MN Wheat On-Farm Research Network 2022 Report

ON-FARM RESEARCH NETWORK
MINNESOTA WHEAT

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Foliar Copper at Tillering

Objective
Assess the return on investment by adding foliar copper sulfate to wheat fields that are below the critical soil test level of 0.4 ppm.

Years of Study
2022

Treatments
Control - No added copper

Treatment - 0.5 pt/acre Ele-max copper chelate at 20 GPA applied alone at 4-5 leaf stage

Methods
- Ele-max was applied alone at tillering at two locations in 2022 (**Table 1**).
- Plots were established and harvested with producer equipment. Plots were one sprayer-width wide by the full length of the field. Treatments were replicated four times in a randomized complete block.
- At harvest, one combine pass from each plot was weighed in a weigh wagon or a grain cart at harvest. Grain was sampled to test moisture content, test weight, and protein content**.**
- All statistical analyses were conducted at the 90% confidence level.

Table 1. Agronomic information for the 2022 locations

	Roosevelt	Beltrami
Variety	TCG Wildcat	AP Murdock
Copper Application Date		6/15/2022
Planting Date	27-May	17-May
Harvest Date	12-Sep	22-Aug
Soil Org. Matter	2.7%	3.0%
Soil Type	Clay Loam	Sandy Loam
Previous Crop	Soybeans	Soybeans
Pre-trial Soil Test Copper	0.3 ppm	0.23 ppm
Total Rain[1]	5.6”	11.4”

1 – Total rain between planting and harvest dates estimated by Climate Fieldview.

Results

Table 2. Yield, protein, moisture, and test weight data from individual and combined locations at Beltrami, and Roosevelt, MN, in 2022

		Beltrami	Roosevelt	Combined
Yield (bu/ac)	Control	84.7 b	64.7 -	74.8 -
	Copper	88.8 a	64.6 -	76.1 -
	LSD 90% CL	3.2	NS	NS
	CV (%)	3.2%	1.9%	14.7%
Protein (%)	Control	13.4 -	13.0 -	13.2 -
	Copper	13.6 -	13.2 -	13.3 -
	LSD 90% CL	NS	NS	NS
	CV (%)	2.1%	2.3%	2.3%
Moisture (%)	Control	12.9 -	14.6 -	13.8 -
	Copper	12.8 -	14.1 -	13.5 -
	LSD 90% CL	NS	NS	NS
	CV (%)	2.1%	3.2%	6.0%
TW (lbs/bu)	Control	61.8 -	63.0 -	62.2 -
	Copper	61.7 -	63.0 -	62.2 -
	LSD 90% CL	NS	NS	NS
	CV (%)	1.2%	0.8%	1.6%

* Lowercase letters (a, b) indicate a treatment is significantly different from other treatments with a different letter at the same location at the 90% confidence level.
** A coefficient of variation (CV) of < 10% generally indicates data are less "noisy" and more reliable than data with a CV > 10%.

Key Take-Aways

- Foliar copper at tillering significantly increased yield by about 4.1 bu at Beltrami (Table 2**).**
- Tissue testing before and after application will be added in 2023.

Figure 1. Wheat showing copper deficiency symptoms near Warren, MN, 7-28-22.

Long-term Elevated P and K Fertility

Objective

To determine optimum levels of Phosphorus (P) and Potassium (K) in a high yield, long term sequence of spring wheat and soybeans in northwest MN using university small-plot trials and large-plot on-farm research trials.

Principal Investigators

Dave Grafstrom, UMN Magnusson Research Farm
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Funding Partners

MN Wheat Research and Promotion Council, MN Soybean Research and Promotion Council, Agricultural Fertilizer Research and Education Council (AFREC)

Years of Study

2019-2022

Treatments

Control – Farmer practice (FP) rate of P and K fertility
Treatment – FP rate of P and K, + 50 units P + 50 units K

Methods

Small Plots

- The small plot treatment rates included 0, 20, 40, 60, 80 and 100 units of P and K and combination of P and K in both wheat and soybeans, plus an untreated control were applied broadcast and incorporated prior to seeding.
- Small plot treatments are outlined below in **Table 5**. In-season data collected included stand-count, relative chlorophyll index (RCI), plant height, and plant tissue analysis.
- Harvest data collected included yield, protein, oil, test weight, harvest moisture, and a complete soil analysis for residual nutrients.
- Wheat yields corrected 12% moisture, and soybean yield was corrected to 13% moisture. Small-plot data and least significant differences were calculated at the 95% confidence level.

