following the name), the only treatment is to practice crop rotation.

A number of leaf-spotting and leaf-drop diseases affect tomatoes, including early blight, late blight, and septoria. Early blight and septoria leaf spots start on the oldest leaves and may move very slowly up the canopy. If symptoms become severe before midseason, it may be necessary to apply a labeled fungicide. Late blight, although somewhat rare, can rapidly kill plants under the right conditions (cool, cloudy, rainy). If present, multiple applications of a good fungicide are required. Because of the threat to potato crops, public media in Idaho deliver warnings when late blight is a local issue. This information will help guide control decisions. It may be necessary to get professional help to distinguish among the tomato leaf-spotting diseases.

Fruit rots often damage the crop as it nears harvest. These fungal and bacterial diseases are best controlled by avoiding overwatering and staking the plants to keep the fruit off the ground.

Harvest

Fruits can be harvested at any time after they begin to turn pink (assuming the cultivar's mature fruit is red). The best-quality fruits with the fullest flavor are those that ripen fully on the vine.

Storage

Store unripe fruit at 50°F–60°F in a relatively dry room. These conditions allow slow and steady maturation and color development. Fully ripe tomatoes can be stored for several days at 50°F with high humidity. They can be stored in the refrigerator for up to 2 weeks, but must be used immediately upon removal due to injury and degradation that occur at cold temperatures.

Consumptive Yield

The required quantity of planted tomatoes varies widely, depending on how they are used. If intended strictly for fresh use, one healthy tomato plant can supply the needs of several people. If used to produce sauces, salsas, and other products, several feet of row may be required for each person. Experience will help define needs.

Nutritive Value

Red tomatoes contain lycopene, which has been shown to protect skin from damage due to ultraviolet radiation. Tomato fruits are also a good source of vitamin A, vitamin C, vitamin B6, vitamin K, manganese, and K. One hundred grams (3.5 oz) of fresh tomatoes contain 0.9 gram of protein, 0.2 gram of fat, 3.9 grams of carbohydrates, 82 calories, and 1.2 grams of dietary fiber. Fresh tomatoes consist of 95% water.

Watermelons

Watermelons (*Citrullus lanatus*) are native to the savannah regions of Africa, where they were used as much for their water content as for their nutrition. They can be a challenge to grow in all but the warmest climates of southwestern Idaho. In short-season climates, they are the epitome of a green-thumb challenge. Regardless of where you live, they are a fitting treat in the heat of late summer.

Most watermelon cultivars are suitable for production in the south-central and southwestern regions of the state. In all other areas, it is important to select early maturing cultivars. Even then, many cultivars developed for earliness in other parts of the country (e.g., Sugar Baby and New Hampshire Midget) do not produce quality melons in Idaho because they are not adapted to cool summer nights. Some of the best melons for short-season areas of Idaho are the yellow-flesh icebox types (e.g., Early Moonbeam, Yellow Doll, and Yellow Baby).

Growing Suggestions

Watermelons are suitable only for fairly large gardens. They do not require as much room as pumpkins or winter squash, but each plant still needs at least 30–40 square feet to produce well. Fruit will not size well if plants must compete with tall or dense plants of other crops.

Watermelons require full sun all day long to produce their sweetest fruit. Shade not only results in inferior flavor, but delays maturity, making production in marginal climates even more difficult.

Watermelons are truly a warm-season crop. Not only are they extremely sensitive to frost, they are injured by temperatures as high as 35°F. It is critical to be patient in waiting for warm, late-spring weather before planting watermelons in the garden. Also, it helps to provide warm growing conditions by planting next to a south-facing structure, planting on black plastic, and/or using row covers.

Soil Type and Soil Preparation

Watermelons are best adapted to lighter soils—sandy loams and loamy sands. They grow faster, mature earlier, and produce the best-quality melons on these soils. However, they can be grown on any soil, as long as irrigation is managed to avoid frequent saturation. Watermelons do not require large amounts of organic matter in the soil.

Planting

Transplanting is an option in order to enhance earliness. However, due to physiological problems created by transplanting, watermelons often produce better if planted directly from seed, even in cold climates. Plant seed 2–3 weeks after the average last frost and then only if daytime soil temperatures are at least 70°F.

Transplanting can be successful if all conditions are correct. Most importantly, use transplants that are healthy and at the right stage of growth. Transplants must be small, rapidly growing, and dark green. A root-hardening response common to this family of plants slows or prevents new growth of less-than-ideal transplants. Transplants that are too old, etiolated, or slow-growing, or those that have been stressed at any time for water or nutrients, seldom produce a vigorous plant.

Place transplants in the garden 2–3 weeks after the last average frost and when the forecast is for mild weather. Once a healthy transplant has been placed in the garden, it must be protected from wind, sun, and cold, even if growing conditions are ideal.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 4–5 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.05
- Row width: 6–8 feet
- Seed depth: 1 inch
- Germination: 5–14 days

*Hill spacing for transplants is the same as for seed.

Fertilizer

Watermelons are heavy feeders and respond positively to adequate levels of N, P, and K. Split applications work best to keep watermelons growing vigorously throughout the season. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar nutrient ratios) is usually adequate.Side-dress an additional 0.3 lb N when the plants begin to form running vines. For side-dressing, select a high-N source such as 21-0-0 or 46-0-0.

Weed Control

Watermelons do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

As they grow, watermelons develop relatively deep, vigorous root systems. Plants will produce the best quality melons if not overirrigated. Irrigation should be deep and infrequent in comparison with most garden crops. Once plants are established and growing well, weekly applications of 2–2.5 inches of water are usually adequate. On very sandy soils, apply smaller amounts, but more frequently.

Insects

Cutworms are the most common pest of watermelons in Idaho gardens. They emerge from the soil at night and cut down newly emerged seedlings. Consistent problems with cutworms may require application of a labeled soil insecticide prior to soil preparation. Spider mites occasionally become problematic and are best controlled by using overhead sprinkler irrigation. Occasionally, application of a miticide may be necessary.

Diseases

Many diseases affect watermelons in humid climates, but the dry air in Idaho limits these problems. In gardens where watermelons, cucumbers, cantaloupes, and squash are frequently grown, a soilborne disease called fusarium wilt can build up. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Partial prevention is possible by practicing crop rotation with at least four-year intervals. Watermelons are also very susceptible to

root rots if they are overirrigated or planted in poorly drained soil.

A few viral diseases, such as curly top, occasionally appear on watermelons. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing or stunting. Remove and destroy plants showing these symptoms to prevent competition with healthy plants.

A physiological fruit rot (not caused by fungi or bacteria) called blossom-end rot occasionally appears on watermelons. It is typified by a black, leathery patch on the end of the fruit opposite the stem. It is caused by repeated drought stress. Proper irrigation usually alleviates this problem.

Harvest

It is important to pick watermelons when fully ripe because they will not finish ripening off the vine. Knowing when to pick a watermelon is an art unto itself and no one is successful all of the time. However, there are three fruit-related signs that will make the decision easier. First, as a melon ripens, the ground spot (the spot on the melon that is in contact with the soil) will turn from white to yellow. Second, a ripe melon will display a dried-up vine tendril. Follow the stem of the fruit to the vine. At the point of attachment, you will see a leaf and a tendril. The tendril is a "curly-cue" that the plant uses to grab and climb. This tendril will dry up when the fruit is ripe. Third, small wasps will sting a ripe watermelon, causing the development of small (usually less than 1 inch in diameter) rings or target spots on the top of the fruit. Additionally, if you are a good watermelon "thumper," the sound of a melon does deepen as the fruit ripens, providing a final test for ripeness.

Storage

Watermelons are usually not stored for any significant length of time. However, they can be held in a cool, unrefrigerated place for a week or more without losing quality. Once cut, the melon should be refrigerated and consumed within a few days.

Consumptive Yield

Compute household planting requirements as follows:

- 3–6 lb fresh watermelon per person
- Each foot of row will yield 0.5 lb

Plant 6–12 feet of row per person.

Nutritive Value

Fresh watermelon consists of 92% water. Due to this high water content, watermelons are relatively low in nutrients, but they are a good source of vitamin C and have trace amounts of many other vitamins and minerals. One hundred grams (3.5 oz) of fresh watermelon contain 0.6 gram of protein, 0.2 gram of fat, 7.6 grams of carbohydrates, 30 calories, and 0.4 gram of dietary fiber.

Further Reading and Resources

Source of nutritional information: USDA/ARS FoodData Central, **https://fdc.nal.usda.gov/**

Additional source of health benefits information: *Nutrition and You, Vegetable Nutrition Facts*. **http://www.nutrition-and-you.com/vegetable-nutrition.html**

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CHAPTER **TWENTY TWO**

FRUIT TREES

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Learning Objectives

- Learn the basics of site selection and preparation for planting fruit trees
- Learn about the different types of fruit and nut trees and their rootstocks
- Learn about the basic cultural practices of fruit trees and how to deal with the common problems associated with them

Introduction

Growing fruit can be an important part of home gardening, but it demands a year-round and year-to-year commitment by the gardener. In addition to the personal satisfaction and enjoyment of cultivating tree-ripened fruits, fruit trees considerably enhance landscape values. Properly cared for, they are attractive in form and display beautiful flowers in the spring. If judiciously placed, they enhance a well-designed landscape.

Site Selection

An ideal location for fruit trees:

WITHOUT FROST POCKETS

A gentle slope with good air drainage works well. Plant the trees three-quarters of the way down the hill. Cold air will drain down the hill and will help limit frost damage in the spring (Figure 1). Frost damage can occur any time from bloom to late spring.

Frost damage to blossoms is a likely problem, particularly with early blooming fruit trees (Table 1). For example, apricots may produce a crop only once every five years because of early spring frosts. Small fruit may fall off soon after a killing frost. Stone

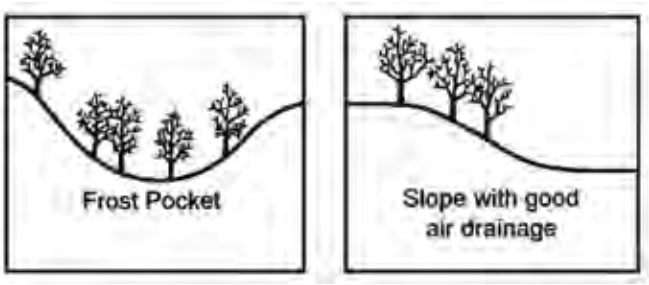

Figure 1. Frost damage is best prevented by proper site selection. Choose a gentle slope with good air drainage.

fruit, such as peaches, may stay on the tree until mid-to late June and then drop. Diagnose for frost damage by cutting open the small fruit. If the **ovules** (the portion that becomes the seed) are brown, the fruit is dead.

IN FULL SUN

Plant fruit trees well away from areas of shade such as large trees and buildings. Not only must the tree itself receive full sun, it must also be properly pruned so that light can penetrate to the inner leaves. This is necessary in order to maintain good flower production and fruit set throughout the tree.

IN WELL-DRAINED BUT NOT DROUGHTY SOIL

A site with deep, fertile, sandy loam soil increases the probability of successful tree growth and fruit production. A site with poor drainage increases the probability of winter injury to fruit trees. A drainage problem, such as a perched water table, can be lessened by breaking through the hardpan layer in the soil. Stone fruits, particularly peaches, do not tolerate "wet feet."

Fruit and Nut Cultivars for Idaho

Once the decision is made to start a home orchard, a lot of thought must go into cultivar selection. Cultivars must be adapted to the climate and soils of your specific area, must provide fruit at the desired time, and must be suited to uses such as freezing, canning, and preserving. Select cultivars that will extend the harvest season from July through October.

Since some cultivars are easier to grow than others, choose only the ones you, your family, and friends really appreciate so your horticultural efforts will be justified. In addition to local expertise, *Western Fruit, Berries and Nuts — How to Select, Grow and Enjoy* (Walheim and Stebbins 1981) is a good reference. Some cultivars can be ordered if you give your local nursery enough notice.

Table 1. Usual order of bloom in fruit trees.

Earliest	Apricots
	Japanese plums
	Peaches
	Oriental pears
	Italian plums
	Cherries
	Pears
Latest	Apples

MASTER GARDENER TIP

Fruit and nut trees are propagated either by grafting or budding to obtain true-to-name trees. A seedling fruit tree cannot produce the same kind or quality of fruit as its parent and it comes into production much later.

Types of Tree Fruits

The complexity of tree fruits can be simplified for study by grouping tree fruits into two categories: pome fruits and stone fruits. Both pome fruits — apples (*Malus*) and pears (*Pyrus*) — share many cultural similarities and pest problems. The stone fruits (*Prunus*) — apricots, cherries, nectarines, peaches, and plums — share cultural similarities.

POME FRUITS (APPLES AND PEARS)

Apples

Apple trees are among the most cold-tolerant fruit trees, but climate adaptability varies according to cultivar. In colder areas of Idaho, it is best to plant midseason cultivars that will escape spring frosts and ripen before extreme cold in the fall. The best vegetative growth and optimal fruit production are obtained in well-drained, deep soil.

Many apple cultivars require a second cultivar for cross-pollination by bees to ensure adequate crops. Crab apples can also cross-pollinate apple cultivars. Bloom times of the cultivars need to overlap to ensure pollination.

Choose cultivars to grow at home that are not readily available in your local grocery store, that you especially enjoy, and that are best for your purpose.

Less commonly grown cultivar suggestions:

King. Large, waxy yellow with red striping. Crisp and sweet. Good for eating and baking.

Northern Spy. Large, red apple with tender, fine-grained flesh. One of the finest for flavor. Stores well. The tree is slow to reach bearing age and tends to bear alternate years.

Spitzenberg. Medium, red with yellow dots. Crisp, fine-grained flesh with a tangy, spicy flavor.

Wealthy. Red-tinted white flesh and a deserved reputation for quality. Good cooking apple; satisfactory for fresh use. It is a particularly good tree for colder areas. Tends to bear alternate years. Good pollinizer for other apples.

Winesap. Large, round, and with a lively flavor, these apples make good desserts. An old-timer that remains a favorite. The trees are vigorous, and are early, reliable bearers.

Pears

Pears will tolerate poor drainage and neglect better than other fruit trees. For best vegetative growth and optimal fruit production, pears should be planted in a well-drained, deep soil and spaced about 16–18 feet apart.

The major problem with pears is fire blight, which primarily attacks young, vigorous wood. Treatment is to cut out and destroy the blackened diseased wood. Train and prune trees only to shape them, limiting cuts to smaller branches as much as possible. Excessive pruning can stimulate vigorous, susceptible growth. Heavy rain during bloom as well as hail-inflicted wounds will increase the chances of fire blight infections. To lessen the incidence of the disease, application of copper can be made during the delayed dormant stage. This will reduce the bacterial inoculum levels on the surface of the tree.

Avoid the use of nitrogen fertilizer unless trees show obvious signs of a deficiency. Excess nitrogen application promotes vigorous growth that will then be vulnerable to fire blight.

Cultivar suggestions include:

Bartlett. A standard commercial variety, matures toward the end of summer and has excellent fresh-eating as well as canning quality.

Bosc. A fine-flavored dessert variety ripening after Bartlett.

Clapps Favorite. Matures before Bartlett and is the earliest pear of good quality.

Seckel. A small gourmet pear with a russet skin; a pickling as well as a dessert pear.

STONE FRUITS

Apricots

Flower very early in spring; consequently, the occurrence of spring frost will affect fruit production. It may help to plant apricots on a northern exposure (but not in shade) to delay bloom, but a safer course of action is to choose later-blooming cultivars. Bloom and maturity dates vary, depending on area, cultural practices, tree age, and season.

Cherries

Do best in deep, well-drained soil. Space sweet cherries about 30 feet apart. The trees may not fill that much space, but the cherry fruits need sunlight to ripen.

Most sweet cherry cultivars need an aid in pollinating in order to produce fruit, so choose the second tree carefully. Black Tartarian, Corum, Republican, Sam, and Van will pollinate any other cherry tree. Stella, Compact Stella, and Garden Bing are self-fertilizing and require no second tree for pollination. Bing, Lambert, and Royal Ann will not produce fruit in any combination.

The most dependable cherries for colder areas of Idaho are the sour type that are self-fertilizing. Montmorency is the most popular cultivar for the home garden as well as being a leader in commercial sour cherry production. Sour cherry trees may be planted 20 feet apart.

Peaches and Nectarines

Differ in their tolerance of cold or mild winters. Be sure to select cultivars that are adapted to your climate.

Generally, there is a risk of damage where winter temperatures fall below -10°F to -15°F. Trees planted on a hillside where the coldest air drains to low-lying

areas or trees planted near large bodies of water may tolerate areas otherwise too cold for them.

Reliance and Polly (Haven Polly) are considered some of the hardiest peach cultivars. Nectarines are more tender than peaches.

Peaches and nectarines are generally self-fruitful (self-pollinating).

Plums and Prunes

The most popular cultivars are derived from either European or Japanese species. These cultivars can grow 15–20 feet high and about as wide. European varieties bloom late and are better adapted to areas with late frost or cool, rainy spring weather than are the early blooming Japanese varieties. Many plum and prune cultivars need another cultivar growing nearby for pollination.

The European-type plum, called the Italian prune, is a high yielder, requires no thinning, hangs on the tree, and ripens to a taste treat that more than justifies its place in the home garden.

NUTS

Filberts or Hazelnuts

These make an attractive, small tree for the garden. Spring to fall, the roundish, ruffled-edged leaves cast a pleasant spot of shade. Showy male catkins hang long and full on bare branches in winter. Female flowers are small and red in color. A crop of round or oblong nuts comes as a bonus in the fall. Plant trees in early spring in well-drained soil and plant at least two compatible cultivars for cross-pollination.

Filberts tend to sucker. If you wish to maintain a single trunk, remove these shoots three to four times a year. Filberts can also be grown as a bush.

The Persian (English) Walnut

Should not be planted as a landscape tree except on a large lot with deep soil. Established trees take some drought, but deep, regular watering is required. Older trees need pruning only to remove dead wood. Plant walnut trees 40–60 feet apart. Walnut flowers are susceptible to spring frosts.

Almonds

Will survive in southwestern Idaho, but they don't produce annual crops because they bloom early in the spring and are usually killed by frost.

Rootstock

Fruit trees consist of two parts: a scion and a rootstock. The scion or fruiting cultivar is the most aboveground part of the tree. It is grafted or budded onto a rootstock to form a new tree (Figure 2). The tree is the same cultivar as the scion and produces fruit of that cultivar. A wide range of rootstock, varying in size as well as other attributes, is available for apples. However, rootstock selections for other tree fruit are more limited.

Dwarfing rootstock is preferred since it produces a more compact fruit tree. It bears fruit earlier in its life, is easier to prune and spray, and is easier to harvest.

APPLES

Apple tree growth may be manipulated to three basic sizes: standard, semidwarf, and dwarf.

1. The standard (seedling) rootstock is adaptable to most conditions. It has an extensive root system and should be planted about 20 feet apart.
2. The semidwarf rootstock (MM-111, MM-106, and EM-7) makes a tree one-half to two-thirds the size of a standard tree.

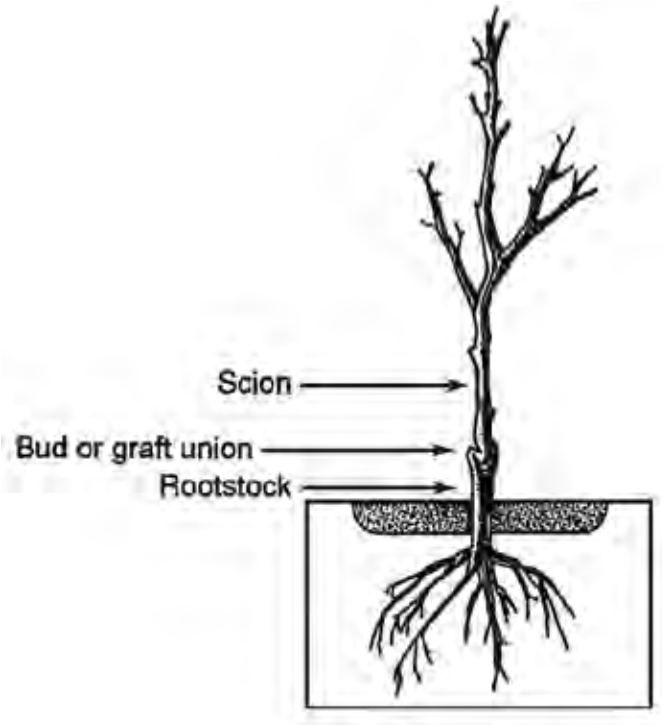

Figure 2. Parts of a fruit tree.

3. The dwarf rootstock (M-26 and EM-9) makes a tree one-third to one-half the size of a standard tree. The more dwarfing the apple rootstock, the more support the tree requires. When the tree is bearing a crop, dwarfing rootstock (M-9 and M-26) needs a stake to hold the tree up in the wind. In general, the more dwarfing the rootstock, the faster the tree bears. It is important to allow sufficient vegetative growth to fill the space before allowing the crop to slow vegetative growth.

PEARS

Pear cultivars are available on semidwarf or seedling rootstock. The seedling rootstock is hardier than other rootstock, making larger but more manageable trees.

STONE FRUITS

Nectarines, peaches, and apricots are grown on seedling rootstock and form fruit on 1-year-old wood. It is easy to keep them the desired size by pruning and still have fruit production on seedling stock. Cherry trees produce large canopies. There is no such thing as a true dwarf cherry. Semidwarf trees on *mahaleb* rootstock reduce tree size a maximum of only 10%. Work is being done to develop a rootstock that will reduce size, but the end results are a few years away.

Cultural Practices and Problems

PLANTING

Fruit trees may be planted in the fall or spring. Bare-root trees are usually available only in the spring. Planting early in the season before the roots dry out ensures the best success. With containerized trees, the time of planting is less critical. Follow these steps to plant a fruit tree:

1. Dig a planting pit with vertical sides and make it large enough to accommodate the root system without crowding. The pit should be a minimum of 2–3 feet deep and should allow at least a 6-inch clearance from the end of the roots.
2. After removing all broken or damaged roots, place the tree in the planting pit. Spread the planting soil around the tree and tamp to firm. Use planting soil that is as good or better than the soil in which the tree originally grew. Avoid using planting soil around the tree that is so different from the native soil that water and roots either do not penetrate the native soil or that water runs around the planting soil in the pit and into the native soil.
3. Pour water into the planting pit until the consistency of thick liquid is attained. Gently raise and lower the tree to allow the soil to fill between the fibrous roots and to eliminate air pockets. Add water and planting soil alternately until the pit is filled to grade.
4. The tree should rest at the depth at which it grew in the nursery and the bud union (the place where the tree was budded in the nursery) should be about 6 inches above the soil level after planting. A collar at the base of the tree, lighter in color than the rest of the trunk, indicates the original growing depth.

TRAINING AND PRUNING

Both can influence **apical dominance**, the tendency for the apex (uppermost bud) to grow more rapidly than the lower buds.

Apical dominance is thought to be caused by a hormonal stimulus produced by the growing apex that suppresses the development of lateral bud growth. Cuts on higher or lower parts of the tree will have differing results in vegetative growth depending on the distance from the apex.

Training

This is the process of giving desirable structure to fruit trees from 1–4 years after planting. The objective of training young trees is to establish the essential structure of the tree and to bring the tree into bearing.

Pruning

This is used to maintain the shape of trees 3 or 4 years after planting as well as after trees are bearing fruit. The objective of pruning older trees is either to open the trees to sunlight or to maintain fruiting by pruning back the overhanging limbs in the upper part of the tree, so that sunlight reaches the lower and inner portions of the tree.

There are two types of pruning cuts:

Heading-back cut. This is an invigorating cut that causes an increase in vegetative growth in the immediate area of the cut. Because the hormonal gradient is destroyed, the growth of the lateral buds is no longer suppressed.

Thinning-out cut. This type of cut removes shoots but does not stimulate vigorous regrowth. Because the hormonal gradient is not interrupted, vegetative growth continues. A thinning-out cut can also be used on upright and overhanging growth. This type of cut will result in an increased flower-bud production over the whole tree.

MASTER GARDENER TIP

Excessive pruning, especially heading-back cuts, will delay fruiting in the early years and reduce fruiting on older trees.

Seasons of Pruning

Trees can be pruned any time after the leaves fall in autumn and before bud break in the spring. Avoid making large saw cuts (over 3 inches in diameter) until hazardous winter temperatures are over. If you have only a few trees, resist the temptation to prune your trees on the first non-subzero day that seems warm enough to be doing something outside. Some commercial peach growers wait until bloom time to see what blossoms exist before they prune.

Winter (dormant) pruning. The dormant period is the most desirable time to prune out broken, damaged, diseased, and weak wood; to remove limbs crossing over other limbs; or to eliminate narrow angled crotches. (Wide-angled branch crotches of 45°F–90°F are the strongest.)

Summer pruning. Trees can be pruned any time during the growing season. Pruning during this period decreases the shoot growth and, therefore, is a common practice where better control of shoot growth is desired. Rub off or pull off water sprouts and suckers that shade the inner parts of the tree, fruits, and spurs. This should be done when shoots are 3–4 inches long and before they become woody. Shoot removal by pulling at this stage damages adventitious buds at the base of the shoot, which limits regrowth.

MASTER GARDENER TIP

Pruning after the first of September or before trees become dormant stimulates growth, making the trees more susceptible to winter injury during early fall freezes.

Pruning Tips

- Don't leave stubs! Cut close to the trunk at the branch collar. Cut back to a live branch or bud.
- Don't paint wounds. Paint traps moisture and encourages rot. Slant cuts so rain runs off.
- Remember, the art of pruning comes from knowing how and where to cut.

WATER MANAGEMENT (IRRIGATION)

The amount of soil moisture (e.g., not too much and not too little) is important to maintain tree vigor, productivity, and fruit size.

Drought or moisture stress alone rarely kills healthy, well-established fruit trees. However, newly set trees with limited root systems or plants damaged by cold injury, diseases, or insects are more susceptible to moisture stress. Occasionally, a prolonged drought results in extensive feeder-root death, which destroys large trees. This is most severe in sandy soils with poor moisture-holding capacity.

Good soil drainage is important, especially in the spring. During the summer and early fall, the trees deplete the available soil moisture. Irrigation is usually required! Poor drainage is common in soils with a high clay content and dense, impervious subsoil or in lowlands with a high water table.

Although fruit trees have deep root systems, most of the roots are concentrated in the upper 2 feet of soil and extend outward slightly beyond the spread of the limbs.

MASTER GARDENER TIP

High soil-moisture levels or frequent watering around the base of the trunk, particularly in heavy soils, can result in the development of **crown rot**, a fungal disease that attacks the roots and kills the tree. Overwatering by itself can also kill roots. Because oxygen is only partially soluble in water and becomes depleted under waterlogged conditions, the roots are asphyxiated. Root or crown damage from excess moisture turns inner-bark tissue brown. Often, damage is not apparent for several months, especially if the excess moisture occurs in late fall or early spring. Crown rot causes earlier leaf-color change in the fall.

Oftentimes trees in lawns and under grass sod are irrigated to maintain a good grass cover, but insufficient water is applied to the root zone of the tree. Tree roots do not compete well with grass roots. To remedy this problem, clean out all grass growing under the dripline of any fruit tree.

MASTER GARDENER TIP

Prunus species, including cherries, peaches, and nectarines, are most susceptible to death of feeder roots in poorly drained soils. Pears, apples, plums, and most small fruits are more tolerant of temporary excess soil moisture, but they can be severely injured or weakened by extended periods of very wet soil conditions.

FERTILIZATION

Nutritional deficiencies are not a direct cause of tree death unless excessive or improper fertilizing results in tree damage. Normally, it is not advisable to fertilize at planting. Young tree roots are easily burned and the tree may die back or die completely.

After growth has begun, however, use a complete fertilizer having essential nitrogen (N), phosphorus (P), and potassium (K) or (N-P-K) with 10% N (such as 10-6-4 or 10-10-10), particularly in the sandy soils.

The amount of N to apply in late fall or early spring (preferably before bud break) depends upon the type of tree fruit and its productive status (Table 2). Much less than these recommended growth rates will result in reduced fruiting wood and a smaller crop the following year.

Table 2. Recommended annual terminal growth of fruit trees.

Nonbearing trees	
Apple	24–36 inches
Pear	12–26 inches
Peach and other stone fruits	16–24 inches
Bearing trees	
Apple	12–14 inches
Pear	6–12 inches
Peach and other stone fruits	10–15 inches

If you are just starting a fertilizer program, ⅛ pound of actual N should be soil-applied to stone fruits for every inch of trunk diameter (measured 1 foot above ground level). In the case of pome fruits (apples and pears), ⅒ pound of actual N should be used for each inch of trunk diameter.

