IWC Annual Report

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Title: Active Canopy Sensors to Prescribe In-Season Supplemental Nitrogen for Wheat

Personnel: Jared Spackman, Assistant Professor, UI Aberdeen; Olga Walsh, Associate Professor, UI Parma; Albert Adjesiwor, Assistant Professor UI Kimberly

Address: Jared Spackman 1693 S. 2700 W. Aberdeen, ID 83210; (208) 312-2454; jspackman@uidaho.edu

Abstract:

The University of Idaho's wheat production guides were last updated in the early 2000s requiring new research evaluating wheat responses to nitrogen. Further, given the high cost of nitrogen fertilizers, improving nitrogen use efficiency is an important aspect of a farm remaining economically viable. Split fertilizer applications may improve fertilizer use efficiency and reduce the total N rate applied. This practice allows time for the wheat crop to integrate weather, mineralization, residual N, and pest pressure into its growth before a producer makes a final N fertility decision. Crop sensing technologies can then be used to rapidly assess the crop's greenness accounting for field variability and providing variable N rate prescriptions. The objective of this study was to evaluate the response of irrigated spring hard red, hard white, and soft white wheat yield, grain protein, and nitrogen use efficiency to increasing nitrogen fertilizer rates applied at planting or split applied as a small amount at planting and the remainder applied at tillering. An additional objective was to determine if in-season soil, plant tissue, and crop canopy sensing measurements could be used to predict yield and nitrogen demand.

Background/Objectives:

It is estimated that <51% of fertilizer nitrogen applied is used by cereal crops with the rest either being lost to the environment or bound in soil organic matter. For wheat production, nitrogen must be carefully managed to prevent excessive vegetative growth and lodging, delayed maturity, pest pressure, and to ensure grain protein meets end-use targets. The University of Idaho's current N fertilizer rate recommendations is determined by accounting for the amount of residual soil inorganic N in the soil, the previous crop, soil mineralization potential, and yield goal. These guidelines were last updated in the early 2000s. One of the objectives of this study is to provide more recent data about the response of wheat yield and grain protein content to nitrogen availability. Further, given the high cost of nitrogen fertilizers, improving nitrogen use efficiency is an important aspect of a farm remaining economically viable. Split fertilizer applications are one approach that may improve fertilizer use efficiency, reduce the total N rate applied, and improve a producer's overall sustainability. Split-applying nitrogen fertilizer allows time for the wheat crop to integrate weather, mineralization, residual N, and pest pressure into its growth before a producer makes a final N fertility decision. Crop sensing technologies can then be used to rapidly assess the crop's greenness accounting for field variability and providing variable N rate prescriptions.

The objectives of this study were:

1) Determine hard red, hard white, and soft white wheat yield, grain protein, and N use

efficiency response to in-season N application

2) Develop crop sensor algorithms for Idaho conditions for different wheat classes

Results / Accomplishments:

We successfully established field plots at the Aberdeen Research and Extension Center.

Gunsight (HRSW)	IDO2002S (HWSW)	IDO1702S (SWSW)
0/0/0	0/0/0	0/0/0
140/0/40	110/0/40	80/0/0
210/0/40	170/0/40	140/0/0
280/0/40	230/0/40	200/0/0
320/0/40	260/0/40	260/0/0
350/0/40	290/0/40	320/0/0
400/0/40	350/0/40	110/0/0
140/70/40	110/60/40	110/30/0
140/140/40	110/120/40	110/90/0
140/180/40	110/150/40	110/150/0
140/210/40	110/180/40	110/210/0
140/260/40	110/240/40	110/70/20

Table 1 Nitrogen fertilizer treatments where the amounts of fertilizer applied at planting/Feekes 5/Boot is denoted in lb/ac.

Treatments are described in Table 1. At planting, urea was banded between the seed rows, whereas the Feekes 5 and boot split applications were broadcast applied and irrigated into the soil within 4 hours of fertilization.

We collected soil samples by replication at 1-foot increments down to 2 feet at pre-plant and analyzed them for complete nutrient analysis. Additional soil samples were collected from each plot at 1-foot increments down to 2 feet at jointing, flowering, and post-harvest for a total of 864 soil samples. Soil samples were stored in a walk-in cooler at 40F until they were shipped to Brookside Laboratories in December for soil nitrate and ammonium content analysis. Our pre-plant soil samples indicated that we had 70 lb N/ac in the top 2'.