Table 5. Small plot P and K fertility treatments.

P	K	P+K
0-46-0 @ 20 units	0-0-60 @ 20 units	0-46-0 + 0-0-60 @ 20 units of each
0-46-0 @ 40 units	0-0-60 @ 40 units	0-46-0 + 0-0-60 @ 40 units of each
0-46-0 @ 60 units	0-0-60 @ 60 units	0-46-0 + 0-0-60 @ 60 units of each
0-46-0 @ 80 units	0-0-60 @ 80 units	0-46-0 + 0-0-60 @ 80 units of each
0-46-0 @ 100 units	0-0-60 @ 100 units	0-46-0 + 0-0-60 @ 100 units of each
Untreated control		

Large Plots

The large-plot on-farm trials were located near Roseau, Baudette, and Elbow Lake, MN in conjunction with small-plot research conducted at the U of MN Magnusson Research Farm near Roseau, MN.

- Two large on-farm research experiments, one soybean and four wheat locations, were harvested near Baudette and Elbow Lake in 2022. Three other plots established near Roseau in previous seasons were lost to prevent-plant this year due to the late, wet spring.
- Fertilizer was applied by the producer's co-op, and plots were harvested by the producer. Individual plots were replicated four times and the treatments were one to two passes of the application equipment by the full length of the field.
- Tissue samples were collected in-season at tillering for wheat, and at the third trifoliate in soybean.
- At harvest, one combine pass from each plot was weighed in a weigh wagon or a grain cart at harvest. The grain was sampled to test moisture content, test weight, and protein content.
- A complete soil test was sampled in each plot after harvest for residual nutrient analysis.

Results

Small Plot Results

The spring of 2022 was cold and wet. Cold fronts were the dominate weather pattern as winds from north and northwest were recorded on 20 days in April (NDAWN). Weather records from the National Weather Service in Grand Forks, ND lists April of 2022 as the second coldest on record with an average temperature of 31.8 °F. Further, the National Weather Service in Grand Forks listed May of 2022 as the 5th wettest on record which dates back 140 years. Temperatures in the first half of May were cold, dominated by high pressure systems and winds from the north and northwest (NDAWN). Springs field work finally began in the latter part of May. The small plot wheat trial was seeded on May 28 and the small plot soybean trial was seeded on June 9. Even with delayed planting and challenging soil conditions at planting, crop emergence and early season growth was good to excellent. Rainfall totals in June were 50% of normal, July was average, and August recorded twice the normal rainfall for the Roseau area. Daily high temperatures were normal to slightly above normal for most of the growing season. However, the daily minimum temperature was average to 10 degrees above normal. (NDAWN).

In 2022, no differences were detected from any of the additional fertility treatments compared to the untreated in wheat or soybeans. These results were contrary to those obtained in 2021 which suggested that the combination of P and K produced more wheat yield than the single products alone, especially at 40, 60, 80 and 100 units of each product. A possible explanation for the differential response of wheat to the fertility treatments between 2021 and 2022 can be found in the North Dakota Fertilizer Handbook. This publication gives a probability of a response to applied fertilizer based on soil test levels in the field. As an example, with soil P levels of 4-7 ppm (Olsen), applied phosphorus would have a 60-80% chance of a positive yield response. Based on this data, the probability of little or no response to applied P would be 20-60%. The 2021 season probably was one of the times with little to no response to applied fertilizer. Another possible explanation would be the average yield levels of wheat and soybeans produced in 2022. With a higher yield potential, the probability of a positive yield response to applied fertilizer would be higher than in years of average yield production.