The actual amount of N differs among products and this difference must be taken into account when computing the amount of fertilizer needed. For example, a 5-inch diameter peach tree will need ⅝ pound of actual nitrogen (AN):

diameter × pounds AN required =
5 × ⅛ = ⅝ lb (.625 lb) AN needed

If ammonium sulfate 20-0-0 (20% N) is used, 3⅛ pound of fertilizer will be required to provide the N needed for a 5-inch peach tree:

$$\frac{\text{lb AN needed}}{\%\text{N}} = \frac{⅝\text{ lb}}{20\%} = \frac{0.625}{0.20} = 3.125\text{ lb}$$

In the case of ammonium nitrate at 33% N (33-0-0), a little over 1⅞ pounds of ammonium nitrate is needed for the same 5-inch diameter peach tree:

$$\frac{\text{lb AN needed}}{\%\text{N}} = \frac{⅝\text{ lb}}{33\%} = \frac{0.625}{0.33} = 1.89\text{ lb}$$

The amount of N to be applied is determined by the amount of growth in the previous year. If too little growth has occurred, increase the N application. If too much growth occurred, reduce the N application. Knowing how much N to apply requires accurate record keeping.

Where organic mulches are used, the amount of N fertilizer may be decreased as the mulch begins to decay, releasing N. Fertilizing with manure is tricky because N and salt levels vary depending on the age and source of the manure.

Other nutrients need to be applied according to the results of a leaf analysis. Zinc, iron, and boron are micronutrients that are often deficient.

INSECT AND DISEASE CONTROL

Success in growing fruit depends on effective control of insects and diseases, recognition of the common diseases and insects, selection of effective pesticides, proper timing of pesticide sprays, and thorough coverage of fruit and foliage with the spray mixture.

Organic control measures are available for some pests but, in general, their results are mixed.

Commercial fruit growers, because of the size of their operations, can afford to buy large equipment to effectively apply pesticides.

Home orchardists with a few fruit trees are at a disadvantage when it comes to obtaining equipment that will do a satisfactory job of spraying fruit trees. In most cases, they are restricted largely by the cost of hand-operated sprayers or those operated by small electric or gasoline motors. The capacity of these machines is small, the pressure is low, and the energy expended to do an effective job is considerable. Yet the homeowner fights the same pests, often on the same size trees, as the commercial grower.

It has been shown repeatedly that the failure of homeowners to adequately control pests on their fruit trees can generally be attributed to not knowing what is causing the damage or what could cause the damage, not applying enough material to cover the trees completely, not making applications on time, and not continuing the spray program late enough into the summer.

MASTER GARDENER TIP

Dormant sprays are an important step in controlling insects and diseases. However, there are different dormant sprays; some control only diseases, while others control only insects. Consult the *Pacific Northwest Insect Management Handbook* and the *Pacific Northwest Plant Disease Management Handbook* for specific recommendations.

RODENT AND DEER DAMAGE

Fruit trees are susceptible to mouse, gopher, and deer damage.

Mice

Eat the bark of the trunk and roots near the soil surface. Damage is easily detected by removing soil from around the base of the tree and the larger roots near the surface. Bark completely removed by gnawing rodents will girdle, weaken, and finally kill the tree. As with other types of mechanical injury, plants weakened but not killed by rodents are more susceptible to drought, cold injury, disease infections, and insect infestations.

To reduce the hazard of mouse damage, clean out all grass and weeds in a 3–4-foot diameter circle around the trunk of the tree. This rids the area of ground cover that might protect mice from predators. Wire guards, constructed from fine wire mesh and placed 1 inch deep in the soil, are effective around young trees.

Gophers

Are best controlled in the home garden by trapping. Poisoned baits are available for mouse and gopher control.

Deer

May damage fruit trees planted near woods or other areas with adequate deer cover. Deer feeding on young growing shoots and buds of fruit trees can severely stunt and weaken the plants. In the late summer and fall, buck deer often break and kill young trees while rubbing the velvet from their antlers. Tall fences or repeated use of approved repellents may be required for adequate deer damage control.

Moles

Moles can sometimes present problems by burrowing directly under trees. In this case, roots dry out and tunnels are used by mice who feed on the roots. Moles do not feed on tree roots.

VEGETATIVE MANAGEMENT DUE TO WEED AND HERBICIDE INJURY

Weeds weaken fruit trees by competing for soil moisture and nutrients. The wise combination of cultivation and approved herbicides helps reduce weed competition.

Improper or excessive herbicide use frequently causes fruit tree death. Contact action herbicides, when misused and allowed to drift onto foliage or tender green bark, can severely injure and ultimately kill a plant. Similarly, systemically absorbed herbicides for weeds can be lethal to fruit plants when improperly sprayed.

Long-term use of the same soil-residual herbicide may eventually result in excessive soil accumulation, causing root injury, plant weakening, or death.

Do not plant fruit trees on sites immediately after corn or grain crops where a persistent herbicide, such as atrazine, was used for weed control. Fallow the soil for one or two growing seasons before planting fruit trees. This allows herbicide degradation and prevents tree injury or death.

Herbicides are safe, effective tools for reducing weeds in fruit crop planting. To prevent herbicide damage or plant death, pay careful attention to label guidelines for application, apply the correct rates, and use only herbicides approved for specific fruit crops.

PREVENTING WINTER INJURY

Normally, vegetative growth stops about early August and a terminal bud is set. Unusually warm fall temperatures and excessive amounts of N may cause continued or renewed growth in the fall. These conditions may predispose trees to cold injury; keep trees in moderately vigorous condition before winter arrives.

Lethal winter injury occurs most frequently in the lower trunk, in the crown region, or in the roots near the soil surface. The tree generally dies shortly after growth begins in the spring if the damage has been severe enough to destroy the inner bark tissue.

Damaged inner bark is brown, while healthy bark and cambium tissue are a greenish yellow. Severe cold injury may result in split bark; however, the splits may later heal.

Sunscald, another type of injury, normally occurs in late winter on the south to southwest side of the main trunk and large branches. Bark, whether brown or gray, absorbs the sun's rays in midafternoon and often warms up as much as 20°F above the surrounding air temperature. As a result, bright sunny days in late winter may activate the cambium and bark tissues on southwestern trunk exposures. This reduces cold resistance and may result in injury because of extremely cold night temperatures. The bark dries, then splits, and finally wood-rotting fungi enter. This may seriously weaken or even kill the tree. The problem is most severe for young trees and smooth-bark trees such as cherry and plum.

To protect a tree from sunscald, wrap the trunk with strips of burlap or a tree wrap material; or paint the trunk with a white indoor latex paint, which lowers bark temperature by reflecting light.

CROPPING PROBLEMS

Biennial bearing (crop overproduction in one year and a need to rest the next year) confuses many home orchardists. This condition will alternate until the tree finally produces fruit only every other year. To correct or reduce this problem, annual thinning done when the fruit is still small allows the tree to handle the crop and to produce higher-quality fruit. Thinning is done by hand when the fruit is about ½ inch in diameter. After thinning, the fruit should be spaced approximately 6 inches between fruits. Do not delay thinning. The later the thinning occurs, the smaller the fruit. Additional cropping problems, their possible causes, and prevention strategies are found in Table 3.

Table 3. Why fruit trees don't bear.

Symptoms	Possible Causes	Prevention Strategy
Trees 4–8 years old have never set fruit buds or bloomed	Trees growing too vegetatively; pruning, especially heading cuts	Spread or tie down branches; reduce N; reduce dormant
Few fruit buds form	Trees under stress (shade, "wet feet," drought, lack of nutrients)	Choose sunny, well-drained site; fertilize and irrigate properly
(same as above)	Trees too vegetative pruning; increase summer pruning	Reduce N; reduce dormant
Fruit buds form only at tips	Fruit buds killed by low temperatures during bud swell	Choose site with good air drainage
Tree blooms, but all flower parts fall off when petals fall, so few or no fruit sets	Frost killed open blossoms	Choose site with good air drainage; choose late-blooming or frost-resistant cultivars
(same as above)	Flowers were not adequately cross-pollinated	When choosing cultivars, be sure to include pollenizers; during spring bloom, place flowering branches of another cultivar in buckets of water in the tree
Tree bears only every other year (e.g., biennial bearing)	Heavy crop one year weakens tree, so few fruit buds form on next year's crop	Thin fruit 4–6 weeks after year; bloom when crop is heavy

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PNW 496 *Propagation of Plants by Grafting and Budding*

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CHAPTER **TWENTY THREE**

SMALL FRUITS

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23 SMALL FRUITS

Learning Objectives

- Learn about the most common small fruits in Idaho
- Learn how to prepare, plant, and maintain small fruits
- Learn about the common problems associated with small fruits

Strawberries

Strawberries are grown all over the United States and perform well throughout the Pacific Northwest.

BOTANY

The strawberry is a member of the rose family (Rosaceae). The fruit is the swollen receptacle of the flower that bears seeds (achenes) on its surface. A high percentage of these seeds must be fertile for the berry to form properly. Plants produce for 3–5 years before production declines and then they should be replaced.

Strawberry varieties, except for everbearing, are affected by day length. Varieties are regionally adapted by latitude. Buy plants locally if possible and base your purchases on regional recommendations.

The two main types of strawberries are June-bearing and everbearing. June-bearing varieties set flower buds in the fall and ripen fruit in June. Everbearing varieties have a spring and fall crop.

The older cultivars of everbearers are day-length sensitive and have a break in production between the spring and fall crops.

The newer day-neutral varieties set the flower buds throughout the season for a very long harvest period with no production break.

Total-season berry production from the everbearing cultivars tends to be lower than the June-bearing and day-neutral types. The June-bearing types produce the highest-quality berries.

CULTIVARS IN IDAHO (IN ORDER OF RIPENING)

Cultivars are June-bearing in Northern Idaho

Be sure to select cultivars that are adapted to northern growing conditions. For southern Idaho, select cultivars that are also adapted to high summer temperatures.

- **Earliglow**: Earliglow bears early in the season and is resistant to many diseases.
- **Crimson King**: The plants of this variety are very hardy and produce large fruit.
- **Honeoye**: Another very hardy variety with large, firm fruit.
- **Sumas**: Sumas have a high yield, but they are susceptible to fruit rot. They grow large fruit.
- **Totem**: These fruits are good fresh and frozen. Totems are disease resistant.
- **Benton**: This variety grows a medium-sized fruit with a light inside color.
- **Shuksan**: Shuksans are susceptible to virus. The fruit is excellent fresh and frozen.
- **Sparkle**: This variety produces a soft fruit with an excellent flavor.

Everbearing — Day Neutral

- **Fort Laramie**: An everbearing plant, the Fort Laramie is very hardy and productive.
- **Quinault**: Another everbearing plant, the Quinault produces small berries, which are soft and have a good flavor.
- **Tristar**: The Tristar is day neutral and productive; it bears relatively large fruit with a good flavor.
- **Tribute**: A variety that is superior to Quinault, day neutral, and later in the season than Tristar, the Tribute has a firm fruit.

CULTURE

Planting

Well-drained soil is required. Heavier soils should be molded to raised beds for improved drainage. Strawberry pyramids and containers work well and give good yields in small spaces. Incorporation of organic matter benefits both light (sandy) and heavy clay soils. Adjust pH to 5.5–6.5.

Established weeds. Gardeners must eradicate all perennial weeds before planting. Use repeated fallow cultivation or heavy mulches.

Matted row culture. Most popular in home gardens. Set plants 1½–2 feet apart in rows 3–4 feet apart. Runners from initial planting are allowed to fill in to form a solid planting, until they reach approximately one plant every 5–8 inches. Remove excess plants or runners. Plants at a higher density will produce fewer and lower-quality berries.

Hill culture. Plants remain as individual plants in the garden; remove all runners. Space individual plants 15–18 inches apart and place them in rows 2½–3 feet apart.

Setting Plants

Plant in early spring or early fall. In areas where frost heaving is a problem, plant only in spring or mulch fall plantings to reduce heaving. If you plant at any time other than early spring, irrigation is important. Plants are mostly available in stores in the spring.

Use certified virus-, disease-, and insect-free stock when establishing a new planting to ensure that pests are not introduced into the garden with planting stock.

Fertilization

Timing

It is important to fertilize and water June bearers in late summer to promote maximum fall growth and flower bud formation.

Spring fertilization results in excessive formation of leaves and runners and in less fruit growth.

Fertilize everbearers and day neutrals with small amounts several times during the growing season.

Amount

Apply a total of 30–60 pounds of actual nitrogen per acre for all types of strawberries.

June-bearing types should be fertilized in early August, if irrigation is available; otherwise, fertilize in mid-September without irrigation.

A balanced fertilizer such as 10-10-10 will supply ample phosphorus and potassium. Any deficiencies should be diagnosed with a soil or plant tissue test.

Irrigation

Consistent watering is essential when plants are first set and during dry periods in spring and summer. Irrigate in the morning to reduce rot.

Critical irrigation periods. These occur during harvest or in late August and fall, when plant growth resumes and the flower buds form for the following year's crop.

Efficient irrigation methods. Black plastic or straw mulch and plastic-tube drip irrigation systems (soakers) are highly adaptable to strawberry culture and water conservation. Strawberries absorb 90% of their water from the top foot of soil.

Renewal (June Bearers Only)

After the harvest early in July, June bearers will benefit from removal of the foliage, which will allow you to rid the plants of disease-infested foliage and will act as a stimulant to the plant for new, vigorous foliage.

Cut the foliage with a lawn mower set high or use hand tools. Be careful not to damage the crowns.

Rake leaves from the plot.

Cold Protection

Winter protection. In colder areas, strawberries will benefit from a mulch. Coarse hay or straw may be placed over the entire planting when the ground begins to freeze. The mulch should be removed from the plants in the spring. Weed-free mulch materials should be used.

Spring frosts. These often kill the early flowers. Sprinkle plants with water during the coldest frosts (when temperature at ground level reaches 34°F). Leave the water running until the temperature is above 32°F or cover plants with a light mulch or a floating row protective fabric.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

Verticillium Wilt

Symptoms: A soilborne fungi, verticillium wilt causes wilting and death of older leaves in individual plants or groups of plants. Black lesions develop on petioles. New roots may be short with blackened tips. Plants may outgrow these symptoms.

Control: Avoid planting strawberries in ground where potatoes, tomatoes, strawberries, or other susceptible crops have been planted. Eliminate infected plants and do not replant in spots. Rotate crops.

Red Stele: Soilborne Fungi

Symptoms: Often there are no symptoms the year of planting. During the first year of fruiting, there may be dwarfing, reddening of leaves, and wilting of older leaves. Root tips may decay, causing "rat-tailed" appearance. The central core or vascular system of root (stele), may be clogged by fungi and show a red discoloration of the stele. Symptoms are most readily apparent early in the season. They may be difficult to see later in the season. Not all the roots of an infected plant will show symptoms.

Control: Use certified plants. Plant in disease-free soil. The soil needs to have good drainage. Earliglow, Sparkle, Tribute, Tristar, and Totem are resistant to this disease.

Viral Diseases

Symptoms: Viral diseases can cause stunting, an unevenness in the field or planting, as well as some foliar symptoms, such as streaking, cupping, and yellowing.

Control: Use certified planting stock. Control the aphid infestation, as aphids are the primary vector of disease.

Fruit Rot/Botrytis

Symptoms: Botrytis is evident in a gray, fuzzy mold on fruit during moist weather. Infections start at bloom. Fruit from the infected blossom rots as it ripens.

Control: Ensure good air circulation, remove infected fruit, and clean straw mulch so that fruit rests on clean, dry surface. Use fungicide during wet springs. Apply fungicide at 10% bloom. Repeat according to label directions.

Common Leaf Spot

Symptoms: Leaf spot causes foliage with dark red or purple spots that gradually become gray white with age. Fully developed spots are 1/8 inch in diameter and have a whitish center with red margin. Infection occurs during moist weather and is most severe during spring and fall. Crimson King is resistant.

Control: Fruit rot fungicide sprays will keep this disease under control. Removing foliage from June bearers after harvest reduces inoculum.

Powdery Mildew

Symptoms: Disease causes upward curling of leaflet edges. Leaf undersides become reddened and coated with a grayish-white fungus. Leaves later

turn purplish red. Totem and Benton strains are very tolerant. Shuksan has moderate susceptibility. Fort Laramie is very susceptible.

Control: Destroy old infected leaves.

Insects

Root Weevils

Damage: Larvae feed on root systems. Adults notch edges of leaves.

Control: Don't use chemical control in the home garden. Collect adults at night on leaves and destroy.

Aphids

Damage: Can spread viruses.

Control: Hose off and use insecticidal soap sprays.

Spider Mites

Damage: There is a stippled appearance to top part of leaves, which leads to bleaching. Webbing and mites will be found on the undersides of leaves.

Control: See aphid control.

Spittle Bugs (small, yellow-green insects similar to the leaf hopper in appearance)

Damage: Nymphs develop "spittle" on plants.

Control: Since this pest is not a major one, there is no need to control.

Slugs (mostly nocturnal; many sizes feed on foliage and fruit)

Damage: Slugs cause leaf damage, often in the leaf center.

Control: Manually remove or use slug bait around the perimeter of the garden. Bury containers of beer with the lip of the container at soil level to attract and drown slugs.

Check containers often.

Red Raspberries

Red raspberries are grown as a commercial crop in the Pacific Northwest. More than 10,000 acres are planted in Washington, Oregon, and British Columbia. Raspberries can be expected to do well in most Idaho locations, although severe freeze injury to canes will occur in many winters in southeastern Idaho.

BOTANY

Raspberries are members of the Rose family (Rosaceae) and belong to the genus *Rubus*, as do blackberries and other caneberries. The plants are perennial, with roots that live 40 years or more. Red raspberries have stiff erect canes, which are usually covered with thorns. Canes are produced freely from adventitious buds on the roots and they generally live two seasons.

Fruit is borne on lateral fruit spurs produced on 1-year-old canes. Fruiting canes die after harvest; meanwhile, new canes (primocanes) have been growing from the root system to be next year's fruiting wood.

The raspberry is an aggregate composed of 75–125 drupelets that separate from the receptacle when ripe, producing a hollow "berry."

Optimum production for red raspberries is in areas with relatively cool summers, a rain-free harvest season, and a mild winter with sufficient cold to satisfy chilling requirements. However, care in cultivar selection will sustain fruit in areas lacking in one or more of these conditions. Raspberries are one of the hardiest of cane fruits. Some cultivars tolerate temperatures to -20°F without damage.

Red raspberries come in two types: Summer bearing and fall bearing.

1. Summer-bearing raspberry canes are biennial, growing one year and producing the next.
2. The fall-bearing raspberry produces canes that bear on the upper part of the primocanes in the same growing season. These canes, if left the second year, will bear fruit on the lower portions.

Alternatively, the canes can be totally removed by mowing to the ground after the fall crop is harvested. When managed in this way, fall-bearing raspberries will bear only the single crop in the fall.

In Idaho locations with short growing seasons, fall-bearing raspberries may not ripen their crop. Trial plantings of these cultivars are recommended to ascertain their ripening characteristics.

CULTIVARS IN IDAHO

Summer Bearing

- **Boyne**: Hardy in cold conditions, Boynes are good fresh and frozen. This variety is productive.
- **Canby**: Canbys produce a thornless plant. They are virus resistant and aphid immune, but sensitive to root rot. This variety is very productive and it is cold hardy through Zone 4.

- **Haida**: Though this variety is hardy and has large, sweet, firm berries, it has short canes and is low in vigor.
- **Latham**: A popular variety, Lathams are hardy and have a nice flavor.
- **Newburgh**: Newburghs are cold hardy, as well as resistant to root rot and mosaic virus.
- **Nootka**: This variety is a firm, flavorful, vigorous plant.
- **Nordic**: Nordics are cold hardy, productive, and resistant to fungal diseases and aphid feeding.
- **Skeena**: A large, bright fruit, the Skeena is hardy and root rot susceptible.
- **Taylor**: A long conic fruit, the Taylor has an excellent flavor and is productive.
- **Titan**: The Titan produces a hardy, large fruit with a mild flavor. It is very productive and root-rot susceptible.

Fall Bearing

- **Amity**: This variety harvests about a week earlier than Heritage. It has a good size, flavor, and firmness.
- **Autumn Bliss**: An early crop variety, Autumn Bliss creates berries that have a large size and good flavor.
- **Heritage**: The Heritage ripens late in fall and produces heavy yields.

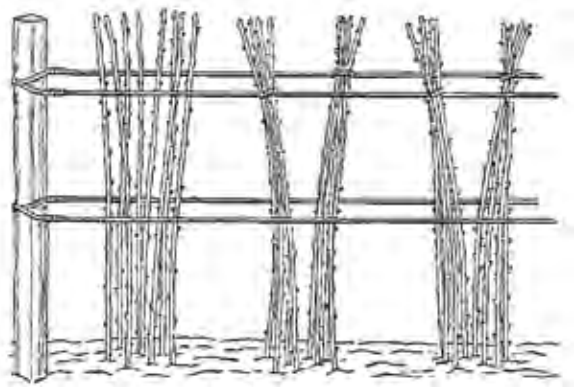


Figure 1. Mature raspberry canes after spring pruning and tying to four-wire trellis.

- **Redwing**: A soft fruit, resistant to high temperatures, this strain ripens earlier than Heritage.
- **Ruby**: Ruby bears a productive, large fruit, which can produce when planted with Amity.
- **Summit**: While this plant has a better flavor than Heritage and is root-rot resistant, it produces a small fruit.

CULTURE

Planting

Plant in raised mounds or beds in heavier soil to improve drainage away from the crown of the plant.

Use certified stock, plants, or root cuttings.

Spacing is generally 1½–3 feet apart in rows 6–8 feet apart. You must ensure a recommended 4-foot minimum depth to the winter water table to create optimum conditions for high fertility and freedom from erosion.

Soil: Good drainage, high water-holding capacity, and adequate depth are essential. Plants are highly susceptible to root rot. Heavy, poorly drained soil severely limits life expectancy of plants. Irrigation is required on sandy or gravelly soils.

Established Weeds

Gardeners must eradicate all perennial weeds before planting. Use fallow cultivation or heavy mulch.

Training

Place top wires at 4½–5½ feet to support canes. You may also have another wire at 2–3 feet. Use one-, two-, or four-wire systems. Plants will be shorter in some climates (Figure 1).

Hill Culture

Maintain plants as individual hills (weeding is easier) or allow to fill in as a solid row. Light distribution is better when each individual cane is spaced along the wire separately. Canes are bundled commercially for labor savings. Tie canes to top wire in fall or winter as in Figure 1. Tie in clumps or individually along the wire.

Pruning

Top dormant canes 6–10 inches above the wire in early spring to stimulate lateral branching. Canes are subject to dieback in a cold winter if they are pruned in the fall.

Remove all fruiting canes after harvest, as that reduces insect and disease problems, helps in

the hardening-off process, and simplifies weed control. Remove weak new canes or those with a small diameter.

Cut off canes close to the soil line. Leave all canes that are over 6 feet and the diameter of your index finger (about 12 healthy canes per hill or in solid rows spaced 4–5 inches between canes). Keep rows no more than about 12 inches wide.

Fertilization

Test the soil to determine plant needs. Broadcast-apply in spring over rows or split application with one-half applied at first growth in the spring and the remaining one-half at the beginning of or at fruit set. Apply a total of about 30 pounds actual nitrogen per acre.

Weed Control

Hand hoe weeds between hills. Cultivate very shallowly.

Remove suckers between rows as they emerge.

Cover crops between rows are effective.

Herbicides can be used to control weeds. Make sure they are registered for use in raspberries.

Irrigation

Watering frequency will vary with conditions. As a general rule, irrigate every 2–3 weeks before and after harvest; then supplement with a weekly irrigation during harvest.

Cold Protection

Winter protection. Good snow cover or mulch will protect crowns. In severe areas or with less hardy cultivars pin canes to the ground and mulch over them.

Spring frosts. See Strawberries.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

Phytophthora root rots. A fungus disease caused by *Phytophthora erythroseptica*.

Symptoms: The disease kills the fine feeder roots, while the interior of any larger roots becomes brown. Suckering is reduced. New primocanes wilt and leaves die.

Floricane leaves turn bright yellow and brown and then die out. Favored by wet, heavy soils.

Control: Use certified plants free of disease. Plant on well-drained soils. Increase drainage by using raised beds.

Virus Diseases

Symptoms: Viruses create stunting or delayed growth in the spring; crumbly berries; ring spotting; and a bright yellow mosaic on the leaves.

Control: Plant certified stock; remove infected plants.

Crown Gall: Bacterial Disease

Symptoms: Dark "knobs or tumors" of growth appear at or below soil line. Crown gall spreads primarily by pruning, when it enters new wounds on pruning shears. It also can come in on infected planting stock.

Control: Remove plants.

Fruit Rot/Botrytis

(see Strawberries)

Spur blight. A common fungal disease (*Didymella applanta*) in damper areas, spur blight causes little damage in this area. Buds on infected canes are more susceptible to winter injury.

Symptoms: Spur blight creates wedge-shaped necrotic lesions on leaves, especially near base of cane. Infected leaves drop, leaving petiole attached to cane. Brown or reddish-brown lesions appear around buds at base of petiole; these lesions are usually limited to one or two buds. Minute black fruiting bodies appear on lesion by fall.

Control: Avoid overhead watering if possible. Remove and destroy infected canes. Thin canes appropriately to allow for air movement. Avoid excessive nitrogen fertilizer.

Verticillium Wilt

(see Strawberries)

Anthracnose

(see Trailing Berries [Blackberries])

Yellow rust. Caused by a fungus, particularly following late spring rains.

Symptoms: Plants develop leaves with yellow spotting and later become dusty from the yellow spores. Lower leaves yellow and drop and the crop is reduced. The fruit dies before maturing. In the winter, infected leaves produce black spores at sites of infection.

Control: Good sanitation. Remove sources of infection; cut old fruiting canes immediately after harvest and destroy.

Insects

Crown Borer

Damage: These insects bore tunnels in lower portions of the canes, which cause the death of the cane.

Control: Dig out infected plants by hand. Replant any new plantings in a different area.

Spider Mites

Damage: Their feeding reduces plant vigor and causes leaves to brown and drop prematurely. When pesticide use kills natural predators, the mites are often a problem.

Cane Borer

Damage: These insects bore tunnels in the upper portions of the cane (causing a bent-over appearance in the cane tips called shepherd's crook).

Control: Prune out any affected cane and destroy. Use no chemical control.

Yellow Jackets

Damage: Yellow jackets hide in ripe fruit and feed on sugars. They are a hazard to those working in the plants.

Control: Keep overripe fruit harvested. Yellow jacket traps can be effective.

Other

Crumbly Berry

Damage: Crumbly berries may reveal a plant with a boron deficiency. Soil testing is recommended. A virus disease may interfere with flower functions, causing crumbly fruit. Poor pollination occurring from lack of bees or from poor weather during flowering also causes crumbly fruits.

Control: Add boron, if necessary; add bees to the field; and replace plants with virus-free stock.

Sunburn/High Temperatures

Damage: The fruit forms, but it doesn't ripen, or it ripens slowly. This problem is caused by excess ultraviolet rays or elevated temperatures.

Control: Shade the plants, especially during high-noon hours. Use shade cloth or plant in the shade of other foliage or structures.

Black and Purple Raspberries

BOTANY

Purple raspberries are hybrids of red and black. The fruits resemble the red more than the black. Both have canes that will root at the tips and are propagated by tip layers.

Black raspberries are less cold hardy than red or purple types. Freeze injury will begin at temperatures around -5°F.

They are susceptible to virus diseases and anthracnose.

Except for Royalty, the following cultivars sucker poorly, so hill culture rather than hedgerow is recommended.

CULTIVARS IN IDAHO

Black Raspberries

- **Allen:** An early fruit with a concentrated ripening, this strain is hardy.
- **Black Hawk:** A late variety, Black Hawk produces large, flavorful berries. A productive variety, it is very hardy, to Zone 5 (-20°F to -10°F).
- **Lowden:** The Lowden is a cross between a purple and a black raspberry with an excellent flavor. The plant has good disease resistance and is hardy.
- **Munger:** The fruit of the Munger has an excellent flavor. Mungers ripen in midseason and are also hardy.

Purple Raspberries

- **Brandywine**: A variety that produces large fruit with a tart flavor, the Brandywine is very winter hardy to Zone 4 (-30°F to -20°F).
- **Royalty**: Royalty produces large fruit, which is sweet when fully ripe. It is a very productive variety and hardy to Zone 4 (-30°F to -20°F). This variety ripens late.

CULTURE

(see Red Raspberries)

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

(see Red Raspberries)

Trailing Berries (Blackberries)

Trailing berries are in the same genus as raspberries (*Rubus*). Their fruit is similar to raspberries, but a white core or receptacle remains part of the fruit when picked.