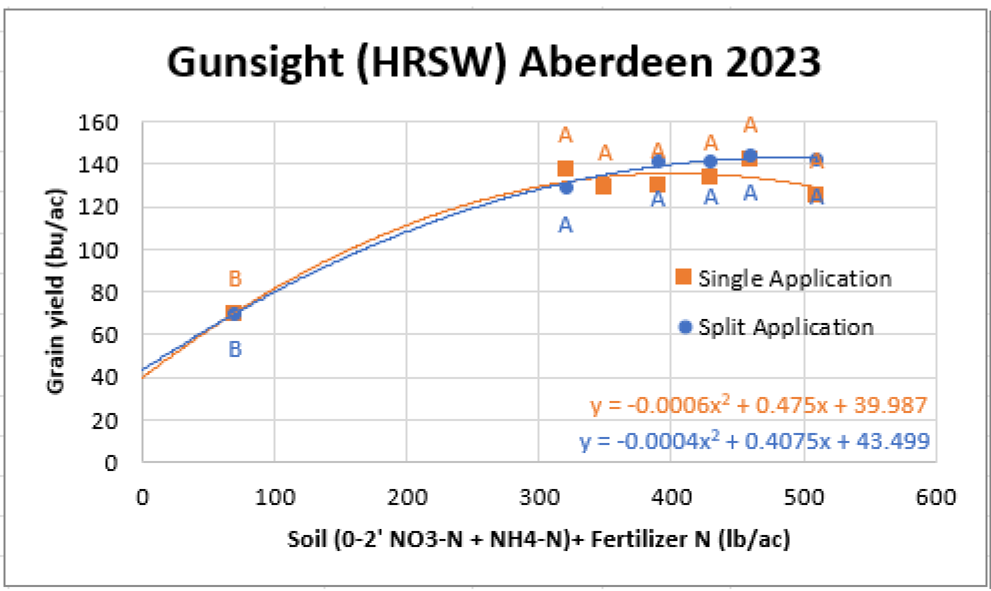
Crop canopy greenness was measured from each plot using the Apogee, SPAD, and Greenseeker sensors at jointing and flowering (864 measurements). Sensor measurements will be transcribed from paper to electronic format by a temporary help. Whole plant tissue samples were collected from each plot at jointing, flowering, and immediately before harvest by harvesting 1 meter of row. Samples collected before harvest are currently being partitioned into heads and straws. The heads were counted and will be threshed to quantify the number of viable heads per meter of row and the average number of kernels per head. All plant tissue samples were dried, weighed, and will be submitted to Brookside Laboratories for total N analysis in February 2024. All harvest grain samples have been analyzed for test weight and have been submitted to the Wheat Quality Lab for bake quality. We will also analyze the grain samples for protein concentration.

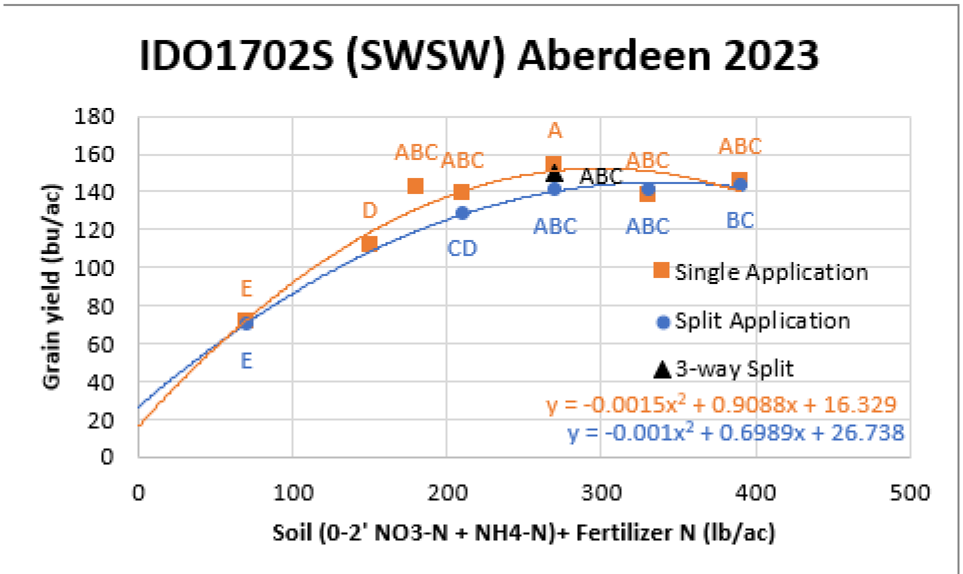
Our initial results for 2023 indicated that all three wheat varieties' yields responded positively to pre-plant and split nitrogen applications. Quadratic responses were observed for all varieties indicating that we applied insufficient to sufficient levels of nitrogen with our treatment structure. The point at which yield plateaus indicates the maximum yield to be achieved under the growing conditions tested and nitrogen rates applied. In these studies, the amount of soil + fertilizer nitrogen required to maximize yield was always greater for the split fertilizer applications than the single application done at planting. This was especially evident for Gunsight where the single application required 396 lb N/ac while the split application indicated 509 lb N/ac was required to maximize yield (Table 2). Despite the differences in nitrogen required, the maximum yield achieved under single or split fertilizer regimes was within 13 bu/ac of each other.