BOTANY

Blackberries are the least hardy of the berries grown in Idaho. These plants can be injured by temperatures between 5°F and -10°F. Boysenberries, loganberries, tayberries, nectarberries, and marionberries are all trailing berries.

CULTIVARS IN IDAHO

- **Cherokee**: The plant has an upright, thorny, strong vigorous growth; it is hardy to Zone 5 (-20°F to -10°F).
- **Chester**: This variety has a semierect plant that is productive and hardy to Zone 5 (-20°F to -10°F). In fact, the Chester is the most hardy of the thornless type. It produces large fruit late in the season.
- **Darrow**: A tall, semierect, variety, the Darrow is the most cold-hardy cultivated blackberry.
- **Hull:** Another semierect variety, the Hull produces large fruit. The plant is thornless and its growth vigorous.
- **Roseborough**: An upright plant, the Roseborough holds up under extreme heat and dryness. It produces heavy crops and is hardy to Zone 5 (-20°F to -10°F).

CULTURE

The planting, fertilization, and soil requirements are similar to those for red raspberries.

Trellising Systems

Long canes of trailing and semierect varieties are generally "woven" on a two-wire trellis system as in Figure 2. Wires are 18 inches apart with the top wire 5 feet from ground level. Upright cultivars will not require trellising or at most a single wire at 5 feet.

Pruning

Remove fruiting canes after harvest. Weave new canes around top wire in fall or spring.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases (see Red Raspberries)

Leaf and cane spot (Septoria leaf spot): Fungal Disease

Symptoms: Leaf spots vary from light to dark brown. They begin as an 1/8-inch purple spot later turning brown. Cane spots are larger and may contain fruiting bodies (spores). Spots girdle and kill cane. The disease is promoted by canes overwintering on or near ground.

Control: Remove fruiting canes after harvest. Provide good air circulation.

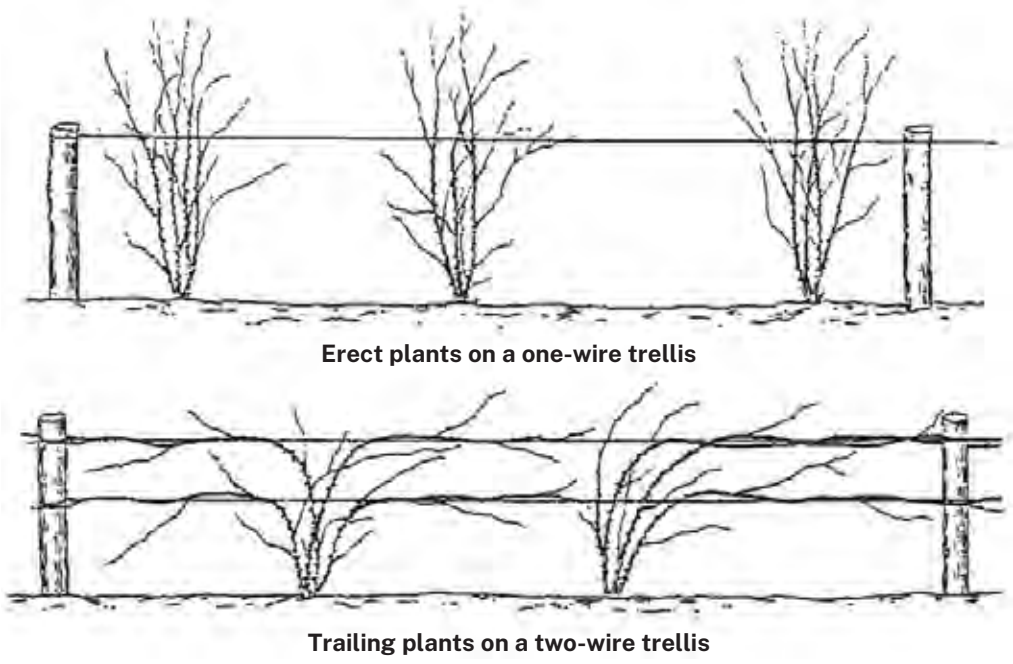


Figure 2. Trellises for blackberries.

Anthracnose. Overwinters on infected canes.

Symptoms: Purple spots appear on canes, then increase in size, and develop light gray centers with brown-purple edges. Spots converge to form large irregular lesions. Canes may dry and crack. On leaves purple spots enlarge to form gray to white areas that drop out. Berries ripen prematurely and are small and dry.

Control: Remove canes after harvest. Leave no old stubs. Thin to allow air circulation.

Insects (see Red Raspberries)

Blueberries

Blueberries, members of the Ericaceae or heath family, prefer a culture similar to rhododendrons or azaleas. Wild blueberries are often called "huckleberries," but are just different species of the cultivated blueberry.

BOTANY

Blueberry production in Idaho will be limited to those sites with acidic soil (pH of 4.5–5.5).

In areas with alkaline soil, grow blueberries in raised beds or large containers with peat. The addition of ground sulfur, 1 pound per 100 square feet in sandy soil, and 2 pounds per 100 square feet in clay soil will lower the pH approximately one point.

Blueberry plants are attractive and can serve as ornamentals and fruit producers because they tolerate partial shading better than other berry crops.

Blueberries are self-fertile but have higher yields with cross-pollination. The plants are hardy.

CULTIVARS IN IDAHO (LISTED IN ORDER OF RIPENING DATES)

- **Earliblue**: This short plant variety flowers very early.
- **Patriot**: The Patriot is a very hardy plant with large, firm fruit.
- **Northland**: A hardy, spreading plant, the Northland has a good flavor.
- **Bluecrop:** A fruit with an excellent sweet flavor, this variety has a vigorous plant.
- **Blueray:** Large, firm fruit.
- **Jersey**: Fair flavor; late, vigorous plant.

CULTURE

Established Weeds

Eradicate all perennial weeds before planting. Use fallow cultivation or mulches.

Planting

Setting: Blueberries are set out as dormant plants in late winter or potted plants in spring or fall.

Soil: The root system is shallow, fibrous, and prefers soil with high organic matter and good water-holding capacity. Add organic matter to soil when planting; mix well with soil in and around planting hole. Mulch to protect the shallow root system from temperature extremes and drying.

Pruning

Prune hard after planting to stimulate new growth. For mature plants, remove older canes to ground or to strong lateral, retaining 1–3-year-old wood.

Fertilization

The amount of fertilizer used depends on the rate of previous growth. Apply light amounts three times in the growing season for optimal growth. Ammonium sulfate is a good nitrogen source to help acidify soil.

Irrigation

Keep soil evenly moist. Plants need adequate drainage. Drip irrigation systems work well. Mulch up to 6 inches deep to conserve water.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

Mummy berry. Fungus disease (*Monilinia vaccinii-corymbosi*).

Symptoms: Infected berries are reddish-buff or tan "mummies." They fall to the ground, gray, shriveled, and hard to overwinter. In spring, as blueberry buds break, fruiting cups grow from mummies on the soil and release infecting spores. Blossoms become infected and turn brown and wither. New vegetative shoot is blackened in the center and wilts and dies. The remaining fruit becomes infected.

Control: Remove and destroy all infected parts including fruit. Mulch thickly to bury any dropped mummies. In early spring destroy developing fruiting cups by cultivation. Apply fungicide during bloom according to label instructions.

Botrytis
Symptoms: Twig dieback in wet weather that invades blossoms and moves down shoots.

Control: Apply fungicide early in spring when growth begins. Repeat, but do not make more than four applications before harvest. Follow label instructions. Prune out and destroy dead twigs.

Insects

Aphids
Damage: Deform leaves, devitalize plants, secrete honeydew.

Control: Light infestations may be controlled by natural insect predators; use insecticidal soap.

Cherry Fruitworm
Damage: Larvae approximately 3/8 inch in size boring into the berries.

Control: Use insecticidal sprays before bloom or after, according to label directions, for cherry fruitworm on blueberries.

Leaf Rollers
Damage: Create webs and feed on foliage and fruit.

Control: *Bacillus thuringiensis* (B.t.) at any time.

Scale
Damage: Weakens plant.

Control: Prune off infested areas as soon as observed.

Birds: Can be a persistent problem. Net plants as the fruit colors. Secure the perimeter of the net carefully. Use mylar strips or balloons to scare away birds.

Hardy Kiwi

BOTANY

The botanical name of the hardy kiwi fruit, also known as Siberian gooseberry, is *Actinidia arguta*. It is a member of the Actinidiaceae family (not related to the common garden gooseberries). Kiwi fruit is native to eastern Asia. Chinese gooseberry (*A. chinensis*) is not hardy anywhere in Idaho, as fruit buds are damaged by temperatures of 10°F–15°F.

The fruit is fuzzy and brown skinned, approximately the size of a large cherry. The flesh is green with edible black seeds and has a unique "fruity" flavor. Fruit is high in vitamin C and stores well.

Kiwi is dioecious (Latin for two houses), which means there are separate male and female plants. One male will pollinate six to eight female plants within 50 feet. Bloom periods between male and female must match. Some varieties are self-fertile.

CULTIVARS IN IDAHO

- **Seedlings:** Many varieties are just listed as *A. arguta*, available in male or female plants.
- **Ananasnaja:** A variety with a fuzzless skin, the Ananasnaja is very sweet and spicy. The Russian name means "pineapple-like."
- **Issai:** Self-fertile, the Issai has fruit with sweet flesh, often used as a fruit-producing pollinator. This variety is very productive.
- **Meader:** A good pollinator for Ananasnaja, the Meader produces sweet fruit and ripens in late August.

CULTURE

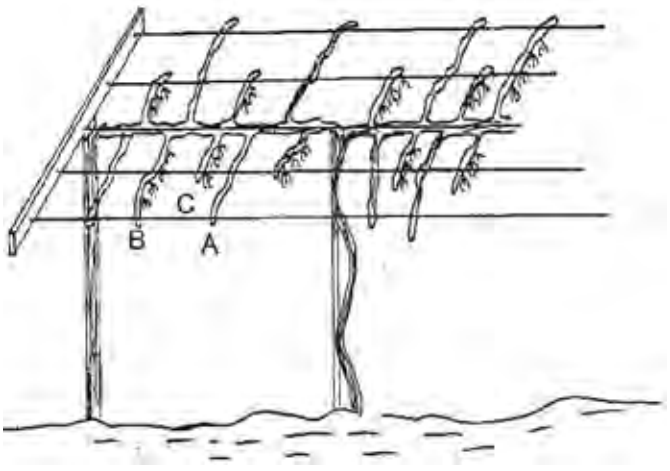
Site

Hardiness. Dormant vines are hardy to -25°F to -30°F and sensitive to late spring frosts. Avoid frost pockets.

Soil. Kiwi need well-drained soil, even soil moisture, and a sunny location free from wind to protect fruit and laterals from damage and drying.

Training and Trellising

The vines are large and heavy so the kiwi needs a strong trellis system as in Figure 3. The kiwi is a perennial with a lifespan of 50–60 years. Pressure-treated posts should be 5–6 feet tall with another 3 feet belowground. Use high tensile 12 or 10 gauge



A = 1-year wood B = 2-year wood C = 3-year wood

Figure 3. Kiwi on trellis.

wire. A T-bar trellis with three to five horizontal wires is recommended. Space the plants 10–15 feet apart in row and 10–15 feet between rows.

Pruning

Summer Pruning. A must for kiwis. Avoid shading of fruiting wood. Prune new growth several times to 6–8 inches during the growing period.

Winter Pruning. Prune during the dormant period. Start by developing well defined leaders or cordons which will be permanent. Set up an evenly spaced system of fruiting arms or laterals.

- Remove fruiting wood that is losing vigor. Start with one-third removal each year.
- Remove fruiting lateral after third year.
- Shorten 1-year wood to two to four buds. Allow second-year wood to fruit freely

Fertilization

Young plants. Add balanced fertilizer split into two applications.

Mature plants. Apply one-half to two-thirds of the balanced fertilizer at bud break; then apply the rest after the fruit is set.

Harvesting

Plants take 3–4 years to bear; they reach full production in 7–8 years. Pick the fruit in late August to November when it is firm-ripe (for best storage ability). Keep refrigerated.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

None.

Insects

None.

Black Currants

BOTANY

The black currant, or *Ribes nigrum*, is a native of central and eastern Europe.

The native plant grows in damp, woodsy places. A fully grown bush may reach 5–6 feet in height and spread, and have an average yield of 10–12 pounds per plant.

There are many cultivars, mostly of European origin. Most are extremely hardy. Black currants are partially self-fruitful, but set a larger drop with another cultivar nearby. Plant nonblister rust-resistant cultivars at least 1,000 feet and preferably ¾ mile from the nearest five-needle pine.

CULTIVARS IN IDAHO

- **Black September:** This variety produces a large, firm fruit with a strong black currant flavor that is hardy to -30°F. The plant is mildew resistant.
- **Consort:** The fruit of the Consort has a sweet, musky flavor, while the plant is self-fruitful, resistant to white-pine blister rust, and hardy to -30°F.
- **Crusader:** The Crusader needs a pollinator; it is rust resistant.
- **Jostaberry:** This variety is a cross between a black currant and a gooseberry. It produces large fruit that is good fresh. The vigorous plant is resistant to mildew and white-pine blister rust and is cold hardy.

CULTURE

Soil

The currant will grow on a wide variety of soils. The ideal pH is 6.5 with good water-holding capacity. Currants will tolerate poorly drained soils. Add organic matter to light soils.

Site

Plants bloom early so avoid frost pockets. Though the currant prefers a sunny location, it will tolerate partial shade. Control all perennial weeds before planting.

Planting

Plant in late winter or early spring. Space the plants 5 feet apart in rows, with 6 feet between rows. Plants grow by stooling; plant 2 inches deeper than in nursery. Cut all shoots to 2-inch stubs at planting. Plants root easily; use prunings as cuttings.

Pruning

Prune annually, as black currants bear best on 1-year wood. Remove all 3-year-old wood annually, as well as any older growth. Cut to strong young shoot, or near base, or off completely. Keep five or six canes each of 1- and 2-year-old wood.

Irrigation and Fertilization

The currant likes even soil moisture. It will require frequent irrigation in arid parts of the state. Currants

are fairly heavy feeders, so apply balanced fertilizer in March and more nitrogen in April.

Weed Control

These plants are shallow rooted, so avoid deep cultivation. Sawdust mulch 4 inches thick is effective in controlling weeds.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

(see Gooseberries)

Red and White Currants

BOTANY

Red currants, or *Ribes rubrum* and *Ribes spicatum*, are native to Europe. A full-grown bush may be 5–6 feet in height and spread. The fruit is smooth skinned and glistening. Red currants are used for jelly, pies, juice, and wine.

The white currant is a sport of the red currant and the culture is the same.

The plants are self-pollinating; the average yield of the mature plant is 8–10 pounds of fruit per plant.

CULTIVARS IN IDAHO

Red Currants

- **Cherry:** This variety has a high fruit quality, is hardy in Zone 3 (-40°F to -30°F), and is productive.
- **Minnesota 71:** A vigorous plant, the Minnesota 71 produces large fruit of good quality.
- **Red Lake:** The Red Lake is productive with a long growing season. It produces early fruit. The dark red berries are widely grown.

White Currants

- **White Imperial:** An old, but vigorous variety, the White Imperial produces very sweet medium to large fruit.
- **White Pearl:** The White Pearl has a pale yellow skin and large fruit.

CULTURE

Soil

Both white and red currants are less tolerant of poorly drained soils than black currants. Ideal pH is 6.5. The plants need good water holding capacity; add organic matter to light soils.

Site

These plants bloom early, so avoid frost pockets. The flowers are hardier than black currants; you'll find them useful for north-facing walls. If you want full flavor in the fruit, then these plants require a sunny location. Control all perennial weeds before planting.

Planting

Plant in late winter or early spring. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at the same depth as in nursery.

Pruning

Your objective is to create a goblet-shaped bush with 8–10 main branches. Prune leaders to outward-facing buds. Prune drooping branches to upward-facing buds. Fruit buds produced in clusters at base of 1-year wood or on short spurs on old wood. Maintain about three canes each of 1-, 2-, and 3-year-old wood.

Irrigation and Fertilization

These currants like even soil moisture. Use mulch on light soils. The plants are fairly heavy feeders, so apply balanced fertilizer in March at bud break.

Weed Control

As the plants are shallow rooted, avoid deep cultivation.

Harvesting

Pick as soon as the berries are clear in color. Pick whole clusters to avoid injury to delicate fruit.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

(see Gooseberries)

Gooseberries

BOTANY

Botanically, gooseberries are known as *Ribes uva-crispa*.

They are self-pollinating and are a deciduous, thorny shrub.

The mature plant has a height and spread of 5 feet and produces 5–6 pounds of fruit. It bears fruit-like red currant at the base of 1-year wood and on spurs of older wood.

Gooseberries are more tolerant of hot weather than currants.

CULTIVARS IN IDAHO

- **Captivator:** This variety is winter hardy and disease resistant. It produces a large 1-inch fruit that is pink to red when it is ripe and has an average flavor.
- **Pixwell:** A hardy, thornless plant, the Pixwell produces fruit with sweet, pink flesh.
- **Poorman:** A vigorous productive variety, the Poorman has a highly flavored, wine-red fruit. The plants are hardy.
- **Welcome:** Welcomes are extremely productive plants with medium to large, light-green fruits that have a sweet-tart flavor.

CULTURE

Soil

The top 18 inches of soil needs to be well drained. An ideal pH is 6.5. Gooseberries need good water-holding capacity; add organic matter to light soils.

Site

Avoid frost pockets, as the plants bloom early and blossoms can be damaged by spring frost. Gooseberries are tolerant of partial shade, though they do best in sunny site. Control all perennial weeds before planting; the thorny plant is hard to weed around.

Planting

Plant in late winter or early spring. Gooseberries are one of the first berry plants to leaf out. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at same depth as nursery.

Pruning

See Red Currants.

Irrigation and Fertilization

The gooseberry likes even soil moisture. Uneven or heavy watering may cause fruit to split as it ripens. Use mulch on light soils. The plants are fairly heavy feeders so apply balanced fertilizer in March at bud break.

Weed Control

As the plants are shallow rooted, avoid deep cultivation.

Harvesting

Protect the plants from birds with netting. Pick as soon as the berries are good size, but while they are still green (June or July). For dessert fruit, thin every other one. Use thinnings for cooking.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

Anthracnose or leaf fungal disease. Overwinters on dead leaves.

Symptoms: The disease creates small leaf and fruit spots. By midseason there is a yellowing and dropping of leaves.

Control: Remove and destroy affected leaves. Prune to open center to allow air circulation.

Powdery mildew. A fungal disease that overwinters on twigs.

Symptoms: The mildew can be seen as a white, powdery growth on the surface of leaves, green shoots, and fruits. Infected plants are stunted.

Control: Prune to maintain an open plant with good air circulation.

White pine blister rust (fungal disease). It is no longer illegal to cultivate *Ribes* in Idaho. (Too many wild *Ribes* combined with rust-resistant pine cultivars). Alternate the host to five-needle pines. Black currant is most susceptible.

Symptoms: Small cuplike spots appear on the underside of leaves and produce orange yellow spores.

Control: Remove and destroy infected plants. Do not plant *Ribes* near five-needle pines.

Insects

Currant fruit fly (gooseberry maggot)

Damage: The larvae enter the soil in late June. They overwinter as pupae in brown cases the size of wheat grains. Flies emerge in April and lay eggs on the developing berries of either currants or gooseberries.

Control: Use shallow cultivation under bushes during July and August, as this method helps expose and kill pupae.

Currant aphid

Damage: A small, yellow aphid appears on new growth in the spring. The aphid overwinters as eggs on bark. It causes cupping and red color on new leaves. Honeydew accumulates.

Control: Use water washes or insecticidal soap.

Currant borer
Damage: The adults are clear winged with blue-black coloring and yellow markings. The larvae tunnel in the canes. Canes wilt in summer and autumn.

Control: Prune out and destroy infected canes.

Imported currantworm
Damage: The larvae are ½-inch long, greenish in color, while the immature have dark spots. They feed along leaf margin and may defoliate the plant when they become numerous. Sawfly adults are black with yellow markings.

Control: Use insecticide according to label recommendations for currantworm on gooseberries.

Two-spotted spider mite
Damage: Adults are ⅕-inch long, tan or greenish in color with two spots on each side of the back. They overwinter as adults on weeds and debris near host plant. Feeding reduces plant vigor and causes stippling on leaves. Webbing, when severe, may cause leaf drop.

Control: Insecticidal soap.

Elderberries

BOTANY

Elderberries belong to the genus *Sambucus* and grow wild over much of the United States and Canada. The blue or black varieties are edible. The fruit, born in flat clusters, makes excellent jelly, jams, pies, and wine. Most elderberries require cross-pollination and all are hardy to Zone 4 (-30°F to -20°F).

CULTIVARS IN IDAHO

- **Adams:** A strong plant with huge clusters, this variety produces sweet fruit.
- **Johns:** This variety bears later than the Adams and produces best when it has been cross-pollinated. It also has huge clusters of large, sweet fruit.
- **Nova:** Pollinate the Nova with the York. The plant produces large, sweet fruit.
- **York**: This hardy, late plant produces the juicy, sweet fruit that is the largest fruit of any elderberry. Pollinate the York with the Nova.

CULTURE

Soil

The elderberry grows on about any soil type, but prefers moist, well-drained, silt-loam soils, neutral to slightly acidic.

Irrigation and Fertilization

The plants need to stay evenly moist. Fertilize lightly, as the root system is shallow.

Weed Control

Elderberries can be grown in sod. Mulch with 4–6 inches of sawdust to control weeds and conserve moisture.

Propagation

Plants are spread by stolons. Propagate with hardwood, greenwood, or root cuttings.

Pruning

This vigorous plant requires pruning to control size and maintain productivity. Cut a few main shoots to the ground each year. Prune out all wood more than 4 years old.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

None.

Insects

None.

Grapes

BOTANY

Grapes account for one-fourth of all fruit production in the world. They are used for wine and juice, preserves, and are eaten as raisins or table fruit.

Grape production in Idaho is limited by cold winter temperatures and, in many locations, short growing seasons.

All grapes in the genus *Vitis* have vines that are generally vigorous and deep rooted. Grape varieties are self-pollinated. Fruit is borne on current season's growth.

CULTIVARS IN IDAHO

Types of Grapes

- **European (*Vitis vinifera*).** European varieties produce a tight-skinned wine, raisin, or table grape. Quality wine types are made from them. Most viniferas require a mild winter such as those in California or Arizona (hardy only to about 10°F). Thompson seedless falls in this group and will not be hardy in Idaho.
- **American (*Vitis labrusca*).** American varieties have a slip skin and a musty or "foxy" flavor. The

Concord is a typical example. Some are quite winter hardy.

- **French and American hybrids.** These are crosses intended to combine the quality of European grapes with the hardiness and disease resistance of American grapes.

Cultivars

- **Betas.** This plant is a productive American blue-black variety with a tangy, wild grape flavor. It is good for jelly and juice and is hardy to -40°F.
- **Black Monukkas.** While this grape is one of the hardiest of the European plants, it still requires winter protection in many parts of Idaho. The fruit is large, reddish black, and mostly seedless. It is sweet and good fresh.
- **Campbell's Early (Island Belle).** A Concord type with early fruit, this variety is good for juice.
- **Concord.** An American, blue-black plant with a vigorous, hardy vine, this variety is cold-resistant to -15°F. The fruit has a distinctive flavor.
- **Fredonia (Early Concord).** Another American variety similar to the Concord, though it bears fruit earlier, this plant is hardy to -40°F.
- **Himrod.** An American variety with a golden yellow, seedless fruit, this grape makes a good table grape. The Himrod is hardy to -15°F.
- **Interlakan Seedless.** A sister of Himrod, the plant is similar, but more productive. It is hardy to -15°F, vigorous, and disease resistant.
- **Reliance.** The Reliance produces a fine quality, seedless grape that is pinkish red in color and has an excellent sweet, fruity flavor. This variety is disease-resistant and hardy to -34°F.
- **Van Buren.** An American Concord, this sweet table grape is hardy to -20°F.
- **Worden.** Another American Concord, except larger and darker, this variety is good for juice and jelly and good served fresh. Worden is disease resistant and hardy to -50°F.

CULTURE

Planting

Plants. Many plants are produced from dormant cuttings. Some cultivars are budded or grafted onto disease, insect, and nematode resistant rootstocks. Rootstocks can modify vigor (increase or decrease) and provide tolerance to a wide range of soil conditions.

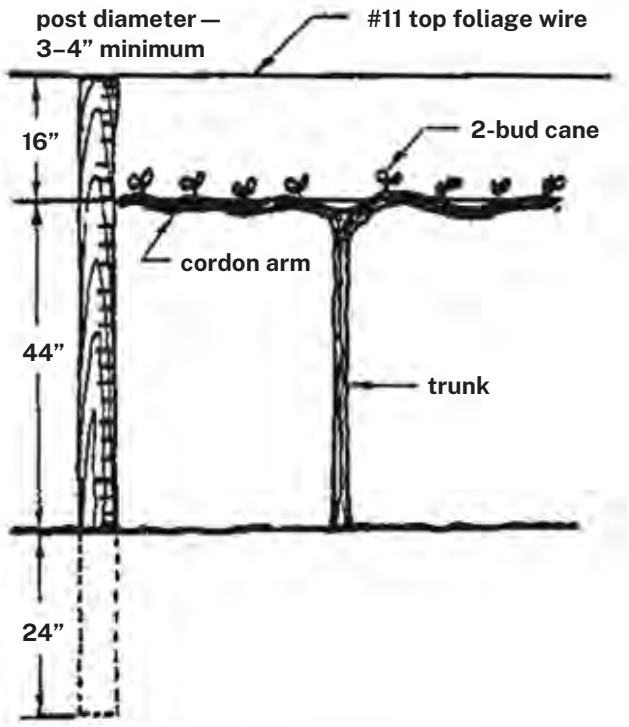


Figure 4. Bilateral cordon training on vertical trellis.

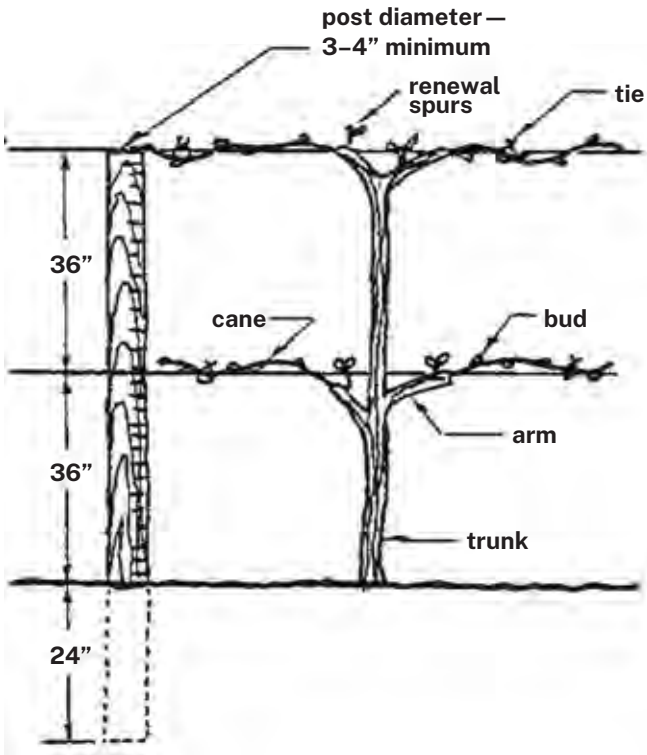


Figure 5. Two-wire vertical trellis Kniffin trained.

Soil. Grapes require a deep, well-drained soil for their extensive root system. Highest yields are on sandy loams. Grapes worldwide are planted on an extreme range of soil types.

Rootstock may be necessary to tolerate some soils.

Spacing. Depends on the vigor of cultivar, soil, and training system used: 8 feet for American grapes and 6 feet on poor soils (sandy or gravelly) and 9 feet plus for vigorous European grapes.

Orientation. Maximize sunlight; plant on a south-facing slope; place rows north to south.

Irrigation

Required for most sites in Idaho.

Fertilization

General. Nitrogen fertilizers are detrimental to a fruit set. Most vines have overvigor problems. Only very old or stressed vines may require a nitrogen boost.

Potassium and phosphorus. Needs are low. See "Common Plant Problems: Diagnosis and Control."

Micronutrient. Boron deficiencies are common. See "Common Plant Problems — Diagnosis and Control" for more information.