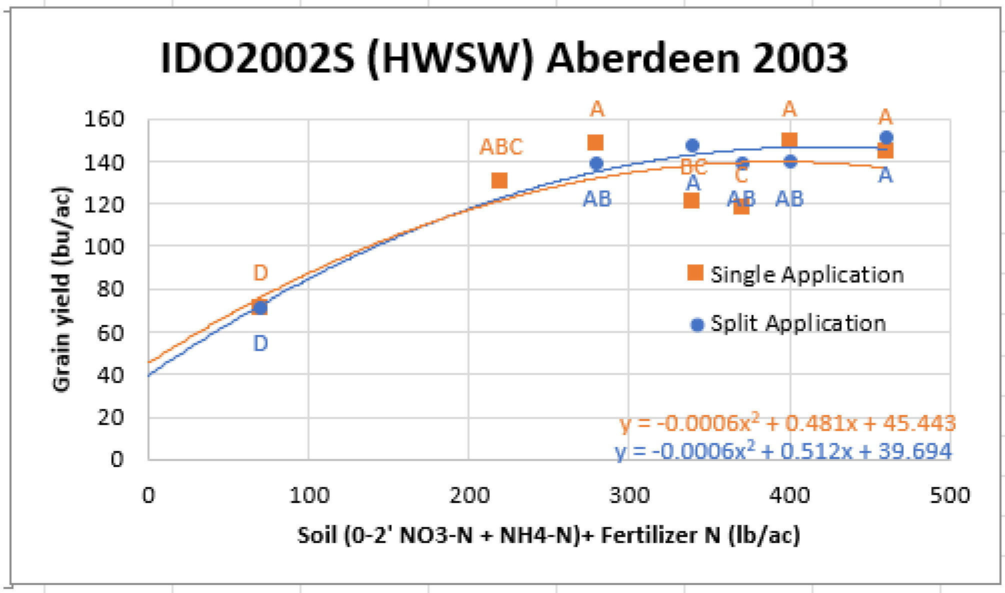
Table 2. The amount of nitrogen (soil + fertilizer) required to maximize yield (yield plateau) for the single and the split fertilizer application treatments in each wheat class tested at Aberdeen 2023.

	Single		Split	
	Soil+Fert N rate (lb/ac)	Yield Plateau (bu/ac)	Soil+Fert N rate (lb/ac)	Yield Plateau (bu/ac)
Gunsight	396	134	509	147
IDO2002S	401	142	427	149
IDO1702S	303	154	349	149

Figures 1,2,3. Grain yield responses to soil+fertilizer nitrogen rate when the majority of nitrogen fertilizer is applied as a single application done at planting or as a split application done at Feekes 5. Data points with the same upper case letter (irrespective of color) within a wheat class indicate that there are no significant differences between treatment means at alpha<0.05. Orange letters correspond to the single application points, blue letters correspond to the split application points, and the black letters (IDO1702S only) correspond to the 3-way split application point.





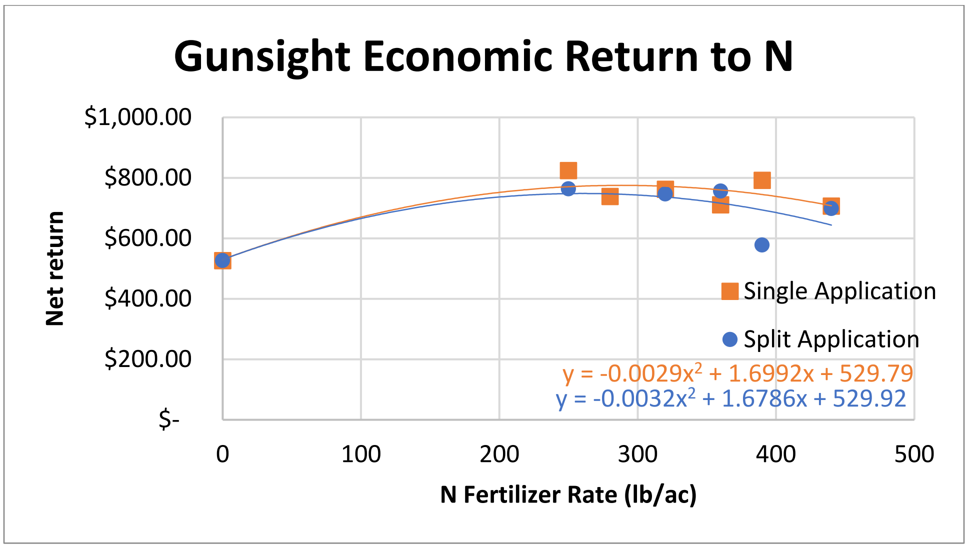


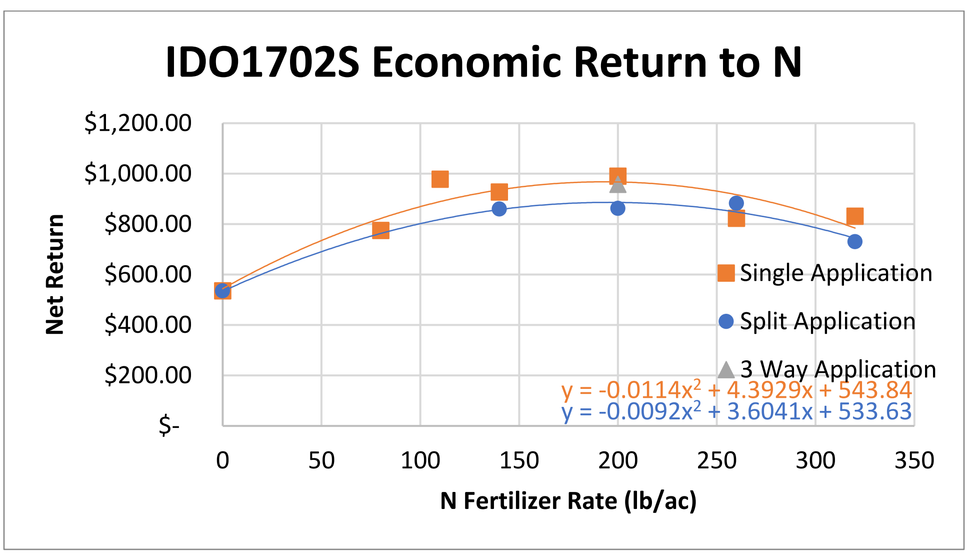
For Gunsight and IDO1702S, there was no difference in yield between the single or split fertilizer applications when the total applied N rate was the same. A similar response was observed for IDO2002S except at the 340 and 370 lb N/ac rates where split applications outyielded a single application done at planting by 24 bu/ac on average.

In previous years, we have observed split applications underperforming, performing as well as, and outperforming single applications. Once we finish processing all of our grain data, the next step will be to synthesize our results to determine what the predominant pattern is for each market class.

While yield response to available nitrogen is an important component of determining the optimal nitrogen rate for wheat production, economics also play a role. The economic nitrogen return rate (Return to N) was calculated by subtracting the cost of the applied nitrogen fertilizer (assumed $0.83 per unit of fertilizer N) from the value of grain yield [assumed wheat was $7.50/bu (average of 6 months reported in AgProud Journal) irrespective of the wheat class]. The net economic return values for each treatment were regressed against the applied nitrogen fertilizer rate. As with yield, the response of net return to nitrogen rate was a quadratic response across all classes of wheat and application timings (Figures 4,5,6) The point at which net return was maximized is considered the economic optimal nitrogen rate. This quick analysis does not account for the costs to apply nitrogen fertilizer that would vary depending on the application method (e.g., fertigation, aerial application, spreader). Accounting for these additional application costs would reduce the economic optimal nitrogen rate for the split applications.

Figures 4,5,6. The economic return from nitrogen fertilizer additions for the single and split application treatments.