Training and Pruning

Types

Cordon or spur pruned (Figure 4): Permanent canes or cordons are trained on a wire 40–45 inches from ground. Spurs are established along a cordon which bear fruiting canes each year. A second wire, placed at a height of 5 feet, is used to tie up fruiting canes in midseason.

Cane-renewal system or Kniffen training (Figure 5): Probably the best system for the homeowner in Idaho. A strong trunk is developed up to the second wire with spurs established at the trunk near the wires. Two canes with 10–12 buds are left as fruiting wood on wires; two to four spurs are left on the base of the cane to grow renewal wood.

Timing

Winter. Prune the grapevines during the dormant season before March. Root pressure builds in the spring and that leads to "bleeding" of water from plants. This has little harmful effect on plants, but it is best to avoid this period.

Summer. Vigorous vines require summer maintenance. Yearly removal of suckers from the base of the plant or on the trunk below the first wire is needed.

Pinching or heading back. The current season's canes will top the wire and flop into the row. Head back to keep plant upright and to prevent shading of clusters.

Leaf removal. On late-season grapes, remove leaves near clusters to provide air circulation and to lessen the chances for the development of bunch rot. Normally detrimental to overall vine vigor due to low sunlight.

COMMON PLANT PROBLEMS — DIAGNOSIS AND CONTROL

Diseases

Powdery Mildew

Symptoms: This disease is the big limiting factor to home production of European grapes. It is the most severe disease for grapes in humid weather.

Control: Regular spray/dust programs of sulfur are essential. Use according to the label. Many recommended American grape varieties are resistant.

Botrytis mold. "Noble rot" for producing a late harvest, sweet wine on many white wine varieties. Not desirable most of the time.

Symptoms: Early infections cause spotting on leaves or infection sites on cluster stems. Bunch rot also occurs during the late season on ripening grapes.

Control: Fungicide sprays according to the label for botrytis on grapes.

Insects

Caterpillars: Includes cutworms.

Symptoms: Feed on buds and shoots.

Control: Pick off at night or use B.t.

Scale

Symptoms: The scale may be round to oblong depending on species and may also have waxy excretions.

Control: Apply insecticide according to the label instructions for scale on grapes.

Leafhoppers

Symptoms: These torpedo-shaped insects hold their wings in a rooflike position when at rest. They cause leaf injury and secrete honeydew.

Control: Insecticidal soap sprays.

Other

2,4-D injury: Grapes are very susceptible to damage by 2,4-D. It has been known to drift for miles and to affect plants.

Symptoms: Terminal growth can be misshapen; venation becomes parallel and fan-shaped; young leaves are thickened and distorted.

Control: Avoid 2,4-D use around grapes. Wait for plants to grow out of problem.

Boron Deficiency

Symptoms: There will be a light set of fruit, while the flower clusters will be affected with a "burning off." Terminal shoots may die in early summer or show leaf chlorosis. Some European grapes are particularly affected.

Control: Soil or leaf analysis is recommended and foliar sprays of soluble boron should be applied to correct the deficiency.

Potassium Deficiency

Symptoms: Chlorosis of outer margins of leaves will leave a dark green area (Christmas tree effect) in the center of leaf and brown spots on the margins.

Control: Apply potassium.

Further Reading

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Farmers Bulletin No. 2165: Growing Raspberries.

Farmers Bulletin No. 2236: Commercial Strawberry Growing in the Pacific Coast States.

University of Idaho Extension

Grapes

BUL 828 *The Economic Feasibility of Growing Wine Grapes in Idaho*

RES 162 *Contribution of the Grape and Wine Industry to Idaho's Economy*

Kiwifruit

PNW 507 *Growing Kiwifruit: A Guide to Kiwiberries and Fuzzy Kiwifruit for Pacific Northwest Producers*

Raspberries

BUL 812 *Growing Raspberries and Blackberries in the Inland Northwest and Intermountain West*

PNW 598 *Commercial Red Raspberry Production in the Pacific Northwest*

Small Fruits

BUL 815 *Growing Blueberries in the Inland Northwest and Intermountain West*

BUL 821 *Growing Western Huckleberries*

CIS 815 *Northern Idaho Fertilizer Guide: Blueberries, Raspberries, Strawberries*

Strawberries

BUL 810 *Growing Strawberries in the Inland Northwest and Intermountain West*

CIS 931 *Strawberry Production: Overview*

Washington State University Extension

Grapes

EB 0637 *Training and Trellising Grapes for Production in Washington*

Small Fruits

EB 1015E *Small Fruits and Berries: Insect Disease Control for Home Gardens*

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CHAPTER **TWENTY-FOUR**

HOUSEPLANTS AND HOME GREENHOUSES

JoAnn Robbins
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Learning Objectives

- Understand the environmental conditions and requirements for houseplants
- Understand the different types of media, containers, and pots used or available for houseplants
- Understand how to control the size and shape of houseplants
- Learn how to diagnose problems associated with growing houseplants, namely insects and diseases
- Understand the method of propagating houseplants
- Understand the materials and structure of a greenhouse and why they are utilized
- Understand the available options for season extension

houseplant. Any plant grown indoors, typically in a container. There are three groups of houseplants: foliage, flowering, and cactus and succulents.

Environmental Conditions and Requirements

PLANT NEEDS

Understanding plant needs and existing conditions helps you to be successful with houseplants. All plants don't have the same needs and average home conditions are basically inhospitable for plants. Normally, conditions are minimally appropriate for a few species. For success you have to be selective and manipulate the environment.

LIGHT

Lack of light is the major constraint to indoor plant growth. Light intensity refers to the amount of light available at a particular site. It is measured in foot-candles (fc) or lux (1 fc = 10.7 lux). The minimum light intensity necessary for plant growth is 50–75 fc. Light is reduced by the reciprocal of the square of the distance from the measured source. In other words, light levels diminish rapidly as you move away from

the window or the lighting fixture. For instance, if you measure the intensity of light one foot from a window at 100 fc the following applies:

- 1 foot from window = 100 fc
- 2 feet from window = $100/2^2$ = 25 fc
- 3 feet from window = $100/3^2$ = 11 fc

An easy way to measure light is with a 35mm camera with a built-in light meter. Set ASA (film speed reading standard, American Standards Association) = 100, aperture to f4. Take reading of a white paper or board filling the camera's viewfinder. Light intensity is reciprocal of appropriate shutter speed (e.g., $1/100$ = 100 fc). Handheld light meters designed for photography will accomplish the same task.

At low light levels, most common houseplants are classified as long-term perishable and should be replaced every two years or so.

Increasing Light

Move your plants to a sunnier window with less overhang, less shading from trees, and a southern exposure. Move your plants closer to the window. Provide reflected light to plants by using white walls and mirrors. Provide artificial light (see section Greenhouses: Lighting).

- Fluorescent bulbs provide low-intensity light. For example a 40-watt bulb at a distance of 2 feet only provides 50 fc of light.
- Incandescent lights are also low intensity. A 60-watt bulb at a distance of 2 feet provides 17 fc of light.
- High-intensity lights such as mercury vapor, sodium, and metallic halide provide significantly higher levels of light intensity.
- Most nonflowering foliage houseplants benefit from receiving light 12–16 hours/day.

Symptoms of Light Anomalies

Low light: Plants not receiving enough light become weak, spindly, and have long distances between nodes. Leaves turn yellow and drop, usually beginning from the bottom of the plant. Growth ceases. Variegated plants revert to solid green.

High light: Plants receiving too much light have leaves that are light colored. The old leaves curl under and develop brown scorched spots or margins. New leaves are thickened.

TEMPERATURE

Most indoor plants are of tropical origin and do not do well in cold temperatures. Most plants tolerate a fairly broad range (55°F–85°F). Plants prefer 75°F days and 65°F nights (in general, ten degrees cooler at night than in the day). The direction the window faces affects temperature. South- and west-facing windows receive more sun, so they tend to be warmer than east- and north-facing windows. Plants lose heat, or radiate, to anything colder. Place sheets of newspaper between plants and windowpanes on frosty nights to avoid cold damage to houseplants.

Symptoms of Temperature Anomalies

High temperatures: If a houseplant receives too much heat the leaves will turn yellow, wilt, drop, or scorch. Low temperatures: If temperatures are too low, leaves will curl up, turn brown, and drop off.

HUMIDITY

Most houseplants prefer a high relative humidity. However, many will adapt to low levels of humidity. Heating systems differ in drying air. Normal humidity inside buildings (especially in winter) is much lower than the lowest range tolerable for good plant growth.

Methods to Raise Humidity

Group your houseplants together to use the water vapor created by the transpiration of other plants to increase the humidity level. A gravel tray beneath the houseplant pot filled with water will provide extra humidity as the water evaporates. Be sure that the base of the pot sits on the top of the gravel and does not touch the water. Humidity can be increased around a houseplant by misting. However, the effect is very short in duration and must be repeated frequently for any beneficial effect. Place plants in areas of high humidity, such as the kitchen or bathroom. Provide a double pot for your houseplants. Place moist sphagnum moss between the inner and outer pots to provide extra humidity. Increase the humidity level in the entire room with a humidifier.

Methods to Lower Humidity

Ventilate the area around the houseplant by opening doors and windows and by using fans and air conditioners. Be sure not to overwater plants or have water standing in trays beneath pots for any length of time.

Symptoms of Humidity Anomalies

Low humidity: Plants growing under low humidity may develop brown leaf tips and yellow leaf margins. The plant may have stunted growth or none at all and will display signs of bud and leaf drop, shriveling, and wilting.

Excessive humidity: Too much humidity will cause the plant to decay and rot. Its leaves and stems will darken, be susceptible to bacterial and fungal invasions, and show soft wilt.

IRRIGATION

Irrigation is the most important and most abused cultural practice with houseplants. Water relations are much more critical for potted plants because of their limited root space and the necessity for soil aeration.

Water requirements vary by plant species from constantly moist to mostly dry. You need to know individual plant requirements, which can be learned by consulting a reliable reference.

Water use depends upon a number of factors.

- Ratio of foliage to pot size: A large plant in a small pot may need to be watered daily due to the large amount of water lost and the small soil reservoir.
- Potting media: Sandy potting soil holds less water than soil with peat or other organic matter. Plants in a sandy mix need to be watered more often.
- Temperature: If temperatures are high, houseplants transpire freely, and water evaporates rapidly from the soil surface. Plants in warm conditions need to be watered more often.
- Humidity: Plants in dry air transpire more and need watering more often than those in moist air.
- Air movements: Plants located in a breeze transpire more and require more water.
- Light: Plants that are photosynthesizing exchange gasses through open stomates, allowing transpiration to occur. Plants in brighter-lit areas, therefore, require more water than those in dimly lit ones.
- Plant species: Some plants simply need more water to grow and be healthy than others.
- Container porosity: Clay and unglazed ceramic pots "breathe" and lose water more quickly than glass, glazed ceramic, or plastic pots, so plants in clay and unglazed ceramic pots need more water.

Water quality varies, particularly in the amount of soluble salts present. Well water in Idaho is often "hard." Many softening processes replace the calcium in the water with sodium that is damaging to houseplants; thus, water houseplants with water that has not been softened by this method. The amount of chlorine found in city water systems generally is not sufficient to cause problems with houseplants. Alkaline water makes growing acid-loving plants such as azaleas and gardenias difficult. Generous use of acidic peat moss and acid-reacting fertilizers help to offset the alkaline content in the water.

All containers should have drainage. Lack of drainage saturates the soil and excludes air from the roots. This condition leads to root rot. Water temperature is important. Many houseplants are tropical and adding cold water to their roots can harm them. African violet and other gesneriad leaves are bleached by cold water. To avoid problems, water your houseplants with barely warm or tepid water. Methods to determine the relative amount of water in a pot include checking with a finger one inch or so below the soil surface for moistness, comparing the "heft" or weight of the pot, or tapping the side of the pot and listening for a hollow sound. The main thing is to check plants regularly.

MASTER GARDENER TIP

Inexpensive moisture meters actually measure conductivity (salinity) of the soil and are not reliable.

The amount of water held and available is dependent upon media ingredients. Peat moss, field soil, and vermiculite hold the most. Sand, perlite, and pumice hold the least.

Symptoms of Water-Related Anomalies

Not enough water: Foliage of broad-leaved plants darkens and turns crisp; the lower leaves drop and plants gradually wilt. The leaves and stems of succulent plants turn pale and shrivel.

Too much water (or insufficient drainage): Leaves curl, wilt, blacken, and drop. Corky scabs or protrusions form on the undersides of leaves or on branches. The leaves and stems become soft and the roots rot.

FERTILIZATION

Nutrients needed for plant growth are generally obtained from "real soil" that your potting mix does not usually contain. There is a limited supply available to houseplants because of the finite size of the pot. Also, the potting soil is usually "artificial" mix that contains little to no nutrients.

The best method is to provide a constant supply of nutrients at relatively low levels. Nutrients will be particularly important during periods of growth. Don't overfertilize. You will get lanky growth, fertilizer burn, and the possibility of root damage. During the winter months, when home temperatures are apt to be cooler and days are shorter, decrease or eliminate fertilization to give plants a short rest of 2–3 months.

There are many types of fertilizers. It is best to use a complete fertilizer that provides nitrogen, phosphorus, potassium, and micronutrients such as iron. No one type of fertilizer is better than the others. Slow-release granules let out a little fertilizer at each watering. Dry fertilizers or fertilizers that dissolve in water can be applied. Organic forms such as fish emulsion provide micronutrients and low amounts of nitrogen. Fertilizer burn is less likely with an organic source.

It is best to fertilize with soluble inorganic fertilizers when the soil is already wet. This way there is less of an uptake shock and, subsequently, less possibility of root damage and/or fertilizer burn. Fertilizer is not a cure-all; it will not make a sick plant healthy. In fact, fertilizing a plant with disease or other stressors and, hence, forcing growth may be the final stressor that kills it.

Nutritional Deficiencies

Macronutrients

Nitrogen (N): Lack of N results in a stunted plant with yellow leaves; older leaves fade first, then turn brown and die.

Phosphorus (P): Lack of P results in retarded growth. The plant remains a deep green leaf color until it turns purple or bronze (or mottled in light and dark tones). The symptoms are apparent in older leaves. Another symptom is retarded flowering.

Potassium (K): Lack of K creates tip and marginal burn on lower leaves. These burns advance up the plant. The leaves crinkle and turn inward, and the plant stops growing.

Micronutrients

Deficiencies in anything more than N, P, K, or iron are unusual. If the addition of a balanced fertilizer doesn't cure deficient symptoms, repot plant in new soil and resume a regular fertilizer schedule.

Iron (Fe): Leaves turn yellow, while veins remain green. The plant will have stunted growth and curled leaves.

Excess chlorine (Cl): Too much chlorine causes thickened leaf tissue, which becomes brittle. Great excesses of Cl burn and destroy plant roots.

SALT DAMAGE

Salt damage is a common problem in houseplants and steps must be taken to avoid it in order to have healthy plants. Salt buildup is indicated by a crusty white substance coating the top of the soil or the rim of the pot. Salt buildup is caused by repeated fertilizing, giving plants too little water at a time, high salt concentrations in tap water, and poor drainage in pots.

The symptoms of salt damage are easy to spot. Plants do not grow well. Leaf tip and marginal leaf burn are evident. Roots are burned and deteriorated. You may also see thick, dwarfed leaves with sunken breathing pores on leaf undersides. To avoid salt buildup in pots:

- Do not water houseplants with water softened by sodium salts.
- Water plants with distilled water; it contains no salts or minerals.
- Flush excess salts out of pots periodically (monthly) by watering heavily and repeatedly until water pours out of the drainage holes.
- Repot plant in new soil and new pot.
- Wash old pots well before reusing for houseplants. Soak clay pots in several changes of clean water to flush out salts absorbed by the clay.

OVERALL ENVIRONMENTAL FACTORS AFFECTING PLANT GROWTH

Plants are living things. The keys to healthy houseplants are to minimize stress and to provide a favorable environment with minimal variation.

Don't overcorrect. Don't make up for underwatering with overwatering. Don't make up for lack of light by placing plant in direct sun. Shocks like this will not benefit growth.

Media, Containers, and Potting

ROOT MEDIA

Because of the physical limitations of the container, houseplants need specialized media. Do not use straight field soil. It lacks correct physical properties. It is best to buy a potting mix from a garden center.

There are some important properties to consider when choosing a container medium. Roots need air to grow, so the percentage of air-filled space for houseplant soil needs to be 10% or more. Container media need to hold enough water to supply what the plant needs. Pure sand makes a poor container medium, as the soil must hold water equal to 40% of volume or more. Container media need to be able to hold nutrients (have a high cation exchange capacity). Organic matter will help increase nutrient-holding capacity. The pH (acid balance) of the soil needs to be favorable for houseplant growth. A pH range of 5.5–6.5 is best. Container media must be free of diseases and toxic substances.

CONTAINER CHOICE

No one container material is better than another, but each container type requires different management. All containers require drainage holes at the bottom.

Basic Container Materials

Clay pots are attractive and plants grow well in them because they breathe and allow air exchange through their walls. As a result, they dry out faster than other types of pots and thus the plants will require more frequent watering. They also tend to accumulate salts in their walls because of the evaporation. These can be flushed out of empty pots by soaking them in several changes of clean water.

Plastic pots are readily available and come in colors to complement your decor. They are impervious to water and their walls do not breathe. Because of this, soil aeration of the media is particularly important. The soil will also hold the water longer, so less frequent watering will be necessary.

Fiber pots are inexpensive and rustic looking. They are porous and allow a limited amount of air and water exchange. The bottoms of these pots tend to break down and fall apart over time.

Wooden pots are attractive but they tend to leak out of the cracks if not lined with a plastic interior. When lined, they essentially become a plastic container.

When using saucers, it's best to lift the pot above the saucer so that after irrigation the pot doesn't sit in drained water. If it does sit in water, be sure the water is all taken up within an hour or two. Sitting in water for days at a time will cause the soil to be saturated, which eventually kills a plant. Decorative containers that hold the entire pot (jardinieres) can be used and should be treated just like saucers.

When reusing containers, clean them well to reduce any carryover of insects or diseases found in plant parts or old soil clinging to the plants. Soaking clay pots in fresh water for several days will leach out any accumulated salts. Scrub other pots with a stiff brush and detergent and rinse in a solution of bleach.

REPOTTING HOUSEPLANTS

There should be a balance between top growth and container size. Too small a container causes rapid water loss and too large a container keeps the soil saturated and leads to root problems.

When potting, cover the drainage hole with old nylon stocking or a pottery shard to minimize soil loss when irrigating. Do not use gravel in the bottom as it only reduces the effective pot size and does not help drainage. Do not press or tamp soil firmly in pots as this reduces aeration. Rather, tap the filled pot on a table to settle soil and remove air pockets. Leave a 1-inch head space at the top of pots for irrigation. Media containing peat moss that has gotten bone dry may need to have the moisture kneaded in before using it for potting. If this isn't done, penetration of the water in the repotted plant will be extremely slow until the peat absorbs the water. In the meantime the roots are completely dry. Water immediately after potting. It's best to irrigate two times to be sure soil is settled well around the roots and that the media is completely wetted.

Repot if compacted or salt-filled soil, poor drainage, soilborne insects, inadequate nutrition, and crowded roots develop or appear. Move up only one pot size at a time. A general rule is to make the internal size of the container about 1 inch larger all around than the old pot. Replant the plant at the same level on the stem as in an old container. How often to repot depends upon the plant's rate of growth, root condition, and media characteristics.

Terrariums typically have no drainage, so use activated charcoal at the bottom of the container and water less.

Controlling Size and Shape

PHOTOTROPISM

Houseplants orient their leaves toward a fixed light source. To keep a balanced shape, rotate plants frequently.

PINCH

Frequently remove terminal growth such as vines and branching plants to keep them bushy and within bounds.

Diagnosis of Problems

BE OBSERVANT

In diagnosis the most difficult task is not to jump to conclusions. Don't be absolute, even though the problem seems obvious. This is particularly true if you are being guided by a description of a problem without actually seeing the plant.

Ninety-five percent of all problems with houseplants have to do with light, water, humidity, and fertilization. Frequently, the problem is a combination of these factors. Diseases are usually a result of some environmental stress.

Be methodical in your questioning. Ask step-by-step questions about plant care and conditions. Learn to ask questions the right way. Not, "Are you watering correctly?" Rather,"How often do you water?" Get a quantitative answer that will help you decide if the watering is correct. Look at the roots of the plant. Roots should be healthy and growing.

Symptoms overlap, so brown tips on the ends or edges of leaves are symptomatic of several problems. It is up to you to ferret out what is causing them.

Insect Pests

Watch for insects when you introduce new plants to a home. Most insects are brought in with new plants and plants that have been outside in the summer. They also hitchhike in on pots, equipment, and your clothes, shoes, and person. Pests have preferences for certain plant species. Thus, some plants are more prone to insect problems.

MAJOR INSECT PESTS

Aphids — These are soft-bodied, small round insects that mass around growing tips and tender tissue. Aphids suck plant juices. Their invasion causes deformed and curled new leaves, buds, and flowers. Some carry virus diseases and some species cause galls. They all secrete honeydew and this is sometimes the first symptom noticed. The honeydew attracts ants, who feed on it.

Whitefly — This small, white-winged fly congregates on the undersides of leaves. Small immature crawlers or larvae suck sap and secrete honeydew. Adults fly up in a random pattern when disturbed and resettle to the plant surface quickly.

Scale — These are small, hard, immobile, disk-like insects. Scales suck plant juices. Their presence causes leaves to develop yellow spots, turn yellow, and drop off. They also have a crawler stage that moves about until it matures. This crawler becomes the disk-like immobile adult that is obvious.

Mealybugs — Mealybugs are scale insects that are covered with layers of white waxy substance. They look like little cotton pieces. They suck sap, resulting in stunted growth, wilting, defoliation, and eventually plant death. They also secrete honeydew.

Spider mites — Spider mites are tiny, eight-legged arachnids that proliferate rapidly in hot, dry growing environments. They suck sap, causing pale blotches, loss of color, and dry, rusty leaf textures. The leaves tend to turn gray, yellow, or to be smothered in fine, mealy cobwebs before dropping off. They can be seen, although they look like moving dust unless viewed with a magnifying lens. They most often congregate on the undersides of leaves.

Cyclamen mites — These microscopic voracious feeders cause distorted, blotchy bloom; stunted, twisted, or shriveled stems; and leaves with stunted and compact plant centers. Their presence is often followed by the dropping off of flower buds and streaky, purplish foliage. These mites are difficult to eradicate. As their name implies they are a particular problem in cyclamen, but also affect other houseplants.

Leaf miners — The larvae of fly, moth, sawfly, or beetle leaf miners eat leaf tissue between the upper and lower leaf surfaces, causing slender, winding trails, tunnels, and blisters on leaves.

Fungus gnats — Light attracts these tiny black flies. The flies zig and zag in irregular flight when disturbed before settling back down on the soil surface. The eggs of fungus gnats hatch into threadlike white maggots that burrow through the

soil, embed themselves in root tissue, and eat small feeding roots, root hairs, and crowns of plants. The plants suffer from root rot, slow weak top growth, and yellowing leaves. Root feeding produces wounds that can permit entry of disease organisms.

INSECT CONTROL

It is essential to quarantine all new plants introduced into your home until you are sure they are pest free.Several effective nonchemical insect control methods are available.

Water: Keep all plant leaves clean by washing or spraying with water. This is especially good for control of aphids. Wash or spray the plant in a bathtub if you can.

Soapy water (use specially formulated insecticidal soaps): Sponge or spray onto leaves. This works well on spider mites and aphids.

Rubbing or denatured ethyl alcohol: Use alcohol on a cotton ball, tissue, or swab to remove insects such as scale and mealybugs. This works well on large, stiff leaves. Be sure to test first to make sure the alcohol will not damage the leaves, especially on soft, thin, and fragile leaves. Applying rubbing/ethyl alcohol is not practical on a plant with tiny leaves, so repeat often for complete control.

Yellow sticky boards: Insects are attracted to the yellow surface and become tangled in its sticky goo. These are best used early when infestations of flying insects are low. This is a good technique for whitefly control.

Predators: These can be insects, nematodes, or mites. Some of these are very specific. They are effective in reducing pests, but may be difficult to keep on the plant and to maintain.

Replacement: If the pest population is too high or complete control seems impossible, discard the plant and buy a new one.

Chemical controls for insects are available. Be cautious when using chemical insecticides. Read the label thoroughly and follow instructions carefully. Not only are excessive rates or unlabeled applications unhealthy for you, they may cause plant damage or phytoxicity.

Use different chemicals for different problems or when one type stops working. Apply the chemical that will control the pest you have. Understand the life cycles and susceptible stages of pests. If you must repeat applications, follow the timing precisely.

Some pests have developed a resistance to certain pesticides. If one is not effective, try another from a different chemical group. Do not increase dosage.

Plant Diseases

Diseases usually occur in plants that are stressed by unfavorable environmental conditions. The most common stresses are high or low temperatures, over-watering, low light, overfertilizing, open wounds, air pollution, and excessive humidity. Parasitic organisms, bacteria, or fungi can cause disease in houseplants.

COMMON DISEASES

Anthracnose — This fungus is characterized by depressed leafy spots with dry centers. The entire end of the leaf may turn dark tan with darker bars crisscrossing the leaf.

Crown and stem rot — These fungal diseases cause stems and bases of affected plants to turn soft and mushy to the touch.

Damping-off — This disease is caused by a soilborne fungus that attacks the lower portion of the seedling stems, which then collapses. The leaves turn inward and look pinched. The seedling wilts and dies.

Leaf spot — This disease creates yellow-margined spots with dark brown or black and damp or blistered centers. Bacterial or fungal invasions cause leaf spot.

Mildews and molds — Black sooty mold on leaves appears as black coating and can be associated with honeydew secreted by aphids, mealybugs, and scale. A white or grayish felt-like coating on foliage is mildew. It causes leaves to curl and shrivel. A gray or white mold on the soil surface can be fungus caused.

Root rot — Root rot invades roots and diminishes roots' ability to absorb water. This rot is fungus caused. It damages new growth, which dies back. The entire plant eventually wilts and dies.

DISEASE CONTROL

Correct the environmental conditions that allow disease to thrive. For instance, many rots thrive in excess water. The recommended treatment is to lower the humidity and cut down on watering. Pick off and destroy infected leaves and plant parts. Repot or replant in new media. Apply fungicidal dusts or drenches as recommended, following label instructions for the specific disease.

Propagation

CLONE

Vegetative or asexual propagation produces a clone of the plant that you propagate from. This is the most common commercial technique. It is fast and ensures genetic consistency. It is also easy to do. Propagate by using cuttings from the stem, leaf, offsets, or stolons. Air layering can be done with many plants by scoring the stem, wrapping it with damp sphagnum moss, and enclosing it in a plastic covering secured above and below by a loose tie.

Factors to consider when propagating houseplants:

Start with vigorous, healthy plants.

- Use sterile, well-aerated rooting media. Most packaged mixes are sterilized before packaging. Peat mixed with either perlite or vermiculite makes a good rooting media.
- Pieces of plants cannot endure water stress while roots are forming. To maintain a good water balance, remove part of the leaves on large-leaved plants and raise humidity by enclosing or misting them.
- Cuttings and newly rooted plants need light for photosynthesis. However, cuttings should not be in direct light unless they are under an automatic mist system. Ease newly rooted plants into high light situations gradually.
- Bottom heat (heat at root zone) helps plants to root. A temperature of 70°F–75°F with an air temperature of 60°F–65°F is ideal. Use a heating cable or mat to provide bottom heat.
- Use rooting hormones to stimulate root initiation and growth. Apply them as a dry powder or a solution in which the cutting is dipped.
- When placing cuttings in media, be careful not to wipe off the hormone.
- When roots have grown on cuttings to where they are large enough to support the cutting, transplant quickly since there is less transplant shock for small root systems.

UNIQUENESS

Seed or sexual propagation may produce an individual similar to the mother plant. With cross-pollination, however, variation will occur, and the resulting seedlings will all be unique individuals.

With seed propagation you can produce more plants. Plant breeders use this method to produce new varieties using the variation produced by seedling variation.

Some seeds need a presowing treatment to break dormancy. Stratification, or a moist cold treatment, is needed for some. Scarification, or scratching or breaking down the seed coat, is needed for some. Seeds from different species of plants have different light and temperature requirements. Use sterile media to avoid seed rot and damping-off of seedlings. Transplant seedlings when they become crowded. Lift plants by a leaf, not by the tender stem or growing tip.

Greenhouses

A home greenhouse is a satisfying addition for the home gardener. Many plants grow in greenhouses, including annual bedding plants, forced bulbs, cacti and succulents, geraniums, gloxinia, orchids, and tropical foliage plants. You can grow vegetables and fruits such as cucumbers, eggplant, lettuce, onions, peppers, radishes, strawberries, and tomatoes in a greenhouse. The various plants require different temperatures and light conditions, so the size of the greenhouse and its cooling and heating equipment may restrict the greenhouse grower to certain plants. Providing proper growing conditions is essential for successful greenhouse gardening.