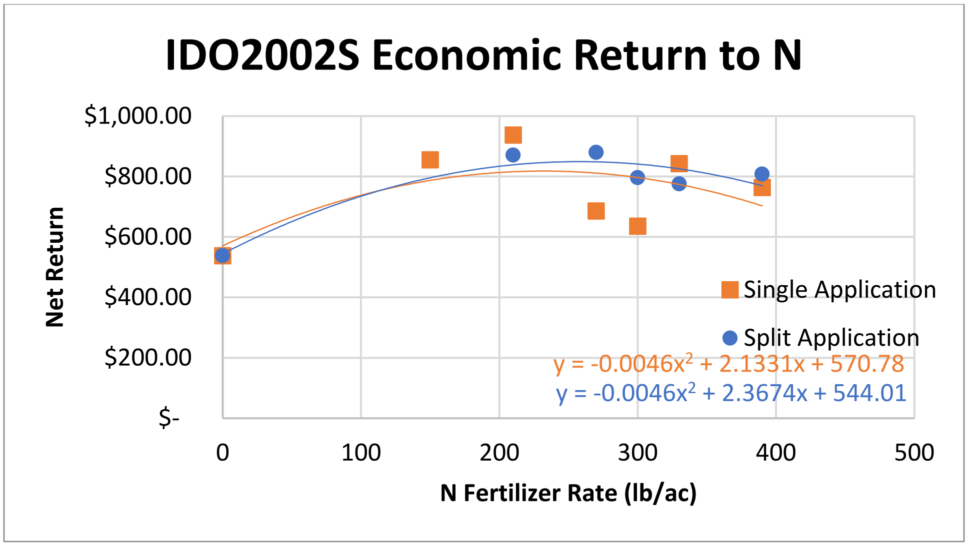


Table 3. The amount of nitrogen fertilizer (N Rate) or soil nitrogen plus fertilizer nitrogen (Soil + Fert N Rate) required to maximize the economic return for a single or split application done in each wheat class tested at Aberdeen 2023. The values in parentheses indicate the range of nitrogen rates that would give a -$1 net return on investment.

	Single Application			Split Application		
	N Rate (lb/ac)	Soil + Fert N rate (lb/ac)	Net Return ($/ac)	N Rate (lb/ac)	Soil + Fert N rate (lb/ac)	Net Return ($/ac)
Gunsight	293 (274-312)	363 (344-382)	$ 779.00	262 (245-280)	332 (315-350)	$ 750.00
IDO2002S	232 (217-247)	302 (277-317)	$ 818.00	257 (242-272)	327 (312-342)	$ 849.00
IDO1702S	193 (183-202)	263 (253-272)	$ 967.00	196 (185-207)	266 (255-277)	$ 887.00

For Gunsight, the economic optimal nitrogen rate was 31 lb N/ac greater for the single application than the split application and returned an additional $29/ac (Table 3). In contrast, for IDO2002S the economic optimal N rate was 25 lb N/ac less for the single application and returned -$31/ac compared with the split application. For IDO1702S, the economic optimal N rate was similar, but the single application returned an additional $80/ac relative to the split application.

Because growers are willing to accept different levels of risk, the economic nitrogen rates reported in Table 3 also contain a range of N rates shown in parentheses. These ranges of nitrogen rates indicate how much less or more nitrogen could be applied that would reduce the net return by $1. The reported ranges in this study are 20 to 38 lb N/ac wide indicating that near the economic optimal nitrogen rate, there is a fair bit of flexibility in N application rates that will minimally impact net return. The next step is to take this data one step further and incorporate grain quality dockage factors (e.g., test weight and protein) and in-season application expenses into the economic analysis.

Outreach / Applications / Adoption:

The data from this study was presented at the University of Idaho and Shell Introductory Workshop on Dairy Sustainability: Nutrient Management in Small Grains meeting on May 10, 2023 and the WERA-103 Idaho State Annual Report. Data from FY2023 was also presented at 1 field day in Aberdeen during our summer cereal tours. At the time of the tour, nitrogen treatment differences were evident. We received excellent participation and questions from growers and industry representatives about nitrogen management strategies. Data from the past three years will be presented at this year's cereal schools.

Next Steps / Projections

After we finish our nutrient analyses and compile the project results from the last three growing seasons, (7 site-years) we will work on publishing the project as three papers. We will use data collected to investigate the relationship of in-season soil and plant tissue nitrogen content to wheat yield and quality and nitrogen use efficiency. We will calculate the soil-crop nitrogen balance. We will also correlate our crop sensor readings to grain yield. We will create algorithms to estimate the in-season N rate required to achieve targeted yield and protein goals. We will also compare the apparent N use efficiency of the single vs split applications. Finally, we will further evaluate the economic optimal nitrogen rates by looking at the factors previously described.

Publications / Presentations / Popular Articles / News Releases / Variety Releases:

Spackman, J.A. University of Idaho and Shell Introductory Workshop on Dairy Sustainability: Nutrient Management in Small Grains. 10 May, 2023.

Spackman, J.A. 2023. Nitrogen Fertilizer Rate and Timing and Humic Acid for Cereal Production. Aberdeen Cereals Field Day. 20 July, 2023.

Spackman, J.A. 2023. WERA-103 State Annual Report 2023.