TYPES OF GREENHOUSES

Attached Lean-To

Built against a building, this greenhouse uses the building's walls for one or more of its sides. Usually, the width is limited to a total of 7–12 feet.

Attached Even-Span

Similar to a freestanding structure, this greenhouse is attached at one gable end to a house or other structure. It is larger and more flexible than the lean-to type.

Attached Window-Mounted

This reach-in unit replaces a window and is ideal for growing a few plants at low cost for heating and cooling.

Freestanding

Set apart to get the most sun, this type of greenhouse can be as large or small as desired. With many shapes or frame types available, it is the most costly type to build and maintain.

LOCATION AND ORIENTATION

Light

Get the most light by placing the attached greenhouse on the southern or southeastern side of the structure. The eastern side is the second-best location followed by the southwestern and western. A northern exposure is the least desirable. Locate free standing greenhouses where large trees, other buildings, and obstructions will not shade them.

Shelter

Locate small greenhouses in a sheltered area to reduce wind-related heat losses. A windbreak or building located far enough away so as to not shade the greenhouse provides shelter. Choose a site that has access to electricity, water, and an energy source for heat.

Orientation

Once you have selected a site, orient the greenhouse to make the most of the available light. An east-west orientation (with the ridge of the house running east and west) is preferable, especially during the winter when light is most critical.

DESIGN AND CONSTRUCTION

Shapes

Many styles of greenhouses are possible, such as Quonset, dome, gothic arch, A-frame, slantleg, gable roof, and tripenta. Plans, kits, or finished houses are available from a variety of sources.

Frames

Wood

Wood contributes to uniform greenhouse temperatures because it does not cool down quickly. Use a wood resistant to decay, and one that is pressure treated or treated with a nontoxic, waterborne, salt-type preservative.

Steel

Provides a more solid structure than wood and lets more light into the greenhouse. Paint steel frames to prevent rust.

Aluminum Alloy

Lightweight and strong, aluminum frames offer a high degree of light reflectiveness and require little maintenance. They transmit heat readily, resulting in greater heat loss.

Plastic

Light, strong, and readily available, plastic (especially PVC pipe) is good for hoop-house construction.

Covering Materials

Glass

Use extra strength or tempered glass. Attractive, permanent, and expensive, it requires periodic recaulking. Leave construction to a manufacturer because glass is difficult to fabricate. A single layer has 90% light transmission.

Plastics

Rigid plastic: Resists breakage, is lightweight, and easy to install. Most degrade under sunlight.

Polyvinyl chloride (PVC): Available in ultraviolet (UV) treated form, PVC allows 88%–90% light transmission. It is flexible, comes corrugated or flat, and lasts 2–7 years.

Clear acrylic (Plexiglas, Perspex, Transpek, and Lucite): Half as heavy as glass, acrylic plastics resist impact and are flexible but expensive. All but Lucite scratch. Most types are available in double-walled panels that last twenty years and allow 90%–95% light transmission.

Polycarbonate: More flexible and less expensive than acrylic, polycarbonate plastic yellows and loses transparency with age.

Film plastic: Inexpensive, but temporary, film plastic requires more maintenance. UV radiation will destroy it if not treated with a UV inhibitor. Use double layer to reduce heat loss.

Polyethylene

Regular polyethylene: Not recommended because of its short life span (9–12 months). Stronger with increasing thickness, it usually splits on the fold. Allows 85%–88% light transmission.

UV-treated polyethylene: Lasts 1–2 years. Use 4–6 mil (thousandth of a inch) thickness. Keep clean to increase winter light; 85%–88% light transmission.

Copolymer films (Monsanto 602): An ethylene and vinyl acetate, copolymer films are stronger with a life of two years. Keep clean for an 85%–88% light transmission.

Reinforced polyethylene: Contains glass or acrylic fiber for additional strength and a two-year life span. Keep clean for an 85% transmission.

Reinforced UV-treated polyethylene: Has similar characteristics to reinforced polyethylene.

Vinyl films: Thicker (8 mil) types are hazy. Keep clean because they attract smog and dirt. This tears easily

when punctured and will last for about 2–5 years. Allows 89%–91% light transmission.

Polyvinyl fluoride films [Tedlar PVF and Teflon fluorinated ethylene propylene (FEP)]: An expensive type of film plastic that lasts 7–8 years with 92% light transmission.

Polyester

Polyester films (Mylar, Melinex, and Llumar): This stiff plastic film tears easily when punctured and degrades rapidly in the sun.

Acrylic laminated to polyester (Flexigard): Reduced UV radiation breakdown and tearing gives this type of plastic a moderately long life.

Fiberglass

Durable, attractive, and moderately priced, fiberglass is more resistant to impact than glass and much lighter.Use UV-treated fiberglass because the untreated types yellow with age. If not treated with UV-resistant materials, the fibers become exposed or "fray." Low maintenance, fiberglass lasts for a year untreated and 15–20 years if UV treated. With a 75%–90% light transmission, fiberglass is not recommended for plants with high light requirements in areas with less than 40% sunny days in the winter. Fiberglass comes corrugated or flat. It is flammable. Buy only clear (not colored) types of high-grade fiberglass.

Benches

Side Benches

Because you access side benches from only one side, they should be no wider than what you can reach across (generally 2–3 feet). Leave about 6 inches between the benches and the side walls for air circulation.

Center Benches

Because you access center benches from both sides, they can be as wide as 6 feet. Small greenhouses may have room only for side benches.

Other Types

Beds, shelves, and imaginative types of benches are all possible in a greenhouse. Tailor them to your needs and plant requirements.

Walkways and Flooring

Walkways should be easy on the feet, well drained, and nonslippery. Use pea gravel, ready-mix concrete, porous concrete, treated wood, brick on a sand bed, porous aggregate, or stepping stones in any combination for walkways and flooring.

Heating

Heating capacity depends on the size of the greenhouse, the type of covering, and the coldness of the external temperature and wind relative to the desired inside temperature. Attached greenhouses often use the home heat source for warmth.

Conventional

Use coal, electricity, gas, or oil heat sources to heat the air directly in a forced air system or to heat water for a hot water or steam system. Use an approved flue to vent gas, oil, and coal. Electricity is often too expensive to use.

Solar

By capturing the sun's heat in water, stone, concrete, or similar heat-absorbing material, you can heat your greenhouse via radiation during nonsunny periods. You should combine solar heat with other methods such as double walls, covers, and blankets to minimize heat loss from the greenhouse.

Blankets and Shutters

Movable blankets and shutters serve as nighttime insulation. They are only as effective as the operator who faithfully opens and closes them. You can make these interior insulating systems from black or clear polyethylene film, aluminized fabric, PVC laminate, spun-bonded polyester, foam-backed fiberglass drapery material, woven and lofted polyester, or clear plastic Bubble Wrap. Fit them on tracks, rollers, or slides or secure with hooks.

Shutters are foam insulation boards cut to fit between wall studs and ceiling rafters. Foam with aluminum foil facing is even more effective. Wood turn knobs or magnetic clips hold the panels in place. They are more effective than thin blanket materials but are labor intensive to install and require a larger storage space.

An alternative is external blankets or insulation. They are more expensive to build, however, because they must be weather resistant. Sleet and snow are difficult to remove and the operator must go outside to install them.

Ventilation and Cooling

Ventilation

Ventilation equipment helps to control temperatures in all seasons. Hand-operated side or roof vents require constant supervision. Automatic ventilation is simple to install and requires only an electric motor, thermostat, and a pulley or gear system.

MASTER GARDENER TIP

Wire all fans to a thermostat set at the temperature desired before beginning ventilation.

Fans provide good ventilation. Use them alone or in combination with other vents. Vent fans draw in the outside air or recirculate internal air. Fans in combination with a polyethylene duct will help to distribute the air evenly throughout the greenhouse.

Exhaust fans draw out heated air. Usually, install them near the roofline to prevent drafts. Use in conjunction with a second vent such as a louvered shutter that opens when the exhaust fan starts. Place the vent at a lower level so cool air moves across the greenhouse, mixing with warmer air.

Cooling

When the external air is not cool enough to provide internal cooling for the greenhouse, use evaporative coolers or mist blowers to cool the air. Evaporative cooling draws outside air through wet fiber pads that cool the air and add some moisture to it.

Mist blowers use fans that blow mist from a fine jet of water into the greenhouse. The mist cools the air and provides needed humidity. Control all cooling systems automatically with thermostats.

Shading

Shading reduces the need to ventilate and cool a greenhouse because it curtails the amount of radiation that enters. Shading also protects plants from the direct rays of the hot summer sun and reduces light intensity. Often needed from June to August. Provide shading by whitewashing the greenhouse, attaching blinds or panels, or covering the house with shade or saran cloth.

Lighting

In the greenhouse, you may need to supplement natural light, especially during long winter nights. Light controls most plant functions, so it is important to understand the needs of your plants.

Light Quality

Plants use red and blue portions of white light for various plant functions. It is important to have red/orange light for germination and maturation and for flower and seed production. Plants use blue/violet light for growth and leaf development. Artificial lights must supply the proper light spectra.

Light Intensity

Some plants require bright light to grow, while others prefer shady areas (less intense light). Light is measured in foot-candles or lux (see Environmental Conditions and Requirements: Light).

Light Duration

A photoperiodic effect is the response of a plant to the length of light and dark periods. Flowering is the most dramatic effect associated with the length of exposure to light. Short-day plants respond to a day length of less than 12 hours. Long-day plants respond to a day length of longer than 12 hours. Day-neutral plants do not respond to variations in the light-dark cycle.

If you want flowering in certain plants, provide the proper day length: extend the days with artificial light; if the days are too long, shade the plants with an opaque black cloth supported on a frame. Do not peek into the shaded area, however, as just a "flash" of light destroys the long-night effect! To provide a longer day length, the light intensity does not need to be as high as it would be for proper growing conditions.

Artificial Lights

Use various types of lamps in the greenhouse. A simple timer is ideal for turning the lights on and off.

Incandescent: These lamps give off red light and infrared radiation that becomes heat. They are not intense enough to supply light to plants with a high light requirement. Light distribution is restricted.

Fluorescent: Fluorescent lamps produce less heat and different types vary in their output in the red-blue areas. One cool-white and one warm-white bulb provide a good spectrum for plant growth.

Mercury vapor, sodium, and metallic halide: These lamps provide high-intensity lighting. They are expensive and more suitable to large-scale production.

Watering

In the home greenhouse, the traditional watering method is a mist or spray nozzle on a garden hose. The greenhouse gardener who is gone a lot can install automatic systems, such as mist nozzles, spaghetti tubes, or capillary mats. In some areas, water quality is a concern. Water high in salts or high in alkalinity may need special treatment for greenhouse use.

Small Beds for Growing Plants

COLD FRAMES

A cold frame is a bottomless box with a removable lid that you can prop open at various degrees. The lid consists of glass or other greenhouse-covering material on a frame.

Cold frames do not require artificial heat or manure. They use the sun's heat to warm the soil during the day and the heat's radiation in the closed cold frame keeps the plants warm at night. During the day, control ventilation and heating by propping open the lid. Use cold frames to plant seeds and produce transplants for main-season gardens and for root cuttings.

HOTBEDS

Convert cold frames to hotbeds simply by adding a heat source such as manure, electricity, steam, or hot-water pipes. Start seeds or force plants in hotbeds.

The amount of extra heat needed depends on available sun and the external temperatures. Soil-heating cable that provides 10–15 watts of electric heat per square foot is ideal for most hotbeds. If the bed is in a sunny, well-sheltered location and the climate is not too severe, 10 watts per square foot should be adequate. Attach your heat source to a thermostat or buy a heat cable with one to provide accurate temperature control in the 50°F–79°F range. On very cold nights, cover the beds with extra insulating materials. Adding manure that heats as it decomposes is an effective practice that has worked for centuries. Modern gardeners, however, rarely use manure as a heat source.

CLOCHES

Protecting plants by providing a cloche, or miniature greenhouse, is standard practice for gardeners. The cloche offers only temporary protection until the outside temperature is favorable enough to produce good growth. Hot caps, commercial "Walls of Water," and one-gallon plastic milk cartons with the bottom cut out are temporary structures that help moderate the temperature around plants.

Producing an entire crop under cover of a cloche is practical wherever the weather is unreliable or predominantly cool. Growing a crop in a cloche allows the gardener to produce plants that otherwise may not grow in the area. Cloches are suited to intensively managed gardens and severe climates. They provide a constant warm temperature and prevent wind, rain, frost, and pest damage. They may be only the size of a single plant or large enough to cover several.

Cloches can have a frame of some type to support the covering material (use any greenhouse material or floating row cover). It may be necessary to use some type of venting system to reduce the heat that solar radiation produces. Construction and anchoring need to be strong enough to withstand the wind conditions of the area. Often cloches are designed to last only one year.

Further Reading

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BOOKLETS AND PAMPHLETS

University of Idaho Extension

CIS 858 *Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes*

CIS 881 *Success with Very Small Seeds*

PNW 151 *Propagating Herbaceous Plants from Cuttings*

PNW 170 *Propagating Plants from Seed*

PNW 171 *Building Hobby Greenhouses*

Washington State University Extension

EB 0695 *Houseplant Pests*

EB 1354 *Houseplants*

To order Washington State University publications, write to WSU Extension Publications, Cooper Publications Building, Washington State University, PO Box 645912, Pullman, WA 99164-5912.

Alberta Agriculture

Agdex 731-5 *Hobby Greenhouses in Alberta*

To order, contact Alberta Agriculture, 7000 - 113 Street, Edmonton, Alberta T6H5T6

VIDEOS

How to Grow Healthy Houseplants, VHS 457, Cooperative Extension District Office, Twin Falls, ID.

Foliage Plants for Interiors, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Indoor Plants, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Plant Propagation: From Seed to Tissue, WSU/UI Regional Media Collection, 1 (800) 999-1765.

SLIDE SETS

Care and Culture of House Plants, ASHS 10, 80 sl., F. Gouin, Eugene Memmler, PO Box 94475, Pasadena, CA 91109.

Indoor Landscaping (House Plants), ASHS 1, 92 sl., Cochran, Eugene Memmler, PO Box 94475, Pasadena, CA 91109.

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

CHAPTER **TWENTY-FIVE**

ORGANIC GARDENING

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Learning Objectives

- Understand the basic definitions of *organic* and organic pesticides
- Learn about organic soil fertility and amendments
- Understand the options for dealing with pests, including weeds, insects, and diseases
- Learn the organic options for controlling pests

Organic Gardening Overview

Over the past several decades, interest in organic farming has steadily increased. The rise in the popularity of growing produce organically has also influenced gardeners.

Organic growing is more of a mindset rather than rules and regulations to be followed, a striving to maintain a natural balance in the growing of plants. This natural balance involves soil, plants grown, water, insects, beneficial fungi, bacteria, wildlife, and other components that complete the natural equilibrium of living things. It is a holistic approach that includes using local materials as much as possible to replenish what is taken away from the total system.

Organic gardening does not involve the use of synthetic fertilizers or pesticides in the production system. It thus requires an added time commitment. Since one cannot rely on quick fixes through the use of synthetic materials, gardening organically often involves much greater hand labor, at least in the first few years, until the garden plot becomes more naturalized to the organic practices being used.

Weeding is generally the major effort of the first few years, but insect and disease pressures also take considerable time to control organically. Once the problems are recognized and methods developed to deal with them, the time commitment is reduced.

Organic gardening is similar to conventional gardening, yet there are important differences.

DEFINITIONS

Legal definitions of organically produced agricultural products must be met if the produce is intended for market. Find further information on growing plants and animals for the organic market at **https://agri.idaho.gov/main/about/about-isda/ag-inspections/organic-certification-program/**.

Because what qualifies as "organic" is legally complex and often confusing or contradictory, this chapter provides some of the basics about what growing in the organic tradition involves.

Basically, organic production entails growing crops and raising animals without the use of synthetically produced materials. In Idaho organically grown food means food products produced without the use of synthetically compounded fertilizers, pesticides, or growth regulators for a period of 36 months prior to harvest. To produce commodities and market them as organic, follow established rules. (See "Pest Control Strategies" for Idaho information.)

ORGANIC PESTICIDES

Organic pesticides can be used by the organic gardener, but many problems exist that are difficult to solve without synthetic pesticides. Because of these challenges, it becomes very important to follow good husbandry practices when gardening in the organic tradition.

SITE SELECTION

The simple step of choosing a gardening site becomes very important when growing organically. If a poor site is picked, the plants will be stressed and subject to insect and disease problems that may be very difficult to control. Weeds can also be a serious problem in an organic garden. Very few herbicides exist that are able to be used in organic production.

Pick a site with good soil, good drainage, and adequate sunlight. Try and find one with few weed problems, if possible, especially noxious weeds. If the soil is poor, add organic matter to help with the tilth, fertility, water-holding capacity, and organic content of the soil.

Soil Fertility and Amendments

Organic gardening begins with the soil. The healthier the soil the healthier the plants and the better success the gardener will have, be it an organic garden or otherwise. Given the limited resources to deal with pest problems, maintaining the health of the plants becomes paramount.

Soil aspects of organic gardening need at least yearly attention. The addition of compost and other organic material is very important to replace nutrients lost in the production and harvesting of garden produce. The sources of this organic matter may be leaves from the trees, vegetables, kitchen scraps, lawn clippings, compost in its various forms, as well as other organic material that may be locally available.

Compost is organic matter that has been broken down by microbial action, insects, and other invertebrate animals. Composting is a natural process that can be easily accomplished by the home gardener. For detailed information on the art and science of composting, refer to chapter 8, Backyard Composting. The composting of material treated with synthetic pesticides is not allowed in organic gardening.

Both inorganic and organic fertilizers can cause plant burn, groundwater contamination, excessive buildup of toxic materials in the soil, and plant nutrient excesses and deficiencies. To avoid these problems, it is important to have an understanding of the types and amounts of nutrients you are applying to the soil when you add any type of material to your garden.

Organic matter is the main source of fertility in organic growing systems. Since synthetic fertilizers are not permitted in organic gardening, it sometimes becomes challenging to find and provide the necessary nutrients that plants need. Before planting a garden, fertilize it with needed components. Plants will get needed nutrients through the compost and other organic matter added yearly to the soil.

Usually plant nutrition consists of animal manures, plant manures, cover crops, compost, compost tea, and/or mixed organic fertilizer. Animal manures are generally the most complete source of nutrients for organic gardening but there are several other sources that can be utilized. Refer to Tables 1–3 to get a relative idea of which types of organic matter add what percentage of nutrients to the soil. There are mineral sources for certain nutrients for the organic gardener.

Green manures have been shown to benefit organic gardening. Not only do they add organic matter to the soil, many of them have the ability to reduce

Table 1. Average plant food content of natural and organic fertilizer materials. Percentage on a dry-weight basis.

Organic Materials	%N	%P	%K	Availability	Soil Reaction
Fish scrap	5.0	3.0	0	slowly	acid
Fish meal	10.0	4.0	0	slowly	acid
Guano, Peru	13.0	8.0	2.0	moderately	acid
Guano, bat	10.0	4.0	2.0	moderately	acid
Sewage sludge	2.0–6.0	1.0–2.5	0.0–0.4	slowly	acid
Dried blood	12.0	1.5	0.8	mod. slow	acid
Soybean meal	7.0	1.2	1.5	slowly	v. sl. acid
Tankage, animal	9.0	10.0	15.5	slowly	acid
Tankage, garbage	2.5	1.5	1.5	very slowly	alkaline
Tobacco stems	1.5	0.5	5.0	slowly	alkaline
Seaweed	1.0	---	4.0–10.0	slowly	---
Bonemeal, raw	3.5	22.0	---	slowly	alkaline
Urea*	45.0	---	---	quickly	acid
Castor pomace	6.0	1.2	0.5	slowly	acid
Wood ashes	---	2.0	4.0–10.0	quickly	alkaline
Cocoa shell meal	2.5	1.0	2.5	slowly	neutral
Cottonseed meal	6.0	2.5	1.5	slowly	acid
Ground rock phosphate	---	33.0	---	very slowly	alkaline
Green sand	---	1.0	6.0	very slowly	---
Basic slag	---	8.0	---	quickly	alkaline
Horn and hoof meal	12.0	2.0	---	---	---
Milorganite	6.0	2.5	---	---	---
Peat and muck	1.5–3.0	0.25–0.5	0.5–0.10	very slowly	acid
Spent mushroom compost	2.0	0.74	1.46	moderately	6.4

Urea is an organic compound, but since it is synthetic, it is doubtful that most organic gardeners would consider it acceptable.

Approximate nutrient content of soil amendment materials commercially available in bulk are listed in this table. It also gives information on the availability of nutrients to soil and plants. Slowly available material means nutrients last relatively longer and are available to plants longer in the soil compared to quickly released nutrients.

The soil reaction column indicates if the material will have an acidifying or alkaline impact on soil. For basic soils, adding acidifying material helps lower the pH. v. sl. = very slightly

Note: Tables 1–3 are slightly modified from CIR375 of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Originally published in April 1993, it was updated in May 2003. Find it at **http://edis.ifas.ufl.edu**.

insect, disease, and weed problems. Members of the Brassica family, especially the oilseed radishes, contain natural chemicals that inhibit and kill soil-inhabiting pest problems.

The three tables that follow offer guidance on managing your compost piles to meet your soils' needs. Chapter 5, Soils and Fertilizers, in this book explains the significance of macronutrients N (nitrogen), P (phosphorous — designated P_2O_5 as phosphate in fertilizers), and K (potassium — designated K_2O or potash in fertilizers).

Dealing with Pests

The first approach to fighting pests is cultural control methods. In some cases this is the only option. For organic growing, the goal is to reach a stability or balance between pests and desirable plants. This balance comes about by maintaining diversity within the system. Reaching a good diversity level in a small garden plot is somewhat more difficult than in a large-scale operation, but it is a sound concept to strive for at any level of organic production.

Table 2. Composition of fresh manure with a normal quantity of water.

Kind of Manure	%Water	%N	%P	%K
Cow	86	.55	.15	.50
Duck	61	1.10	1.45	.50
Goose	67	1.10	.55	.50
Hen	73	1.10	.90	.50
Hog	87	.55	.30	.45
Horse	80	.65	.30	.45
Sheep	68	1.00	.75	.40
Steer or feed yard	75	.60	.35	.55
Turkey	74	1.30	.70	.50

This table gives an approximate amount of the noted nutrients that are added to the compost pile when composting fresh manure. The finished compost will vary in nutrient level depending on composting efficiency.

The initial cultural practice to adopt is crop rotation. Crop rotation is the habit of rotating different families of plants in the same area in the garden — for example, planting potatoes one year then tomatoes the next. This encourages both soilborne and aboveground pests that cause problems in this family to increase.

Table 3. Composition of various materials thrown into compost piles.

Compost Material	%N	%P	%K
Banana skins (ash)	---	3.25	41.76
Cantaloupe rinds (ash)	---	9.77	12.21
Castor bean pomace	5.00	2.00	1.00
Cattail reeds	2.00	0.81	3.43
Coffee grounds	2.08	0.32	0.28
Corncob ash	---	---	50.00
Cornstalks and leaves	0.30	0.13	0.33
Crabgrass, green	0.66	0.19	0.71
Eggs, rotten	2.25	0.19	0.15
Feathers	15.30	---	---
Fish scrap	2.00–7.50	1.50–6.00	---
Grapefruit skins (ash)	---	3.58	30.60
Oak leaves	0.80	0.35	0.15
Orange culls	0.20	0.13	0.21
Pine needles	0.46	0.12	0.03
Ragweed	0.76	0.26	---
Tea grounds	4.15	0.62	0.40
Wood ashes*	---	1.00	4.0–10.00

The composition of materials commonly found in or near the home are listed. If your soil is deficient in a certain nutrient, add material to the compost pile that is high in that nutrient to raise its level in the finished compost.

*Note: Do not compost wood ashes if you are going to apply the finished compost to alkaline soil.

However, following carrots, which tend to compact the soil, with corn, which tends to loosen it, helps soil tilth. Very few pests attack both of these crops.

- Higher crop yields — Through crop rotation, the garden area reaps several benefits. Higher crop yields have been demonstrated when crops are rotated.
- Microbial biomass — There is also an increase in soil microbial biomass, which helps ward off soilborne diseases and increases carbon dioxide generation.
- Nitrogen (N) increase — There is also an increase in N (related to the increased microbial biomass), which can decrease the need to add more N.
- Drainage and moisture holding — Crop rotation has also been demonstrated to increase drainage and moisture-holding capacity and reduce soil compaction.
- Weed suppression — Another great benefit of crop rotation is weed suppression. Different crops are prone to different types of weeds. For example, squash is considered a weed-suppressive crop because it shades the ground and inhibits weed seed germination, while corn is generally widely spaced and takes some time to grow sufficiently to shade out weeds.

Pest Control Strategies (Idaho Information)

One may think that any organic substance is allowable for use in organic production. This is not the case. For example, tobacco dust (nicotine sulfate) is not allowed in Idaho because of its extreme toxicity. Federal and state regulations list what materials may be used in organic food production. In Idaho, get detailed information by writing to Idaho State Department of Agriculture, Ag Inspections Division, PO Box 790, Boise, Idaho, 83701-0790.

Weed Control

Weed control is probably the most challenging part of organic gardening. Very few acceptable organic chemical controls are available for fighting weeds.

VINEGAR

One notable exception is vinegar, which has been shown to control many annual weeds when used at 10%–20% strength. Household vinegar is typically about 5%. In its concentrated state, vinegar can cause burns and eye damage. Availability is somewhat limited, but as the demand grows it will become more available in local nurseries. Sources can be found on the internet. As with any pesticide, care should be taken when using vinegar for controlling weeds.

CORN GLUTEN

Corn gluten is another herbicide that may be used in organic growing. Used as a preemergent, it has been shown to be effective against a large number of weeds. It reduces weed seed germination with no apparent effects on transplanted materials. It is also effective in lawns as a preemergent herbicide. Corn gluten can usually be found in well-stocked nurseries and also on the internet.

CULTIVATION

The most common way to control weeds is through cultivation. In small garden plots, the hoe becomes your best friend. In larger gardens, a rototiller can be used effectively, especially if crop rows are properly spaced. A drawback to the use of rototillers is that they can damage crop roots if you go too deep or too close to desirable plants. Another disadvantage is that you can create a hardpan in your soil through repeated use. As the tines go down into the soil and rotate they tend to compact the soil just below the depth of the cultivation. Overall, however, rototillers are a great asset in the battle against weeds.

MULCHING

Mulching is a very effective way to keep weeding to a minimum. Almost any material that will allow moisture to reach the soil but keep the light off the soil works as a mulch. Such things as compost, sawdust, grass clippings, leaves, weed matting, newspapers (noncolored inks), and black plastic with perforations to allow water to reach the soil, as well as many other items will greatly aid in the fight against weeds. Make sure the mulch is thick enough to keep sunlight from hitting the soil surface, but do not pile it so high as to reduce oxygen in the soil or to start the composting process, which could produce heating problems around the desirable vegetation. Probably 4 inches is a good maximum depth. Mulching can be done anytime of the year.

THERMAL WEEDING, FLAMING

Another technique that saves time in a large garden is thermal weeding or flaming. This method dehydrates weeds and is very effective. It can be used as a preplant, preemergent, postemergent, or preharvest treatment. A device such as a propane burner is lighted and passed over the tops of the offending weeds just before planting the desired crop. A good technique in preemergence crops, especially in carrots and beets, is to allow weeds to germinate and then plant crop seeds among weed seedlings. Wait about a week, then flame the weeds in the preplant state, thus allowing seeds to sprout in a weed-free environment. During postemergence and preharvest, keep the heat of the flame away from desirable vegetation, either by distance or use of heat-resistant shields, such as tin or other metal. Also use preharvest flaming to remove potato foliage prior to harvest.

SOIL SOLARIZATION

A method of controlling weeds, soil-dwelling insects, and soilborne diseases is soil solarization. Soil is more or less pasteurized through the heat of the sun. Benefits include reduction of pest problems and stimulation of beneficial organisms. First, till the soil to enhance the conduction of heat, moistening the ground to be treated to at least 1 foot deep.

Then place clear plastic over the soil. Anchor the ends securely to keep the plastic in place. This technique is mainly useful in United States Department of Agriculture Zones 5 and above. If you live in Plant Hardiness Zone 4 or less, the generated heat units will probably not be sufficient to heat the soil enough to kill very many weed seeds, insects, or disease organisms.

SOAP-BASED AND OIL-BASED HERBICIDES

Some soap-and oil-based herbicides are cleared for organic food production. They work by burning the foliage back and can be effective in certain situations. When using them, keep desired vegetation protected because they will burn the leaves of all plants. They generally are not effective in controlling perennial weeds.

OTHER METHODS

Other methods also may reduce weed pressure.

Weed-Free Manure/Mulch

Make sure manure and mulch sources are weed free, if possible.

Remove Weeds

Remove weeds from the garden before they go to seed.

Avoid Weed Hitchhikers

If you borrow equipment, check to see that you do not bring in weed seeds from soil or other matter adhering to the equipment. Vehicles, clothing, and animals may also transport weed seeds.

Composting

Composting weeds that have weed seed attached is not a good plan. If the composting process is done incorrectly, weed seeds may survive and become a problem.

Timing Your Planting

The timing of planting may prevent weed pressures. For example, mustards are generally an early spring problem. Delaying planting until the mustards have emerged and been removed may reduce weed problems.

Avoid Bare Soil, Green Manure

Maintain a crop cover instead of leaving bare soil to inhibit or prevent weed seed from germinating. To accomplish this, use green manures before or after the crop is put in. Green manures such as winter rye, buckwheat, mustards, oilseed, radishes, crimson clover, hairy vetch, or subterranean clover have all demonstrated the ability to suppress certain weeds.

Geese

Several species of geese have been used successfully to weed out grasses from crops and may be of some use in a garden.

Insect Control

The best control of insect pests is through maintaining healthy plants. Many insect pests are attracted to unthrifty plants. An ounce of prevention is indeed worth a pound of cure. Insects can pose serious problems in an organic garden. It is vital that you scout your garden for insects and try and control them before they have a chance to multiply. Three methods can be used to control insects organically: mechanical control, biological control, and insecticides (chemical control).

MECHANICAL CONTROL

Mechanical control is the first line of defense in combating insect pests.

Remove By Hand

Probably the most common way to control insects is to use the tried and true method of removing them physically from the plants. This method is very effective in a small garden. You can either pluck them from the surface or use a leaf to squash them. You will also be able to see egg clusters and remove them before they hatch.

Water Jet

Another easy way to remove certain insects from plants is to use a strong jet of water and wash them off the plant. This is especially effective with aphids. Once on the ground, aphids become prey for several ground-dwelling predators.

Floating Row Covers

A very effective defense against flying insects are floating row covers, available at well-stocked lawn and garden stores. They work by physically excluding flying insects access to the crop. Row covers are generally ineffective against soil-dwelling insects. They need to be in place before the insects have a chance to lay eggs on the plants. Floating row covers are effective in controlling lepidopteron larvae (caterpillars), flying pests of onions, carrots, and some leaf-mining insects, as well as other pests.

Sticky Traps

Sticky traps used in combination with insect attractants can be effective.

Bug Vacuums

Bug vacuums available commercially are very useful in removing large numbers of insect pests. However, they remove all insects, including beneficial ones. If you have beneficial insects helping you out, then this is a less attractive method.

Ultraviolet (UV) Bug Zapper

Should you be tempted to use a UV bug zapper to control insects, be aware that you will probably kill more beneficial insects than injurious ones.

BIOLOGICAL CONTROL

This method uses insect predators, parasites, and pathogens to help control pestiferous insects. When using this method of control, it is important to recognize and understand beneficial insects, their life cycles, and how to maintain them.

Strategies

Plant Diversity

Plant diversity is important in maintaining a viable beneficial insect population. Many helpful insects are nectar feeders so flowering plants are desirable. Many plants in the Apiaceae (formerly known as Umbelliferae) family — such as fennel, angelica, coriander, dill, parsley, and wild carrot — provide several tiny flowers needed by parasitoid wasps. Clovers, yarrow, and rue also attract parasitoid and predatory insects.

Low-Growing Plants

Ground-dwelling beneficial insects such as ground beetles seek low-growing plants for protection. Thyme, rosemary, or mint provide such shelter. Composite flowers, such as daisy and chamomile, and mints attract predatory wasps, hoverflies, and robber flies.

Safe Haven

If possible, dedicate a small area of the garden to plants that attract beneficial insects. Think of it as a safe haven. Insects will be able to maintain their populations by living off the deleterious insects in nearby untreated areas.

Helpful Beneficial Insects

The following is a partial list of organisms that can be used to your advantage in combating insect infestations.

Ladybird Beetles (Ladybugs)

These familiar insects are very beneficial in consuming soft-bodied insects, especially aphids and mealybugs. Both adults and larvae dine on these pests, but the larvae consume substantially more than do adults. The larvae somewhat resemble miniature alligators and many gardeners think they are harmful, so make sure you recognize them. Ladybird beetles may be purchased from several sources. Be sure to have some way to contain them, such as a fine-meshed net or a tent (be careful to ventilate to avoid heat buildup), for a few days when you release them to get them established in your backyard. When first released they have a tendency to disperse and mate.

Lacewings

These insects also prey on soft-bodied insects, eggs, and mites. Adults have delicate wings and the faint smell of mothballs. The larvae, as with ladybird beetles, are voracious eaters. Lacewing eggs are laid singly on a stalk and are fairly common in organic as well as conventional systems.

Wasps

Many wasp species parasitize several different orders of insects. They are generally very small and pose no threat to humans. They attack insect eggs, larvae, and adults.

***Bacillus Thuringiensis* (Bt)**

Several strains of this bacterium have been very effective in controlling insect pests. They form a crystal that is toxic to certain insects but not to warm-blooded mammals.

The crystal dissolves in an insect's digestive system. When first discovered, these bacteria were found to be very useful in controlling lepidopteran pests (caterpillars), including codling moths and cabbage loopers. Since then, other Bt strains have been found that are effective against certain coleopteran pests (beetle family), including Colorado potato beetles. For this control method to work, the material has to be eaten by the insect. Several products on the market contain Bt. Make sure you purchase the type that is effective against pests you are trying to control. Unfortunately, some resistance to Bt has begun to show up in certain insect populations, especially the diamondback moth, a pest to cole crops, so caution is advised when using Bt as a control. Whenever there is a possibility of a pest species gaining resistance to a certain control strategy, it is very wise to rotate control methods.

In several crops, this toxin has been genetically engineered into the plant. Any genetically engineered plant or other organism is not acceptable in organic production.

Nematodes

These organisms are microscopic simple roundworms. Several nematodes are available that control several soilborne pests. Nematodes may be purchased at many well-stocked lawn and garden outlets. When purchasing them, be sure you know the targeted pests you wish to control because the nematodes have a fairly specific host range. They have been shown to be very successful in controlling certain insect pests when applied strictly according to label instructions. They are very sensitive to desiccation (extreme drying) and to UV radiation. Nematodes that are especially beneficial for Idaho pests include

- *Heterorhabditis bacteriophora* — for root weevils on ornamentals, billbugs, and scarabs (june bugs) in lawns and also for root weevils in berries
- *Steinernema feltiae* — for fungus gnats
- *S. carpocapsae* — for armyworms, cutworms webworms, girdlers, and wood borers.
- Other nematode species may also be effective. There are undoubtedly other nematodes that will be developed to control problem insects.

Beneficial Fungi

Specific fungi are commercially available that have shown control in aphids, whiteflies, leafhoppers, flies, beetles, caterpillars, thrips, mites, and some beetle larvae. These fungi may also attack beneficial insects. Under the right conditions they can be very effective, but as with most fungi, humid conditions are usually needed for efficacious control. *Beauveria bassiana* is the most common fungal insecticide used.

Beneficial Viruses

Certain viruses are effective in controlling insect pests, mainly in the Lepidoptera (moths) family. To be effective, viruses must be consumed by the insect. As with the other biological control methods previously mentioned, these viruses pose no threat to human health. They also do not directly cause problems for insect predators. Viruses are currently limited in their availability but through diligent searching one may find a source. Check the internet for leads or with universities or private companies to find out if they are involved in this line of research.

CHEMICAL CONTROL

Initially, the use of pesticides in organic gardening seems incompatible with the total concept of organic gardening, yet several pesticides are used in organic production. They are not synthetically made, however, and materials allowed in organic pest control are subject to close scrutiny. The fact that pesticides are considered okay to use in organic food production and are naturally derived does not mean that they are nontoxic. Some allowed substances are very toxic and it is vital to read and understand labels before using any pesticide. Just as common chemicals are given toxicity ratings, so are chemicals from botanical and mineral-bearing sources. **CAUTION** means low toxicity or fairly safe to use; **WARNING** means moderately toxic; and **DANGER** means highly toxic. To qualify as an organic pesticide, the product must be from natural

sources, cannot be genetically modified, and must be certified as a pesticide that is usable in organic food production.

The following insecticides are some of the more common ones currently registered in Idaho for use in organic production. This is not a complete list. New pesticides become available to the organic grower on a fairly regular basis.

Each state may recognize different chemicals as proper to use in organic production. If you are growing produce to sell organically, check the most current information. Contact information for Idaho is listed at the end of the chapter.

Pyrethrum/Pyrethrin

Extracted from chrysanthemums, this pesticide affects the nervous system of insects and is very effective against a wide variety of insect pests. Several formulations are available, some containing ingredients that are not allowed in organic production.

One common additive — piperonyl butoxide — is not permitted in organic production systems, so read the label carefully when purchasing pyrethrum-based insecticides. Several instances of allergic skin reactions have been reported, so take care to keep it off your skin.

Pyrethroids are synthetically made materials based on the chemistry of natural pyrethrins. Because they are synthetic, they are not allowed for use on organic crops.

Boric Acid

Boric acid has been used for a long time in controlling pests. It is allowable in organic production systems as long as it does not get on edible portions of the plant. There are various bait and dust formulations.

Diatomaceous Earth

This material is composed of the fossilized skeletons of microscopic water plants called diatoms. They extract silica from the water and incorporate it into their skeletal systems. When they die their skeletons form a diatomite deposit. After being ground, this material turns into very small glass-like particles able to cut the cuticle of insects and cause desiccation. It is fairly safe to use, but the dust can irritate lungs and eyes.

Sabadilla

Derived from seeds of the sabadilla lily, the active ingredient is an alkaloid known as veratrine. It is both a contact poison and a stomach poison. Sabadilla is one of the least toxic of the botanical pesticides. It can, however, be highly irritating to the eyes and can cause sneezing if inhaled. Sunlight quickly inactivates this material so applications in the evening are best.

Neem

Used in India and Africa for more than 4,000 years for medicinal and pest-control purposes, neem is derived from seeds of the neem tree, a native of India. Compounds derived from the seeds have both insecticidal and fungicidal properties. Neem blocks a molting hormone in insects and terminates the molting process. Effective against a wide range of insect pests, neem is an effective, but not a fast-acting insecticide, so do not expect quick results. It has a very low mammalian toxicity.

Rotenone

A compound produced by the roots of two members of the Leguminosae family, rotenone is effective on leaf-feeding insects such as caterpillars, beetles, aphids, and thrips. As with neem this is a slow-acting chemical. Insects stop feeding shortly after ingesting the material. This material is extremely toxic to fish but only moderately toxic to most mammals.

Horticultural, Summer, Dormant Oils

Oils, effective against a wide range of insects, are only to be used on woody plants. They can be very effective in controlling things like scale, mealybugs, and insect eggs, coating and smothering insects and their eggs. Oils are relatively more effective against active insects than dormant ones. Several different and sometimes confusing names are used for horticultural oils.

Heavier oils are used during the dormant period — late winter and early spring — on woody plant material, so they are called dormant oil. Summer oils or horticultural oils are lighter in consistency and relatively safe to use when plants are in leaf, but may cause leaf burn. Most horticultural oils are petroleum-based, but other types of oils — neem, vegetable, and fish — can also be effective.

Sulfur is sometimes a problem in horticultural oils and some oils have a "UR" (unsulfonated residue) rating. The higher the UR rating, the lower the sulfur content. Most horticultural oils have a UR rating of 90 or above. Oils are fairly safe around beneficial insects because most of them have the ability to escape. Some beneficials, such as predatory mites, succumb to oil applications since they cannot remove themselves from harm's way.

Oils such as carrot and weed oils are not permitted for use in organic production. A few plant species are very sensitive to oil applications, among them Japanese and red maple, hickories and black walnut, plume cedar, and smoke tree. Other sensitive plants are redbud, juniper, cedar, spruce, and Douglas fir. If you apply oil to a blue spruce, the blue color will be lost.

Insecticidal Soaps

Insecticidal soaps are very safe and useful in controlling a wide variety of insects. Many gardeners are tempted to buy material that is labeled for insect control. All clothes detergents, however, cause harm to plants as do most other forms of dry soaps (burnt foliage). Insecticidal soaps are formulated with potassium salt of fatty acids. Commercially available insecticidal soaps are selected to control insects, to minimize potential plant injury, and are of consistent manufacture.

Sulfur

Sulfur is probably the oldest-known pesticide in use. The Greek poet Homer described the benefits of "pest-averting sulfur" 3,000 years ago. It can be used in several forms such as a dust, wettable powder, paste, or liquid. It can help control spider mites, psyllids, and thrips and can be used on a variety of crops, including beans, potatoes, tomatoes, and peas. It also is used on a number of fruit crops such as apples, cherries, grapes, peaches, pears, plums, and prunes. Sulfur is relatively safe to use, although it may cause eye and skin irritation, and, if applied when temperatures are above 90°F, it can burn the plant. Also, it reacts with other pesticides so it is best to apply it alone. If you use oils, be sure not to use sulfur within 20–30 days because sulfur and oil react together to cause phytotoxicity.

Other Products

Several other effective products are available to control insects and are certified for use in organic production, including garlic and herb preparations, lime sulfur, insect extracts, pheromones, etc. As you gain experience with organic gardening, you will become more familiar with these products. See the end of this chapter for several books and online resources to help you further resolve pest problems, along with additional reading material.

Disease Control

As with insect control, the best way to control diseases is to maintain healthy plants. Choosing the proper plants for the garden, matching the plant to the soil type, proper light levels and irrigation needs, correct sanitation, and proper fertilization and pruning go a long way to maintaining a healthy garden.

Prevention is extremely important when it comes to dealing with plant diseases. Once established, diseases are almost impossible to eradicate from stricken plants and they act as a reservoir for the infection of healthy plants. Don't start out with a disease problem. Purchase disease-free stock. Generally, vegetatively propagated material has some type of certification stating it is either virus free or, at worst, that low levels of virus are present.

In fighting diseases, remember the disease triangle. The three components needed to have disease are a susceptible host, a pathogen capable of causing disease, and the proper environment for the disease to thrive.

Armed with this basic knowledge, approach disease control from several angles. For example, if you have problems with your tomatoes and *Verticillium* wilt, probably the easiest way to correct them would be to purchase *Verticillium*-resistant tomato plants. Many garden vegetables that are susceptible to *Verticillium* wilt have cultivars with resistance bred into them.

Another approach to minimizing disease is to remove diseased plant material, thus reducing the pathogen population. Such steps as removing fallen diseased leaves, pruning out diseased portions of a plant, or removing the entire diseased plant help to reduce disease pressure.

Most plant diseases are caused by fungi. Fungi like high humidity. By changing the environment through such things as drip irrigation and wider spacing of plants, the overall humidity is reduced thus decreasing the chances of fungi-causing problems.

Organic fungicides are available that are fairly effective against several disease problems faced by gardeners. As with herbicides and insecticides, fungicides should be used only after other controls have failed.

POPULAR FUNGICIDES

Below is a brief discussion on some of the more popular fungicides used by organic gardeners.

Sulfur

In addition to being an effective insecticide, sulphur has fungicidal properties and is effective in controlling and suppressing several plant diseases. First used some 2,000 years ago by the Greeks to control rust on wheat, sulfur is used as a preventive fungicide, which means to be effective it has to be on the plant surface before the disease gets inside the plant.

It is useful against powdery mildews, rose black spot, rusts, and other diseases. It works by inhibiting the germination of the fungal spores. It is available in several forms, including dusts, liquids, and wettable powders.

Keep in mind that sulfur can burn foliage if the temperatures are above 80°F and if oils have been used within the last 20–30 days. Plants sensitive to sulfur include apricots, some raspberries and blackberries, gooseberries, currents, and cucurbits.

Lime Sulfur

Lime sulfur is made by boiling lime and sulfur together. The lime helps the sulfur penetrate the plant tissue. The mixture has insecticidal properties as well as fungicidal ones. It helps control diseases such as anthracnose and powdery mildew when used as a dormant spray. It also aids in the control of scale insects, thrips, and eriophyid mites.

Drawbacks to using lime sulfur are its smell of rotten eggs and it can burn exposed skin and eyes. It will also injure plants if temperatures are above 80°F.

Bordeaux Mixture

This is a natural pesticide produced by a reaction between copper sulfate and calcium hydroxide (hydrated lime). It was first used in Bordeaux, France, to control downy mildew on grapes, hence its name.

Like sulfur, Bordeaux is a preventive fungicide that needs to be in place before the disease shows up. It has a very long track record — more than 150 years. Fungicidal as well as bacterial properties extend its utility in organic production.

Bordeaux has the advantage of sticking to plants despite rain or irrigation. It controls bacterial leaf spots, blights, various types of anthracnose, downy mildews, and cankers. It also repels many insects.

Uses. Bordeaux is labeled for use on many vegetables, tree fruits, and nut crops.

Drawback. One drawback is that, like sulfur and lime sulfur, it can be phytotoxic to plants. It can burn leaves and cause russeting of fruits if applied in cool wet weather.

Formulations. There are various formulations of Bordeaux mixture, but perhaps the best all-around mix is 4-4-50 — four pounds of copper sulfate and four pounds of hydrated lime in fifty gallons of water. Generally a weaker solution of Bordeaux is recommended for foliage in early spring and a heavier solution for late-in-the-season applications for protection against serious diseases like late blight.

Copper caution. One caution to keep in mind with Bordeaux mix is that excessive use will cause a buildup of copper in the soil. Copper is toxic to fish and is a heavy metal. Bordeaux fungicide can be purchased premixed, but it is more effective if prepared just before use. Plants, including ornamental sorghum and corn, are sometimes sensitive to copper-based pesticides. Also, use caution when applying Bordeaux to tender leaves of apple, pear, plum, or rose as they may be burned. Geraniums, ivy, pansy, celery, strawberry, azaleas, dogwood, and juniper are also sensitive so use of dilute sprays is advised.

Other Fungicide Options

Neem oil has fungicidal properties. Hydrogen peroxide, dormant oils, the antibiotics streptomycin and tetracycline, as well as several mineral- and plant-based materials can be valuable in protecting your crop. See “Further Reading” at the end of the chapter and the online resources to aid your search for solutions to these problems.

Seek Reliable Data

When using compounds to control pests in an organic system, it is advisable to make sure reliable data supports its use and that it is registered for use on the intended plant species you wish to treat. Many homegrown recipes purportedly solve all sorts of problems. In some cases, they may be effective but may also cause unwanted side effects, such as the buildup of harmful compounds in the soil, unexpected detrimental effects on beneficial fauna and flora, and possible toxic-generated materials and side effects.

Summary

Gardening organically can be very rewarding. Through the process one will gain a much greater appreciation of natural checks and balances. By working within nature's parameters, we gain a deeper understanding of how natural processes work in our favor. Organic food production involves a certain state of mind, as well as a defined food production system. Organic growing involves a holistic approach to growing, instead of the more common approach of treating problems individually. There will certainly be a learning curve associated with this approach, but once a gardener understands how things interrelate, the process becomes much more manageable and enjoyable.

Further Reading

BOOKLETS AND PAMPHLETS

University of Idaho Extension

BUL 775 *Planning an Idaho Vegetable Garden*

CIS 993 *Management of Vegetable Diseases in Home Gardens*

CIS 1066 *Composting at Home*

EXT 726 *Weed Control in the Home Garden*

PNW 328 *Using Horticultural Mineral Oils to Control Orchard Pests*

PNW 533 *Fertilizing with Manure*

PNW 550 *Encouraging Beneficial Insects in Your Garden*

Oregon State University Extension

EC 1247 *Gardening with Composts, Mulches, and Row Covers*

PNW Pest Management Handbooks: Insect Management, Plant Disease, and Weed Management, **https://pnwhandbooks.org/**

Utah State University Extension

HG-510 *Selecting and Using Organic Fertilizers*

Washington State University Extension

EBO 648 *Organic Gardening*

BOOKS

Ball, J. 1988. *Rodale's Garden Problem Solver; Vegetables, Fruits, and Herbs*. Emmaus, PA: Rodale Press. ISBN 0-87857-762-9.

Organic Gardening Magazine. 1978. *The Encyclopedia of Organic Gardening*. Emmaus, PA: Rodale Press. ISBN 0-87857-225-2.

Ware, W. W. 1988. *Complete Guide to Pest Control With and Without Chemicals*. Fresno, CA: Thomas Publications. ISBN 0913702-09-9.

WEBSITES

Organic certification information: **https://attra.ncat.org/topics/organic-certification/**

Idaho State Department of Agriculture Organic Program: **https://agri.idaho.gov/main/about/about-isda/ag-inspections/organic-certification-program/**

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Pesticide laws and labels change frequently and may have changed since this publication was written. Some pesticides may have been withdrawn or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless the specific plant, animal, or other application site is specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Trade Names — To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater — To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

GLOSSARY

abiotic disease. A condition caused by nonliving, nonparasitic, or noninfectious agents.

abscission. The dropping of leaves, flowers, or fruit by a plant. Can result from natural growth processes (e.g., fruit ripening) or from external factors such as temperature or chemicals.

abscission layer. Specialized cells, usually at the base of a leaf stalk or fruit stem, that trigger both the separation of the leaf or fruit and the development of scar tissue to protect the plant.

absorption. The intake of water and other materials through root or leaf cells.

accumulated heat units. Number of heat units in a growing season. Usually calculated at temperatures above 50°F, but can be calculated at other temperatures, depending on the crop. A day's heat units are calculated as

$$\frac{\text{Max temp(°F)+Min temp(°F)}}{2} - 50°\text{F}$$

acid soil. Soil with pH below 7 on a pH scale of 1–14. The lower the pH, the more acid the soil. (See also pH.)

active ingredient. The chemical in a pesticide formulation that actually kills the target pest.

additive. A substance that, when added to a pesticide, reduces the surface tension between two unlike materials (e.g., spray droplets and a plant surface), thus improving adherence. Also called an adjuvant or surfactant.

adjuvant. See additive.

adventitious. Growth not ordinarily expected, usually the result of stress or injury. A plant's normal growth comes from meristematic tissue, but adventitious growth starts from nonmeristematic tissue.

adventitious bud. A bud that develops in locations where buds usually do not occur. An example would be buds found on root pieces used for propagation; roots do not have buds.

adventitious root. A root that forms at any place on the plant other than the primary root system.

aeration. The practice involving the removal of cores or turf plugs and soil to reduce compaction and improve air flow.

aerial root. An unusual type of root that develops on stems aboveground.

aerobic. Active in the presence of free oxygen.

after-ripening. The seed maturation process that must be completed before germination can occur.

aggregation. The process by which individual particles of sand, silt, and clay cluster and bind together to form soil peds.

agriculture. The study of plants in relation to field crop production.

agronomy. The science of crop management, including the study of soils.

alkaline soil. Soil with pH above 7 on a pH scale of 1–14. The higher the reading, the more alkaline the soil. (See also pH.)

allelopathy. The excretion by some plants' leaves and roots of compounds that inhibit the growth of other plants.

alternate leaf arrangement. Leaves are attached at alternating points from one side of the stem to the other.

ammonium. A plant-available form of nitrogen contained in many fertilizers and generated in the soil by the breakdown of organic matter. (See also nitrogen cycle.)

anaerobic. Active in the absence of free oxygen.

analogous. In landscaping, use of adjacent colors on the color wheel such as blue, violet, and red.

anatomy. The study of plant structure.

angiosperm. Flowering plants. Plants that have a highly evolved reproductive system. Seeds enclosed in an ovary such as a fruit, grain, or pod.

anion. Negatively charged ion, for example, chloride.

anion exchange. The interaction of anions on the surface of an active material with those in solution.

anion exchange capacity (AEC). The sum total of exchangeable anions that a soil can absorb expressed in meq/100 g (milliequivalents per 100 grams) soil.

annual. Plants that grow, mature, flower, produce seed, and die in one season.

Anoplura. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts (sucking lice).

anther. The pollen-bearing part of a flower's male sexual organ. The filament supports the anther; together they are referred to as the stamen.

anthracnose. Plant disease characterized by black or brown dead areas on leaves, stems, or fruits.

anvil pruner. A pruning tool that cuts a branch between one sharpened blade and a flat, anvil-shaped piece of metal. Has a tendency to crush rather than make a smooth cut.

apex. The tip of a stem or root.

apical dominance. The inhibition of lateral bud growth by the presence of the hormone auxin in a plant's terminal bud. Removing the growing tip removes auxin and promotes lateral bud break and subsequent branching, usually directly below the cut.

apical meristem. Area of the plant shoot and root tips where cells actively divide to provide more cells that expand and develop into the tissues and organs of the plant. Also called shoot meristem.

arboretum. An area devoted to specimen plantings of trees and shrubs.

asexual propagation. See vegetative propagation.

aspect. Direction of exposure to sunlight.

assimilation. Building of cell matter from inorganic (minerals) and organic materials (carbohydrates and sugars).

attractant. A material that lures pests.

auxin. One of the best-known and most important plant hormones. Most abundantly produced in a plant's actively growing tips. Generally stimulates growth by cell division in the tip region and by cell elongation lower down the shoot. Growth of lateral buds is strongly inhibited by the normal concentration of auxin in the growing tip.

available water supply. Soil water that is available for plant uptake. Excludes water bound tightly to soil particles.

axil. The upper angle formed by a leaf stalk (petiole) and the internodes above it on a stem.

axillary bud. An undeveloped shoot or flower that is found at the node. Also called the lateral bud.

bacillus thuringiensis. A bacterium used as a biological control agent for many insect pests.

bacterium. A single-celled, microscopic organism that has a cell wall but no chlorophyll. Reproduces by cell division.

balled and burlapped. A plant dug with soil. The root ball is enclosed with burlap or a synthetic material.

band. To apply a pesticide or fertilizer in a strip over or along each crop row.

bare-root. A plant with little or no soil around its roots; deciduous plants and small evergreens are commonly sold bare-root.

basal. (1) At or near the base of a branch or trunk. (2) At or near a plant's crown.

basal break. New growth that develops at the base of a branch or near a plant's crown.

beneficial fungi. Fungi used in controlling organisms that attack desirable plants.

beneficial insect. An insect that helps gardening efforts. May pollinate flowers, eat harmful insects or parasitize them, or break down plant material in the soil, thereby releasing its nutrients. Some insects are both harmful and beneficial. For example, butterflies can be pollinators in their adult form but destructive in their larval (caterpillar) form.

berry. The fleshy fruit of cane fruits, bush fruits, and strawberries.

biennial. Plants that take two years, or a part of two years, to complete their life cycle.

biennial bearing. Producing fruit in alternate years.

binomial. A biological species name consisting of two names: the genus name and specific epithet.

biological insect control. The use of beneficial organisms to control pest insect populations.

biosolids. A by-product of wastewater treatment sometimes used as a fertilizer, also known as municipal sewage sludge.

blackleg. Darkening at the base of a stem.

blade. The flat thin part of a leaf.

blanch. To exclude light from plants or parts of plants to render them white or tender. Often done to cauliflower, endive, celery, and leeks. Also used to promote adventitious root formation on stems.

blight. Rapid death of leaves and other plant parts.

blotch. A blot or spot (usually superficial and irregular in shape) on leaves, shoots, or fruit.

bole. See trunk.

bolting. Producing seed or flowering prematurely, usually due to heat. For example, cool-weather crops such as lettuce bolt during summer; leaf crops are discouraged from bolting by removing flower heads. (See also deadhead.)

bonsai. One of the fine arts of horticulture; growing carefully trained, dwarfed plants in containers selected to harmonize with the plants. Branches are pruned and roots trimmed to create the desired effect.

botanical insecticide. An insecticide, such as rotenone or pyrethrum, derived from a plant. Most botanicals biodegrade quickly. Most, but not all, have low toxicity to mammals.

botanical maturity. In fruits, refers to a final stage of development when the fruit is still on the plant and cell enlargement and the accumulation of carbohydrates and other flavor constituents are complete.

botany. The science that studies all phases of plant life and growth.

botrytis. A fungal disease promoted by cool, moist weather. Also known as gray mold or fruit rot.

bract. A modified leaf, usually small, but sometimes large and brightly colored, growing at the base of a flower or on its stalk. Clearly seen on dogwoods and poinsettias.

bramble. A spiny cane bush with berry fruits (e.g., raspberries and blackberries).

branch. A subsidiary stem arising from a plant's main stem or from another branch.

break. (1) Any new growth coming from a bud. (2) See bud break.

broadcast. (1) To sow seed by scattering it over the soil surface. (2) To apply a pesticide or fertilizer uniformly to an entire, specific area by scattering or spraying it.

broadleaf evergreen. A non-needled evergreen.

brown rot. Soft rot of fruit covered by gray to brown mold.

BTU. British thermal unit. Amount of heat required to raise the temperature of 1 pound of water 1°F.

bud. A small protuberance on a stem or branch, sometimes enclosed in protective scales, containing an undeveloped shoot, leaf, or flower.

bud break. The resumption of growth by resting buds.

budding. A method of asexual plant propagation that unites one bud (attached to a small piece of bark) from the scion to the rootstock.

bud head. A swollen or enlarged area where a bud was grafted to a stock.

bud scale. A modified leaf that forms a protective covering for a bud.

bud sport. See mutation.

bud stick. A shoot or twig used as a source of buds for budding.

bud union. The suture line where a bud or scion was grafted to a stock. Sometimes called a graft union.

bulb. A belowground stem (for example, in tulip) that is surrounded by fleshy scalelike leaves that contain stored food.

bulbil. A small bulblike organ that sometimes forms on aerial plant parts.

bulblet. (1) An underground bulb formed in the leaf axis on a stem. (2) A tiny bulb produced at the base of a mother bulb.

calcium carbonate. A compound found in limestone, ashes, bones, and shells; the primary component of lime.

callus. Tissue that forms over the wounds on plants.

calorie. Amount of heat required to raise the temperature of 1 cubic centimeter of water 1°C.

calyx. The entire set of sepals on a flower.

cambium. A layer of meristematic tissue that produces new phloem on the outside, new xylem on the inside, and is the origin of all secondary growth in plants. The cambium layer forms the annual ring in wood.

candelabrum. A strong, dominant rose cane with accelerated growth that originates from a bud union and explodes with many blooms.

candle. On a pine tree, new terminal growth from which needles emerge.

cane. The externally woody, internally pithy stem of a bramble or vine.

canker. Sunken, discolored, dead areas on twigs or branches, usually starting from an injury, wound, or pathogen.

canopy. (1) The top branches and foliage of a plant. (2) The shape-producing structure of a tree or shrub.

capillary action. The force by which water molecules bind to the surfaces of soil particles and to each other, thus holding water in fine pores against the force of gravity.

capitulum. (1) A dense, short, compact cluster of sessile flowers, as in composite plants or clover. (2) A very dense grouping of flower buds, as in broccoli.

caterpillar. See larva.

catfacing. Disfigurement or malformation of a fruit. Fruits typically affected include tomatoes and strawberries. Catfacing is caused by insects or adverse weather during fruit development, as well as other unknown factors.

cation. Positively charged ion. Plant nutrient examples include calcium and potassium. (See also anion.)

cation exchange capacity (CEC). A soil's capacity to hold cations as a storehouse of reserve nutrients.

cell. A structural, functional unit of a plant.

central leader. (1) A trunk or stem extending up through the axis of a tree or shrub and clearly emerging at the top. (2) A system of pruning that uses the central leader as a basic component. (See also leader.)

cercus. A threadlike or sometimes forceps-like tail near the tip of an insect's abdomen (usually a pair). Plural = cerci.

chelate. A complex organic substance that holds micronutrients, usually iron, in a form available for absorption by plants.

chemical insect control. The use of chemicals or insecticide to control insect populations.

chlorophyll. The green pigment in plants responsible for trapping light energy for photosynthesis.

chloroplast. A specialized component of certain cells. Contains chlorophyll and is responsible for photosynthesis.

chlorosis. Yellowing or whitening of normally green tissue.

clay. The smallest type of soil particle (less than 0.002 mm in diameter).

climber. A plant that climbs on its own by twining or using gripping pads, tendrils, or some other method to attach itself to a structure or another plant. Plants that must be trained to a support are properly called trailing plants, not climbers.

cloche. A plastic, glass, or Plexiglas plant cover used to warm the growing environment and protect plants from frost.

clone. A plant group whose members have all been derived from a single individual through constant propagation by vegetative (asexual) means, e.g., by buds, bulbs, grafts, cuttings, or laboratory tissue culture.

C:N ratio. The ratio of carbon to nitrogen in organic materials. Materials with a high C:N ratio (high in carbon) are good bulking agents in compost piles, while those with a low C:N ratio (high in nitrogen) are good energy sources.

cold composting. A slow composting process that involves simply building a pile and leaving it until it decomposes. This process may take months or longer. Cold composting does not kill weed seeds or pathogens.

cold frame. A plastic-, glass-, or Plexiglas-covered frame or box that relies on sunlight as a source of heat to warm the growing environment for tender plants.

cole crops. A group of vegetables belonging to the cabbage family; plants of the genus *Brassica*, including cauliflower, broccoli, cabbage, turnips, and Brussels sprouts.

Coleoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (beetles, weevils).

collar. A swollen area at the base of a branch where it connects to a trunk. Contains special tissue that prevents decay from moving downward from the branch into the trunk. (See also shoulder ring.)

Collembola. A major order of insects that are wingless and have chewing mouthparts (springtails).

compaction. Pressure that squeezes soil into layers that resist root penetration and water movement. Often the result of foot or machine traffic.

companion planting. The practice of growing two or more types of plants in combination to discourage disease and insect pests.

compatible. Different varieties or species that set fruit when cross-pollinated or that make a successful graft union when intergrafted. (See also pollenizer.)

complementary. In landscaping, use of opposite colors on the color wheel such as red and green, orange and blue, and yellow and violet.

complete fertilizer. A fertilizer that contains all three macronutrients (N, P, K).

complete metamorphosis. A type of insect development in which the insect passes through the stages of egg, larva, pupa, and adult. The larva usually is different in form from the adult. (See also simple metamorphosis.)

compost. The product created by the breakdown of organic waste under conditions manipulated by humans. Used to improve both the texture and fertility of garden soil. (See also humus.)

compound bud. More than one bud on the same side of a node. Usually, unless growth is extremely vigorous, only one of the buds develops and its branch may have a very sharp angle of attachment. If it is removed, a wider-angled shoot usually is formed from the second (accessory) bud. Ashes and walnuts are examples of plants that typically have compound buds.

conifer. A cone-bearing tree or shrub, usually evergreen. Pine, spruce, fir, cedar, yew, and juniper are examples.

conk. A fungal fruiting structure (e.g., shelf or bracket fungi) formed on rotting woody plants.

cordon. (1) A method of espaliering fruit trees, vines, etc., to horizontal, vertical, or angled wire or wooden supports so the maximum branch surface is exposed to the sun, resulting in maximum fruit production. (2) A branch attached to such a support.

cork cambium. On woody plants, the layer of cells that produces bark, or cork, located just below the bark layers.

corm. A belowground stem that is swollen (for example, in crocus).

cormel. A small, underdeveloped corm, usually attached to a larger corm.

cornicle. A short, blunt horn or tube (sometimes buttonlike) on the top and near the end of an aphid's abdomen. Emits a waxy liquid that helps protect against enemies.

corolla. Part of a flower; all of the petals together.

cortex cells. Found beneath the epidermis, these cells help move water from the epidermis and are active in food storage.

corymb. A usually flat-topped flower cluster in which the individual flower stalks grow upward from various points on the main stem to approximately the same level.

cotyledon. A seed leaf, the first leaf from a sprouting seed. Monocots have one cotyledon, dicots have two.

Cover crop. (1) A crop planted to protect the soil from erosion. (2) A crop planted to improve soil structure or organic matter content.

crop rotation. The practice of growing different types of crops in succession on the same land chiefly to preserve the productive capacity of the soil by easing insect, disease, and weed problems.

cross-pollination. The fertilization of an ovary on one plant with pollen from another plant, producing an offspring with a genetic makeup distinctly different from that of either parent. (See also pollenizer.)

crotch angle. The angle formed between a trunk and a main scaffold limb. The strongest angles are 45°–60°.

crown. (1) Collectively, the branches and foliage of a tree or shrub. (2) The thickened base of a plant's stem or trunk to which the roots are attached. (3) Compressed aboveground stems as occurs in grasses.

crown gall. A specific disease caused by the bacterium *Agrobacterium tumefaciens* that causes excessive, undifferentiated growth that may girdle roots, stems, or branches.

cultivar. Contraction of cultivated variety. Propagation of cultivars results in little or no genetic change in the offspring, which preserves desirable characteristics.

cultural insect control. Controlling an insect population by maintaining good plant health and by crop rotation and/or companion crops.

curlytop. Rolling and curling of leaves at the growing point. May be indicative of viral infection.

cuticle. (1) A waxy layer on the epidermis on a leaf. (2) The outer layer of an insect's body.

cutin. (1) A waxy substance on plant surfaces that tends to make the surface waterproof and can protect leaves from dehydration and disease. (2) A waxy substance on an insect's cuticle that protects the insect from dehydration.

cutting. One of several forms of asexual propagation.

cyme. A flower stalk on which the florets start blooming from the top of the stem and progress toward the bottom.

cyst. The swollen, egg-containing female body of certain nematodes. Can sometimes be seen on the outside of infected roots.

damping-off. Stem rot near the soil surface leading to either failed seed emergence or to the plant's falling over after emergence.

day-neutral plant. A cultivar or species capable of flowering without regard to day length. (See also short-day plant; long-day plant.)

deadhead. To remove individual, spent flowers from a plant for the purpose of preventing senescence and prolonging blooming. For effective results, the ovary behind the flower must be removed as well.

deciduous. A plant that sheds all of its leaves annually.

decomposers. The microorganisms and invertebrates that accomplish composting.

decomposition. The breakdown of organic materials by microorganisms.

defoliation. The unnatural loss of a plant's leaves, generally to the detriment of its health. Can be caused by several factors such as high wind, excessive heat, drought, frost, chemicals, insects, or disease.

dehorning. A drastic method of pruning a neglected tree or shrub. Entails the removal of large branches, especially high in the crown, a few at a time over several seasons.

Dermaptera. A major order of insects that have two pairs of wings, or are wingless, and have mouthparts (earwigs).

desiccation. Drying out of tissue.

determinate. A plant growth habit in which stems stop growing at a certain height and produce a flower cluster at the tip. Determinate tomatoes, for example, are short, early fruiting, have concentrated fruit set, and may not require staking. (See also indeterminate.)

dethatch. To remove thatch (a tightly intermingled layer of stems and roots, living and dead, that forms between the soil surface and green vegetation of grass).

diatomaceous earth. The fossilized remains of diatoms (a type of tiny algae) used to kill insect pests, snails, and slugs.

dicot. See dicotyledon.

dicotyledon. Plants with two seed leaves. Also referred to as dicot.

dieback. Progressive death of shoots, branches, or roots, generally starting at the tips.

differentiation. A change in the composition, structure, and function of cells and tissues during growth.

dioecious. Plants that have male and female flowers occurring on separate plants (e.g., holly).

Diptera. A major order of insects that have one pair of wings and sucking or siphoning mouthparts as adults and chewing mouthparts as larvae (mosquitoes, flies, and gnats).

disbud. The selective removal of some flower buds so remaining buds receive more of the plant's energy and produce larger, showier flowers. Roses, chrysanthemums, and camellias often are disbudded.

division. The breaking or cutting apart of a plant's crown for the purpose of producing additional plants, all genetically identical to the parent plant.

DNA. Deoxyribonucleic acid is the genetic information that dictates all cellular processes. DNA is organized into chromosomes and is responsible for all characteristics of the plant.

dormancy. The annual period when a plant's growth processes greatly slow down.

dormant. Resting or not growing. A deciduous tree is dormant in the winter.

dormant bud. A bud formed during a growing season that remains at rest during the following winter or dry season. If it does not expand during the following growing season, it is termed latent.

dormant oil. An oil applied during the dormant season to control insect pests and diseases.

double, semidouble. A flower with more than the normal number of petals, sepals, bracts, or florets. May be designated botanically by the terms flore pleno, plena, or pleniflora.

double worked. Grafted twice, i.e., grafted to an intermediate stock.

drainage. The ability of soil to transmit water through the surface and subsoil.

dripline. An imaginary line on the ground directly beneath the outermost tips of a plant's foliage. Rain tends to drip from leaves onto this line.

drip zone. The area from the trunk of a tree or shrub to the edge of its canopy. Most, but not all, of a plant's feeder roots are located within this area.

drupe fruit. See stone fruit.

dwarfed. Restricted plant size without loss of health and vigor.

ecology, plant. The study of the complex relationships of plants in biological communities.

economic threshold. The level at which pest damage justifies the cost of control. In home gardening, the threshold may be aesthetic rather than economic.

emasculate. To remove a flower's anthers.

embryo. The tiny plant that is formed inside a seed during fertilization. It has two growing points, the radicle (a tiny root) and the plumule (a tiny shoot).

embryo dormancy. Common in seed of woody perennial plants. A physiological condition in the embryo that prevents it from growing. This type of dormancy can be overcome by stratification.

enation. Epidermal outgrowths on leaves or stems.

endoskeleton. The internal body support found in most animals outside the insect kingdom.

endosperm. The food-storage area in a seed that feeds the embryo.

enzyme. A biological catalyst that aids in conversion of food and other chemical structures from one form to another.

epidemic. A widespread and severe outbreak of a disease.

epidermis (leaf). The outer cell layers on the top and bottom of a leaf.

epidermis (root). The cells that protect the root surface. The epidermis contains the root hairs and is responsible for the absorption of water and minerals dissolved in water.

epidermis (stem). In nonwoody plants, the outer single layer of surface cells that protects the stem. As in leaves, this layer is usually cutinized, or waxy, and on young stems it has stomata.

epinasty. An abnormal downward-curving growth or movement of a leaf, leaf part, or stem.

espalier. The training of tree or shrub to grow flat on a trellis or wall. Espalier patterns may be very precise and formal or more natural and informal.

etioliation. Long internodes and pale green color of plants growing under insufficient light or in complete darkness.

evergreen. A plant that never loses all its foliage at the same time.

excise. To remove or extract, as an embryo from a seed or ovule.

excurrent. A tree form in which the main trunk remains dominant with small, more or less horizontal branches. Fir and sweet gum are examples.

exfoliating. Peeling off in shreds or thin layers, as in bark from a tree.

exoskeleton. An insect's outer body support.

exotic. Non-native.

fallow. To keep land unplanted during one or more growing seasons.

family. A suborder in the classification of plants.

fasciation. Distortion of a plant that results in thin, flattened, and sometimes curved shoots.

feeder roots. Fine roots and root branches with a large absorbing area (root hairs). Responsible for taking up the majority of a plant's water and nutrients from the soil.

fertility (soil). The presence of minerals necessary for plant life.

fertilization. (1) The fusion of male and female germ cells following pollination. (2) The addition of plant nutrients to the environment around a plant.

fertilizer. Any substance added to the soil (or sprayed on plants) to supply those elements required in plant nutrition.

fertilizer analysis. The amount of nitrogen, phosphorus (as P_2O_5), and potassium (as K_2O) in a fertilizer expressed as a percentage of total fertilizer weight. Nitrogen (N) is always listed first, phosphorus (P) second, and potassium (K) third.

fertilizer ratio. The smallest whole number relationship among N, P_2O_5, and K_2O.

fibrous root. A root system that branches in all directions, often directly from the plant's crown, rather than branching in a hierarchical fashion from a central root. (See also taproot.)

filament. The stalk supporting a flower's anthers.

flagging. Loss of turgor and drooping of plant parts, usually as a result of water stress.

floating row covers. Covers, usually of a clothlike material, placed over growing plants and used to protect the plants growing beneath from undesirable pests and climate.

floricane. Second-year growth of cane berries. Produces fruit on laterals.

flower bud. A type of bud that produces one or more flowers.

foliar fertilization/feeding. Fertilization of a plant by applying diluted soluble fertilizer, such as fish emulsion or kelp, directly to the leaves.

force. To bring a plant into early growth, generally by raising the temperature or transplanting it to a warmer situation. Tulips and paper whites are examples of plants that often are forced.

form. (1) A naturally occurring characteristic different from other plants in the same population. (2) The growth habit (shape) of a plant.

formal. (1) A garden that is laid out in precise symmetrical patterns. (2) A flower, such as some camellias, that consists of layers of regularly overlapping petals.

frond. Specifically, the foliage of ferns, but often applied to any foliage that looks fernlike, such as palm leaves.

fruit. The enlarged ovary that develops after fertilization occurs.

fruiting habit. The location and manner in which fruit is borne on woody plants.

fumigation. The application of a toxic gas or other volatile substance to disinfect soil or a container, such as a grain bin.

fungicide. A compound toxic to fungi.

fungus. A plant organism that lacks chlorophyll, reproduces via spores, and usually has filamentous growth. Examples are molds, yeasts, and mushrooms.

gall. A growth on plant stems or leaves caused by abnormal cell growth stimulated by the feeding of some insects (e.g., aphids) or by viral, fungal, or bacterial infection or genetic abnormality.

genetically modified. A plant or animal that has had genetic material introduced to its genome from other organisms through artificial means.

genus. A subdivision of family in the classification of plants. Plants of the same genus share similarities mostly in flower characteristics and genetics. Plants in one genus usually cannot breed with plants of another genus.

geography, plant. The study of the distribution of plants throughout the world.

geotropism. The turning or curving of a plant's parts in response to gravity. A root growing downward is an example. Geotropism is controlled largely by the hormone auxin.

germination. The processes that begin after planting a seed that lead to the growth of a new plant.

girdling. The damaging, cutting, removing, or clamping of cambium all the way around a trunk or branch. Sometimes, girdling is done deliberately to kill an unwanted tree, but often it results from feeding by insects or rodents. Wires and ties used to support a tree can cause girdling, as can string trimmers.

glabrous. Hairless, but not necessarily smooth.

glaucous. Covered with a grayish, bluish, or whitish waxy coating that is easily rubbed off. Blue spruce needles are an example of glaucous leaves.

gradual metamorphosis. See simple metamorphosis.

graft union. See bud union.

grafting. A method of asexual plant propagation that joins plant parts so they will grow as one plant.

gravitational water. Water in excess of a soil's capacity. Drains downward to groundwater.

green cone. An enclosed composting unit often used for composting food waste.

green manure. A herbaceous crop plowed under while green to enrich the soil.

ground cover. Plants used for holding soil, controlling weeds, and providing leaf texture.

growing season. The period between the beginning of growth in the spring and the cessation of growth in the fall.

growth regulator. A compound applied to a plant to alter its growth in a specific way. May be a natural or synthetic substance. (See also hormone.)

guard cells. Cells on either side of each stoma. They swell to open the stoma and shrink to close it.

gymnosperm. Plants that have seed not enclosed in an ovary (e.g., conifers).

haltere. A small, knoblike organ (sometimes shaped like a baseball bat or bowling pin) located on the thorax of insects of the order Diptera. Takes the place of hindwings and helps balance the insect in flight.

hardening off. (1) The process of gradually exposing seedlings started indoors to outdoor conditions before transplanting. (2) The process of gradual preparation for winter weather.

hardpan. An impervious layer of soil or rock that prevents root growth and downward drainage of water.

hardy. Frost or freeze tolerant. In horticulture, this term does not mean a tough plant nor one that is resistant to insect pests or disease.

haustorium. A modified hyphal branch of a parasitic plant. Grows into a host plant's cell to absorb food and water.

head. (1) To cut off part of a shoot or limb rather than remove it completely at a branch point. (2) The part of a tree from which the main scaffold limbs originate.

heartwood. The central cylinder, often dark colored, of xylem tissue in a woody stem.

heeling in. The temporary burying of a newly dug plant's roots to prevent their drying until a new planting site is prepared. Nurseries heel in bare-root berries, trees, and shrubs.

Hemiptera. A major order of insects that have two pairs of wings and piercing-sucking mouthparts (bedbugs, stink bugs, cinch bugs).

herbaceous. A soft, pliable, usually barkless shoot or plant. Distinct from stiff, woody growth.

herbaceous perennial. A plant that dies back in the winter and regrows from the crown in the spring.

herbicide. A chemical used to kill undesirable plants.

heterozygous. Having mixed hereditary factors, not a pure line.

Homoptera. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts (aphids, leafhoppers, scales, mealybugs).

homozygous. Having purity of type, a pure line.

honeydew. A sticky substance excreted by aphids and some other insects.

hormone. A naturally occurring compound that alters plant growth in a specific manner. (See also growth regulator.)

horticultural oil. An oil made from petroleum products, vegetable oil, or fish oil used to control insect pests and diseases. Oils work by smothering insects and their eggs and by protectively coating buds against pathogen entry.

horticulture. The science of growing fruits, vegetables, flowers, and other ornamental plants.

host. A plant on which an insect or disease completes all or part of its life cycle.

host plant. A plant that is invaded by a parasite.

host range. The various plants that may be attacked by a parasite.

hotbed. An enclosed bed for propagating or protecting plants. Has a source of heat to supplement solar energy.

hot composting. A fast composting process that produces finished compost in 4–8 weeks. High temperatures are maintained by mixing balanced volumes of energy materials and bulking agents, by keeping the pile moist, and by turning it frequently to keep it aerated.

humus. The end product of decomposing animal or vegetable matter. (See also compost.)

hybrid. The results of a cross between two different species or well-marked varieties within a species. Hybrids grown in a garden situation will not breed true to form from their own seed.

hydroponics. A method of growing plants without soil. Plants usually are suspended in water or polymers and plant nutrients are supplied in dilute solutions.

Hymenoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (wasps, bees, ants, sawflies).

hypha. A single filament of a fungus.

hypocotyl. The seedling stem that develops below the cotyledons.

imbibition. The portion of the germination process that involves the absorption of water, causing the seed to swell, and that triggers cell enzyme activity, growth, and the bursting of the seed coat.

immobilization. The process by which soil microorganisms use available nitrogen as they break down materials with a high C:N ratio, thus reducing the amount of nitrogen available to plants.

immune. A plant that does not become diseased by a specific pathogen. (See also resistance; tolerant.)

imperfect flower. Flowers lacking one or more of the sexual parts.

incompatible. Kinds or varieties of a species that do not successfully cross-pollinate or intergraft.

incomplete flower. A type of flower that lacks one or more of the four parts: pistil, stamen, sepals, or petals.

incomplete metamorphosis. See simple metamorphosis.

incubation. A period of development during which a pathogen changes to a form that can penetrate or infect a new host plant.

indeterminate. A plant growth habit in which stems keep growing in length indefinitely. For example, indeterminate tomatoes are tall, late fruiting, and require staking for improved yield. (See also determinate.)

infection. The condition reached when a pathogen has invaded plant tissue and established a parasitic relationship between itself and its host.

infiltration. The movement of water into soil.

inflorescence. The arrangement of flowers on an axis or stem or a flower cluster.

inflorescence collective. A group of individual flowers. The grouping can take many forms, such as a spike (flowers closely packed along a vertical stem, e.g., snapdragons), an umbel or corymb (flowers forming a flattened dome, e.g., yarrow), a panicle (a complex hierarchical arrangement of flowers, e.g., hydrangeas), or a capitulum (tightly packed disc flowers, e.g., the center of a daisy).

inoculation. The introduction of a pathogen to a host plant's tissue.

inoculum. Any part of a pathogen that can cause infection.

inorganic. Being or composed of matter other than plant or animal.

insectary plant. A plant that attracts beneficial insects.

insecticidal soap. A specially formulated soap that is only minimally damaging to plants, but kills insects. Usually works by causing an insect's outer shell to crack, resulting in its interior organs drying out.

insecticide. A chemical used to control, repel, suppress, or kill insects.

instar. The stage of an insect's life between molts.

integrated control. An approach that attempts to use several or all available methods for control of a pest or disease.

integrated insect control. The use of a variety of insect control methods, beginning with simpler methods and progressing to include aspects from all types of control.

integrated pest management. A method of managing pests that combines cultural, biological, mechanical, and chemical controls, while taking into account the impact of control methods on the environment.

intensive gardening. The practice of maximizing use of garden space, for example by using trellises, intercropping, succession planting, and raised beds.

intercalary meristem. Found mostly in monocots, these cells divide and provide the growth of the leaf from the base of the plant.

intercropping/Interplanting. The practice of mixing plants to break up pure stands of a single crop.

internode. The area of the stem that is between the nodes.

interstem, interstock. The middle piece of a graft combination made up of more than two parts, i.e., the piece between the scion and the rootstock. Often has a dwarfing effect.

invasive. Growing vigorously and outcompeting other plants in the same area; difficult to control.

ion. An electrically charged particle. In soils, an ion refers to an electrically charged element or combination of elements resulting from the breaking up of an electrolyte in solution.

isolation. The separation of a pathogen from its host by culturing on a nutrient medium or on an indicator plant.

Isoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (termites).

joint. A node; the place on a stem where a bud, leaf, or branch forms.

juvenile stage. (1) The early or vegetative phase of plant growth characterized by the inability to flower. (2) The first stage of an insect's life cycle after the egg, either a larva or a nymph. (3) The immature stage of an organism.

K. See potassium.

key, dichotomous. A tool for plant or animal classification and identification. Consists of a series of paired statements that move from general to specific descriptions.

knot garden. A formal garden in which two or more kinds of plants with different-colored foliage, often herbs, are planted and pruned so they interweave and form a knot pattern.

larva. The immature form of an insect that undergoes complete metamorphosis. Different from the adult in form, a caterpillar, for example.

latent bud. Buds that do not grow for long periods of time and can become embedded in the enlarging stem tissue. These buds grow only when conditions necessary for their growth occur, such as drastic pruning. Not all plants have latent buds.

lateral. A branch attached to and subordinate to another branch or trunk.

lateral bud. An undeveloped shoot or flower that is found at the node. Also called the axillary bud.

lateral meristem. Cylinders of actively dividing cells that start just below the apical meristem and are located up and down the plant. Also called the vascular cambium.

layering. A method of stimulating adventitious roots to form on a stem. There are two primary methods of layering. In ground layering, a low-growing branch is bent to the ground and covered by soil. In air layering, a moist rooting medium is wrapped around a node on an aboveground stem.

leaching. Movement of water and soluble nutrients down through the soil profile.

leader. A developing stem or trunk that is longer and more vigorous than the laterals. (See also central leader.)

leaf curl. Rolling and curling of leaves.

leaflet. A single division of a compound leaf.

leaf scar. A visible, thickened crescent or line on a stem where a leaf was attached.

lenticel. A small opening on the surface of fruits, stems, and roots that allows gas exchange between internal tissues and the atmosphere.

Lepidoptera. A major order of insects that have two pairs of wings and sucking or siphoning mouthparts as adults and chewing mouthparts as larvae (moths, butterflies).

lesion. A localized area of discolored or dead tissue.

life cycle. The successive stages of the growth and development of an organism.

lime. A rock powder consisting primarily of calcium carbonate. Used to raise soil pH (decrease acidity).

loam. A soil with roughly equal proportions of sand, silt, and clay particles.

lodge. To fall over, usually due to rain or wind. Corn and tall grasses are examples of plants susceptible to lodging.

long-day plant. A plant requiring more than 12 hours of continuous daylight to stimulate a change in growth, e.g., a shift from the vegetative to reproductive phase. (See also short-day plant; day-neutral plant.)

macronutrient. Collectively, primary and secondary nutrients.

macropore. A large soil pore. Macropores include earthworm and root channels and control a soil's permeability and aeration.

Mallophaga. A major order of insects that are wingless and have chewing mouthparts (chewing lice).

mandible. The first pair of jaws on insects: stout and toothlike in chewing insects, needle or sword-shaped in sucking insects. The lateral (left and right), upper jaws of biting insects.

maturity. (1) In fruit, ripeness, usually the state of development that results in maximum quality. (2) The flowering phase of plant growth.

mechanical insect control. Manual removal of insects and eggs from infested plants.

meristem. Plant tissue in the process of formation; vegetative cells in a state of active division and growth, e.g., those at the apex of growing stems and roots and responsible for enlarging the stem diameter.

mesophyll. In between the epidermal layers, where photosynthesis occurs.

metamorphosis. The process by which an insect develops. (See also complete metamorphosis; simple metamorphosis.)

microclimate. Climate affected by landscape, structures, or other unique factors in a particular immediate area.

micronutrient. A nutrient, usually in the parts per million range, used by plants in small amounts, less than 1 part per million (boron, chlorine, copper, iron, manganese, molybdenum, zinc, and nickel).

micropore. A fine soil pore, typically a fraction of a millimeter in diameter. Micropores are responsible for a soil's ability to hold water.

microscopic. Organisms so small that they can be seen only with the aid of a microscope.

mixed buds. Buds that produce both shoots and flowers.

mixed fertilizer. A fertilizer that contains at least two of the three macronutrients (N, P, K).

modified central leader. A system of pruning used primarily on fruit trees. The central leader is encouraged for the first few years, then suppressed. This system allows for well-placed scaffolds and strong crotches, but keeps the tree's crown relatively close to the ground for easy harvesting.

molt. The shedding of exoskeleton during insect growth. The form assumed between molts is called an instar.

monochromatic. In landscaping, use of the various tints, shades, and hues of only one color.

monocot. See monocotyledon.

monocotyledon. Plants with one seed leaf. Also referred to as monocot.

monoecious. Plants that have imperfect flowers (male and female) occurring on the same plant (e.g., corn).

morphology. The study of the origin and function of plant parts.

mosaic. Nonuniform foliage coloration with a more or less distinct intermingling of normal green and light-green or yellowish patches.

mottle. An irregular pattern of light and dark areas.

mulch. Any material placed on the soil surface to conserve soil moisture, moderate soil temperature, and/or control weeds. Wood chips, bark chips, and shredded leaves are mulches that eventually add organic matter to the soil; inorganic materials such as rocks are also used.

mutation. A genetic change within an organism or its parts that changes its characteristics. Also called a bud sport or sport.

mycelia. Masses of fungal threads (hyphae) that make up the vegetative body of a fungus.

mycology. The study of fungi.

mycoplasma. See phytoplasm.

mycorrhizae. Beneficial fungi that infect plant roots and increase their ability to take up nutrients from the soil.

N. See nitrogen.

native plant. A plant indigenous to a specific habitat or area.

naturalize. (1) To design a garden with the aim of creating a natural scene. Planting generally is done randomly and space is left for plants to spread at will. (2) The process whereby plants spread and fill in naturally.

necrosis. Death of tissue.

nectaries. Cells of the petal of a flower that secrete nectar.

nematicide. A material that kills or protects against nematodes.

nematode. Microscopic roundworms that live in soil and living tissue, as well as water, and survive as eggs or cysts.

nitrate. A plant-available form of nitrogen contained in many fertilizers and generated in the soil by the breakdown of organic matter. Excess nitrate in soil can leach to groundwater. (See also nitrogen cycle.)

nitrifier. A microbe that converts ammonium to nitrate.

nitrogen. A primary plant nutrient, especially important for foliage and stem growth.

nitrogen cycle. The sequence of biochemical changes undergone by nitrogen as it moves from living organisms to decomposing organic matter, to inorganic forms, and back to living organisms.

nitrogen fixation. The conversion of atmospheric nitrogen into plant-available forms by rhizobia bacteria living on the roots of legumes.

node. The area of the stem that bears a leaf or a branch. The joint of a stem.

nomenclature. The assigning of names in the classification of plants.

nonpoint source. A relatively small, nonspecific source of pollutants that, when added to other sources, may pose a significant threat to the environment. (See also point source.)

nonselective pesticide. A pesticide that kills most plants or animals.

nonviable. Not alive; nonviable seeds may look normal but will not grow.

noxious weed. (1) Weeds that have been declared by law to be a species having the potential to cause injury to public health, crops, livestock, land, or other property. (2) A very invasive, difficult to control plant.

N-P-K. Acronym for the three major plant nutrients contained in manure, compost, and fertilizers. N stand for nitrogen, P for phosphorus, and K for potassium.

nucleus. The organelle within a cell that contains chromosomes and thus controls various cellular processes, including division into new cells.

nutrient. Any substance, especially in the soil, that is essential for and promotes plant growth. (See also macronutrient; micronutrient.)

nymph. The immature stage of an insect that undergoes simple metamorphosis. Usually similar in form to the adult.

offset. A new shoot that forms at the base of a plant or in a leaf axil.

oil. See horticultural oil.

open-pollinated seed. Seed produced from natural, random pollination so that the resulting plants are varied.

opposite leaf arrangement. Two leaves attached at the same point on the stem, but on opposite sides.

organelle. A structure within a cell, such as a chloroplast, that performs a specific function.

organic. (1) Relating to, derived from, or involving the use of food produced with the use of feed or fertilizer of plant or animal origin without employment of synthetically formulated fertilizers, growth stimulants, antibiotics, or pesticides. (2) Being or composed of plant or animal matter. (3) A labeling term that refers to an agricultural product produced in accordance with government standards.

organic fertilizer. A natural fertilizer material that has undergone little or no processing. Can include plant, animal, and/or mineral materials.

organic matter. Any material originating from a living organism (peat moss, plant residue, compost, ground bark, manure, etc.).

organic pesticide. Pesticides derived from plant or animal sources.

organic production. The production of food using accepted naturally occurring materials.

organism. A living being.

ornamental plant. A plant grown for beautification, screening, accent, specimen, color, or other aesthetic reasons.

Orthoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (grasshoppers, crickets, and cockroaches).

osmosis. Passage of materials through a membrane from an area of high concentration to an area of lower concentration.

outer seed coat. The protective outer shell of a seed.

ovary. The part of a flower containing ovules that develop into seeds upon fertilization. Along with the style and stigma, it makes up the pistil (female sexual organ).

ovule. Within the ovary, a tissue/structure that develops into a seed after fertilization.

oxidative respiration. The chemical process by which sugars and starches are converted to energy. In plants, known as respiration.

P. See phosphorus.

palisade mesophyll. The cells just beneath a leaf's upper epidermis that contain most of the leaf's chlorophyll and that are responsible for most photosynthesis.

palmate. (1) A leaf whose veins radiate outward from a single point somewhat like the fingers of a hand. (2) A form of espalier training.

parasite. An organism that lives in or on another organism (host) and derives its food from the latter.

parasitic seed plant. A plant that lives parasitically on other seed plants. An example is mistletoe.

parterre. A formal garden in which shrubs, flowers, and paths form a geometric pattern of matched pairs.

parthenocarpic. Development of fruit without fertilization.

pathogen. Any organism that causes disease.

pathology. The study of plant disease.

ped. A cluster of individual soil particles.

pedicel. The stem of an individual flower.

peduncle. The main stem supporting a cluster of flowers (as opposed to a pedicel, which is the stem of an individual flower).

pendulous. More or less hanging or declined.

perennial. A plant that lives more than two years and produces new foliage, flowers, and seeds each growing season.

perfect flower. A type of flower with both stamens and pistils.

perianth. Collectively, sepals and petals form the perianth.

permanent wilting point. The point at which a wilted plant can no longer recover.

permeability. The rate at which water moves through a soil.

persistent. (1) Adhering to a position instead of falling, whether dead or alive, e.g., flowers or leaves. (2) A pesticide that retains its chemical properties in the soil for a long time.

petals. Part of a flower, the floral structure inside the sepals, often brightly colored.

petiole. The stalk of a leaf.

pH. The acidity or alkalinity of a solution on a scale of 0–14, with a value of 7 signifying neutral, values below 7 signifying acidic, and values above 7 signifying alkaline. Relates to the concentrations of hydrogen (H+) ions in the soil. pH values are logarithmic.

phenological stage. Crop development stage.

pheromone. A vapor or liquid emitted by an insect that causes a specific response from a receiving insect. Some pheromones are used to find a mate. Synthetic pheromones are used as attractants in insect traps.

phloem. The principle nutrient-conducting structure of vascular plants.

phosphate. The form of phosphorus listed in most fertilizer analyses.

phosphorus (P). A primary plant nutrient, especially important for flower production. In fertilizer, usually expressed as phosphate.

photoperiod. The amount of time a plant is exposed to light.

photosynthate. A food product (sugar or starch) created through photosynthesis.

photosynthesis. Formation of carbohydrates from carbon dioxide and a source of hydrogen (as water) in the chlorophyll-containing tissues of plants exposed to light.

phototropism. The phenomenon of plants growing toward the direction of a light source.

physiology. The study dealing with the functioning of plants, their mechanisms of response, and their physical and biochemical processes.

phytoplasm. Microscopic, single-celled organisms that lack distinct cell walls and that cause destructive diseases in plants.

phytotoxic. Toxic to a plant.

picotee. A pattern of flower petal coloration in which the edges of the petal are in a color that contrasts with the flower body.

pinch. To remove a growing tip from a stem, thus causing axillary shoots or buds to develop. (See also deadhead; shear.)

pistil. The female component of the flower. It is in the center of the flower and has three parts, the stigma, the style, and the ovary.

pistillate. Female flowers; flowers with no stamens (pistils only), also called imperfect because they lack the stamen.

plant classification. The scientific grouping and naming of plants by characteristics.

plant disease. Any lasting change in a plant's normal structure or function that deviates from its healthy state.

plant growth regulator. See growth regulator.

plant nutrition. A plant's need for and use of basic chemical elements. (See also macronutrient; micronutrient.)

plant pathology. The study of diseases in plants: what causes them, what factors influence their development and spread, and how to prevent or control them.

plant tissue culture. Plant material grown *in vitro* under sterile conditions in an artificial medium. A primary means of rapidly increasing the number of plants from a single mother plant.

pleach. To intertwine branches of trees, vines, or shrubs to form an arbor or hedge.

pleniflora. A term used in botanical names to indicate a double-flowered cultivar. (See also double.)

plumule. The shoot portion of an embryo.

point source. A single, identifiable source of pollutants such as a factory or municipal sewage system. (See also nonpoint source.)

pollard. A method of tree pruning that involves heading back severely to main branches each year so as to produce a thick, close growth of young branches.

pollen. A plant's male sex cells, which are held on the anther for transfer to a stigma by insects, wind, or some other mechanism.

pollenizer. A plant whose pollen sets fruit on another plant. (See also cross-pollination.)

pollen tube. A slender tube growing from the pollen grain that carries the male gametes and delivers them to the ovary.

pollination. The first step in fertilization; the transfer of pollen from anther to a stigma.

pollinator. An agent such as an insect that transfers pollen from a male anther to a female stigma.

polychromatic. In landscaping, use of all the colors and their tints, shades, and tones.

pome fruit. A fruit having a core, such as an apple, pear, or quince.

pomology. The science of fruits and the art of fruit culture, especially tree fruits.

postemergent. A product applied after crops or weeds emerge from the soil.

potash. The form of potassium listed in most fertilizer analyses.

potassium (K). A primary plant nutrient, especially important for developing strong roots and stems. In fertilizers, usually expressed as potash.

powdery mildew. Fine, white to gray, powdery fungal coating on leaves, stems, and flowers.

predator. An animal that eats another animal.

preemergent. A product applied before crops or weeds emerge from the soil.

preharvest interval. The amount of time that must elapse (legally) after application of a pesticide before harvest takes place.

preplant. A product applied before a crop is planted.

prickle. A rigid, straight, or hooked outgrowth of bark or stems. Often called a thorn, but technically different. Roses are examples of plants with prickles. (See also thorn.)

primary nutrient. A nutrient required by plants in a relatively large amount (nitrogen, phosphorus, and potassium).

primocane. First-year growth, usually vegetative, on caneberries. Only fall-bearing raspberries produce fruit on primocanes in late summer.

processed fertilizer. A fertilizer that is manufactured or refined from natural ingredients to be more concentrated and more available to plants.

propagate. To start new plants by seeding, budding, grafting, dividing, etc.

prune. To remove plant parts to improve a plant's health, appearance, or productivity.

pseudobulb. A thickened, aboveground, modified stem that serves as a storage organ. Found in some orchids.

Psocoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (barklice, booklice).

pubescent. Hairy.

pupa. The stage between larva and adult in insects that go through complete metamorphosis.

quarantine. A regulation forbidding sale or shipment of plants or plant parts, usually to prevent disease, insect, nematode, or weed invasion in an area.

quick-release fertilizer. A fertilizer that contains nutrients in plant-available forms such as ammonium and nitrate. Fertilizer is readily soluble in water.

raceme. A flower stalk on which the florets start blooming from the bottom of the stem and progress toward the top.

radial spacing. The horizontal spacing of branches around a trunk.

radicle. The root portion of an embryo.

region of maturation. The area of the root where the enlarged root cells turn into the various root tissues.

regulatory insect. Term used to describe insects that have an unknown impact in a new environment to which they may be moved.

relative humidity. The ratio of water vapor in the air to the amount of water the air could hold at the current temperature and pressure.

resistance. The ability of a host plant to prevent or reduce disease development by retarding multiplication of the pathogen within the host.

respiration. The process by which carbohydrates are converted into energy. This energy builds new tissues, maintains the chemical processes, and allows growth within the plant.

reversion growth. A stem that originates from and has the characteristics of the plant's rootstock. (See also sucker.)

rhizobia bacteria. Bacteria that live in association with roots of legumes and convert atmospheric nitrogen to plant-available forms, a process known as nitrogen fixation.

rhizome. A stem that forms the main axis of the plant. Can form at or just below the ground (for example, in bearded iris).

rhizosphere. The thin layer of soil immediately surrounding plant roots.

rogue. To uproot or destroy diseased or atypical plants.

root and stem rot. Soft and disintegrated roots and lower portions of the stem; sometimes results in the death of the plant.

root bound. A condition in which a plant's roots have completely filled its container. Typically, the roots begin to encircle the pot's outer edge. Further growth is prevented until the plant is removed from the container.

root cap. The cells that protect the root tip as it pushes through the soil. These cells slough off and are replaced by others as the roots grow downward.

root cutting. An asexual method of propagation that involves removing a section of root from a 2–3-year-old plant during the dormant season and placing it into growing medium.

root hair. Thin hair-like structure that grows from the epidermis of the region of maturation of the root. This structure absorbs water and nutrients from the soil.

root knots. Swelling and deformation of roots.

root meristem. A type of apical meristem located at the tips of roots. Provides for elongation of the roots and produces the cells that will become the epidermis, cortex, xylem, cambium, and phloem of the mature root.

root pruning. The cutting or removal of some of a plant's roots.

rootstock. The portion of a plant used to provide the root system and sometimes the lower part of the stem for a grafted plant.

root sucker. See sucker.

rosette. A small cluster of leaves radially arranged in an overlapping pattern.

rot. Decomposition and destruction of tissue.

rotation. The practice of growing different plants in different locations each year to prevent the buildup of soilborne diseases and insect pests.

row cover. A sheet of synthetic material used to cover plants in order to retain heat and exclude insect pests.

rugose. Wrinkled.

runner. See stolon.

russet. Yellowish-brown or reddish-brown scar tissue on the surface of a fruit. Also naturally occurring tissue on potato tubers.

rust. Raised pustules on leaves, stems, and fruits; contain yellow-orange or rust-colored spore masses.

sand. The coarsest type of soil particle.

sanitation. The removal and disposal of infected plant parts; decontamination of tools, equipment, hands, etc.

saprophyte. An organism that can subsist on nonliving matter.

scab. Slightly raised, rough areas on fruits, tubers, leaves, or stems.

scaffold branches. The principal branches of a tree or shrub arising from the trunk or another main branch to form the plant's framework.

scale. (1) A modified leaf that protects a bud. (2) A type of insect pest.

scarification. Artificial methods to soften the seed coat, including scratching or rupturing the seed coat with sandpaper, nicking it with a knife, or degrading it with concentrated acid.

scion. The portion of a plant or cultivar that is grafted onto a separate rootstock, consisting of a piece

of shoot with dormant buds that will produce the stem and branches.

secondary nutrient. A nutrient needed by plants in a moderate amount: calcium, magnesium, and sulfur. (See also macronutrient; primary nutrient.)

secondary root. A type of root system that forms after the primary root emerges from a seed and branches outward.

seed. Matured ovule that occurs as, or in, mature fruits.

seed coat. The outer layer of a seed that provides protection for the enclosed embryo.

seed coat impermeability. Caused by a hard seed coat that is impermeable to water, preventing the seed from germinating.

seed dormancy. An adaptive feature of some plants to keep the seeds from germinating until conditions exist that favor seedling survival.

seed leaf. See cotyledon.

seed scarification. Involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process.

selective pesticide. A pesticide that kills only certain kinds of plants or animals; for example, 2,4-D kills broadleaf lawn weeds but leaves grass largely unharmed.

self-fertile. A plant that produces seed with its own pollen.

self-fruitful. A plant that bears fruit through self-pollination.

self-pollination. Pollination that can occur when the anther and stigma are in the same flower or if the anther and stigma are in different flowers on the same plant or in different flowers on different plants of the same species, variety, or cultivar.

self-sterile. A plant that needs pollen from another species, variety, or cultivar (e.g., cross-pollination).

self-unfruitful. A plant that requires another variety for pollination. (See also pollenizer.)

senescence. The aging process. Also used to describe a plant that is in the process of going dormant for the season, although technically only the parts that are dying (the leaves) are becoming senescent.

sepal. The outer covering of the flower when it is in the bud stage. They are leaflike in structure and usually green; however, they can be colored and look like petals, as in tulips. They may fold back as in roses or remain upright as with carnations. Together, all the sepals form the calyx.

separation. A term applied to a form of propagation by which plants that produce bulbs or corms multiply.

sessile. Stalkless and attached directly at the base, as in sessile leaves.

shear. To cut back a plant (as opposed to selective pruning or deadheading). Often used to regenerate plants with many small stems, where deadheading would be too time consuming.

shoot. One season's branch growth. The bud scale scars (ring of small ridges) on a branch mark the start of a season's growth.

shoot meristem. The apex of a shoot where cells actively divide to provide more cells that will expand and develop into the tissues and organs of the plant. Also called apical meristem.

short-day plant. A plant requiring more than 12 hours of continuous darkness to stimulate a change in growth, e.g., a shift from the vegetative to reproductive phase. (See also long-day plant; day-neutral plant.)

shot hole. Roughly circular holes in leaves resulting from the dropping out of the central dead areas of spots.

shoulder ring. One of the ridges around the base of a branch where it attaches to a trunk or to another branch. (See also collar.)

shrub. A woody plant that grows to a height of 3–12 feet. May have one or several stems with foliage extending nearly to the ground.

side-dress. To apply fertilizer to the soil around a growing plant.

sign. The part of a pathogen seen on a host plant.

signal word. An indication of toxicity on pesticide labels. Pesticides labeled "caution" are the least toxic, those labeled "warning" are more so, and those labeled "danger" are the most toxic.

silt. A type of soil particle that is intermediate in size between sand and clay.

simple metamorphosis. A type of insect development involving three stages: egg, nymph, and adult. The nymph usually resembles the adult. (See also complete metamorphosis.)

Siphonaptera. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts as adults and chewing mouthparts as larvae (fleas).

slow-release fertilizer. A fertilizer material that must be converted into a plant-available form by soil microorganisms.

smut. Black masses of spores produced by fungi that may form on stems, ears, etc.

soft pinch. To remove only the succulent tip of a shoot, usually with the fingertips.

soil. A natural, biologically active mixture of weathered rock fragments and organic matter at the earth's surface.

soilless mix. A potting medium consisting of ingredients such as sphagnum peat moss and vermiculite but no soil.

soil salinity. A measure of the total soluble salts in a soil.

soil solution. The solution of water and dissolved minerals found in soil pores.

soil structure. The arrangement of soil particles or their aggregates.

soil texture. How coarse or fine a soil is. Texture is determined by the proportions of sand, silt, and clay in the soil.

solitary flower. A plant that forms a stalk that bears a single flower, such as a tulip.

soluble salt. A mineral (salt) often remaining in soil from irrigation water, fertilizer, compost, or manure applications.

sonic repeller. A sonic wave-emitting unit said to disrupt the activities of small mammals or insects but not proven to be effective.

species. A group of individual plants interbreeding freely and having many (or all) characteristics in common.

specific epithet. The second word in a Latin binomial. Sometimes called trivial name.

specimen. An individual plant with outstanding characteristics (leaves, flowers, or bark), generally used as a focal point in a landscape.

split complementary. In landscaping, use of a pure color and a color from either side of its complementary counterpart.

spongy parenchyma. The lower layer of cells in the mesophyll.

spore. (1) The reproductive body of a fungus or other lower plant, containing one or more cells. (2) A bacterial cell modified to survive in an adverse environment. (3) The reproductive unit of ferns.

sport. See mutation.

spot treatment. To apply a pesticide to a small section or area of a crop.

spur. Short, stubby stems common on fruit trees such as apples and pears. These spurs produce the flower buds.

stamen. The male, pollen-producing part of a flower consisting of the anther and its supporting filament.

staminate. Male flowers; flowers with no pistil (stamens only), also called imperfect because they lack the pistil.

standard. A plant pruned so that it consists of a single bare vertical stem, atop which a shaped mass of foliage, usually globular, is maintained.

stem cutting. A section of a stem prepared for vegetative propagation; forms adventitious roots on the stem.

sterile. (1) Material that is free of disease organisms (pathogens), as in a potting medium. (2) A plant that is unable to produce viable seeds.

stigma. The receptive surface on a pistil that receives pollen.

stipules. A pair of appendages found on many leaves where the petiole meets the stem.

stock. See rootstock.

stolon. A horizontal stem, either fleshy or semiwoody, that runs along a soil surface.

stomate, stomata (plural). An opening into a leaf that is formed by specialized epidermal cells on the underside (and sometimes upper sides) of the leaf.

stone fruit. A fleshy fruit, such as a peach, plum, or cherry, usually having a single hard stone that encloses a seed. Also called a drupe.

strain. A variation within a cultivar or variety.

stratification. Chilling seed under moist conditions. This method mimics the conditions a seed might endure after it falls to the ground in the autumn and goes through a cold winter on the ground.

style. On a pistil, a tube connecting the stigma and the ovary.

stylet. A nematode's lancelike or needlelike mouthpart. Used to puncture and feed from plant cells.

subapical meristem. Aids in formation of shoots and flowering stalks.

subspecies. A major division of a species, more general in classification than a cultivar or variety.

succession. The progression of a plant community to a stable mixture of plants.

succession planting. (1) The practice of planting new crops in areas vacated by harvested crops. (2) Several smaller plantings made at timed intervals.

sucker. A shoot or stem that originates underground from a plant's roots or trunk or from a rootstock below the graft union. (See also reversion growth.)

summer annual. Annual plant in which the seed germinates in the spring and the plant develops, matures, and produces seed by the end of the growing season.

summer oil. A light refined horticultural oil used during the growing season to control insect pests and diseases.

sunscald. Winter or summer injury to the trunk of a woody plant caused by hot sun and fluctuating temperatures. Typically, sunscalded bark splits and separates from the trunk.

surfactant. See additive.

susceptibility. The condition of a plant in which it is prone to the damaging effects of a pathogen or other factor.

sustainable gardening. Gardening practices that allow plants to thrive with minimal inputs of labor, water, fertilizer, and pesticides.

symbiotic. Mutually beneficial.

symptom. Visible reaction of a plant to disease such as wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth, or stunting.

synthetic fertilizer. Chemically formulated fertilizers, mainly from inorganic sources.

synthetic pesticide. Chemically formulated pesticide, mainly from inorganic sources.

systemic. Spreading internally throughout the plant.

systemic pesticide. A pesticide that moves throughout a target organism's system to cause its death.

taproot. A type of root system that grows straight down with few lateral roots.

taxonomy. Classification or naming of plants or animals.

temporary branch. (1) A small shoot or branch left on a young tree's trunk for protection and nourishment. (2) A low lateral allowed to remain until a tree is tall enough to have scaffolds at the desired height.

tender. Not tolerant of frost and cold temperatures. In horticulture, tender does not mean weak or one that is susceptible to insect pests or diseases.

tendril. A slender projection used for clinging, usually a modified leaf. Easily seen on vines such as grapes and clematis.

terminal. The tip (apex), usually of a branch or shoot.

terminal bud. The bud that is found at the tip of shoots.

thatch. A brown, fibrous, spongy layer located between the soil and the grass blades.

thermoperiod. The change in temperature from day to night.

thermophilic. Growing at high temperatures, as in microorganisms that break down organic matter in a hot compost pile.

thin. (1) To remove an entire shoot or limb where it originates. (2) To selectively remove plants or fruits to allow remaining plants or fruits to develop.

thorn. A hard, sharp-pointed, leafless branch. Hawthorn is an example of a plant that produces thorns. (See also prickle.)

Thysanoptera. A major order of insects that have two pairs of wings, or are wingless, and have rasping-sucking mouthparts (thrips).

Thysanura. A major order of insects that are wingless and have chewing mouthparts (silverfish, firebrats).

tiller. A shoot that arises from a plant's crown. Generally associated with grass species.

tilth. The state of aggregation of a soil, especially, in relation to its suitability for crop growth.

tissue culture. The process of generating new plants by placing small pieces of plant material onto a sterile medium.

tolerant. A plant that will produce a normal yield even if infested by a disease or insect pest. (See also immune; resistance.)

top-dressing. The practice of spreading a thin layer (¼ inch) of soil, compost, humus, or a sand and peat mix over the turf or soil.

topiary. A tree or shrub shaped and sheared into an ornamental, unnatural form, usually a geometric shape or the shape of an animal.

totipotency. The ability of any cell to develop into an entire plant.

trace element. See micronutrient.

transpiration. The loss of water through the leaf stomata. The transpired water comes from the photosynthetic process and also from water in the cells.

tree. A woody plant that typically grows more than 12 feet tall and has only one main stem or trunk.

triadic. In landscaping, use of three colors that are at equal distances from each other on the color wheel.

trichomes. The "hairs" that are extensions of the epidermal cells on a leaf.

tropism. The tendency of a plant part to turn in response to an external stimulus, either by attraction or repulsion, as a leaf turns toward light. (See also geotropism; phototropism.)

trunk. The main stem of a tree. Also called a bole.

truss. A flower cluster, usually growing at the terminal of a stem or branch.

tuber. A belowground stem used for food storage (e.g., potato).

tuberous root. An underground storage organ made up of root tissue. Sprouts only from the point at which it was attached to the stem of the parent plant. Dahlias are an example.

tuberous stem. A belowground stem consisting of a swollen hypocotyl, lower epicotyl, and upper primary root (for example, in tuberous begonias).

turgor. Cellular water pressure; responsible for keeping cells firm.

twig. A young stem (1-year-old or less) that is in the dormant winter stage (has no leaves).

umbel. A group of flowers growing from a common point on a stem.

understock. See rootstock.

USDA zones. Areas derived by the USDA that indicate average-low winter temperatures. Used as a plant hardiness indicator. Other plant hardiness zones developed by other entities use different numbering systems.

vaporization. The evaporation of the active ingredient in a pesticide during or after application.

variety. In the wild, a plant growing within a species that is different in some particular characteristic from other members of that species. When grown from seed, a variety will maintain all of its particular characteristics. Also called a botanical variety.

vascular pathogen. A disease-causing organism that invades primarily the conductive tissues (xylem or phloem) of the plant.

vascular system. The internal structure of the stem that transports water, minerals, and sugars throughout the plant.

vascular tissue. Water, nutrient, and photosynthate-conducting tissue. (See also xylem; phloem.)

vector. A living organism that is able to transmit or spread a pathogen.

vegetative bud. A type of bud that develops into shoots.

vegetative propagation. The increase of plants by asexual means using vegetative parts. Normally results in a population of identical individuals. Can occur by either natural means (e.g., bulblets, cormels, offsets, plantlets, or runners) or artificial means (e.g., cuttings, division, budding, grafting, or layering).

venation. The pattern of veins in leaves.

vernation. The arrangement of new leaves within an older leaf sheath (e.g., on a grass plant).

vertical spacing. The vertical space between branches on a tree.

viability. A seed's ability to germinate.

viable. Alive; seeds must be alive in order to germinate.

virulent. Capable of causing severe disease.

virus. An infectious agent composed of DNA or RNA, too small to see with a compound microscope. Multiplies only in living cells.

water-holding capacity (WHC). The ability of a soil's micropores to hold water for plant use.

water-soaking. Lesions that appear wet and dark and usually are sunken and or translucent. Often a symptom of bacterial disease.

water sprout. A vigorous shoot originating above the ground on a plant's trunk, older wood, or bud union. Usually breaks from a latent bud. Often the result of heavy pruning.

weed-and-feed. A combination fertilizer and herbicide sometimes used on lawns.

whorled leaf arrangement. Three or more leaves attached at the same point on a stem.

wilt. Drooping and drying plant parts due to interference with the plant's ability to take up water and nutrients.

wilting point. Point at which the water content within plant cells is low enough that cellular turgor is lost and the plant wilts.

winter annual. Annual plant in which the seed germinates in the fall, producing a plant that over-winters, matures, and produces seed the following growing season.

witches' broom. Abnormal brushlike development of many weak shoots.

woody perennial. A plant that goes dormant in winter and begins growth in spring from aboveground stems.

xeric. A plant or landscape that conserves water. Most xeric plants need minimal supplemental water after an establishment period (18–24 months after planting) unless there is extreme drought.

xylem. The principal water-conducting tissue of vascular plants.

zone of elongation. The area of the root where the cells expand.

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