Table 6. Wheat small-plot results, Magnusson Research Farm, Roseau, 2022

TRT#	Units P & K [1]	Yield[2]	Test Wt.	Protein[3]	Height (In)	RCI[4]	Plant pop.[5]
1	0-20-0	75.5	60.6	16.6	29	340	1.264
2	0-40-0	78.1	60.8	16.7	29	381	1.296
3	0-60-0	76.5	60.5	16.8	29	323	1.296
4	0-80-0	79.0	60.7	16.8	28	360	1.306
5	0-100-0	78.2	60.5	16.7	30	360	1.264
6	0-0-20	74.3	60.7	16.9	28	284	1.264
7	0-0-40	74.7	60.7	16.8	29	313	1.166
8	0-0-60	75.0	60.8	16.9	28	251	1.188
9	0-0-80	77.2	60.7	17.0	28	275	1.264
10	0-0-100	78.2	61.0	17.1	28	299	1.372
11	0-20-20	73.7	60.5	16.6	28	332	1.426
12	0-40-40	78.7	60.7	16.7	29	355	1.296
13	0-60-60	81.1	60.9	16.7	29	379	1.154
14	0-80-80	79.3	60.7	16.9	29	338	1.34
15	0-100-100	77.9	61.1	16.9	29	328	1.296
16	0-0-0	77.4	60.5	16.7	29	291	1.296
	LSD 95% CL	3.9	0.6	0.3	1	77	0.182
	LSD 90% CL	3.2	0.5	0.3	1	66	0.15
	CV (%)	3.5%	0.6%	1.2%	3%	16%	10%

- [1]Units P & K - 0-46-0 super phosphate and 0-0-60 potash were used for P and K sources above farmer's usual fertility.
- [2]Yield – Bushels per acre were corrected to 12% moisture for wheat.
- [3]Protein – content was measured on a dry matter basis
- [4]RCI – Relative chlorophyll index 6/8/22 – where the higher the number, the more chlorophyll.
- [5]Plant pop. – Plant count in millions per acre on 6-22-2022.
- Experimental Design: RCB with 4 replications.
- All plots use best management practices.
- 160-0-0 applied to all plots, incorporated prior to seeding.
- Plot size = 6' x 15', Harvest area= 5' x 10'.
- Seeding date: 5/28/22, Linkert at 120 lb/acre.
- Harvest date: 9/5/22.

Conclusions – Wheat Small-plots

- Wheat yields ranged from 74.3 to 81.1 bu/ac (**Table 6**).
- The average yield in the untreated plots was 77.4 bu/ac.
- At the 0.05% confidence level, wheat yields were similar for all fertility treatments compared to untreated plots. These results are contrary to the wheat yields in 2021 which indicated that the combination of P & K produced more grain yield than the single products alone, especially at 40, 60, 80 and 100 units of each product.
- In 2022, test weight ranged from 60.5 to 61.1 lb/bu.
- Protein ranged from 16.6 to 17.1%. At the 0.05% confidence level, test weight and protein were similar to the untreated.
- Further, no treatment differences were detected in plant height or plant populations.

Table 7. Soybean small-plot results, Magnusson Research Farm, Roseau, 2022

TRT#	Units P & K[1]	Yield[2]	Test Wt.	Protein[3]	Oil[3]	Height (In)	RCI[4]	Color[5]	Plant pop.[6]
1	0-20-0	54.1	59.4	40.0	19.7	36	265	1.3	0.207
2	0-40-0	47.2	59.9	40.2	19.5	34	282	1.8	0.194
3	0-60-0	50.6	59.6	40.2	19.3	37	272	1.8	0.177
4	0-80-0	48.8	59.7	39.9	19.4	35	275	1.8	0.172
5	0-100-0	52.0	59.2	39.9	19.4	37	264	1.3	0.191
6	0-0-20	48.7	59.6	39.7	19.6	35	263	1.5	0.161
7	0-0-40	49.9	59.2	39.3	20.0	35	255	1.3	0.193
8	0-0-60	50.2	59.0	39.3	20.0	34	268	1.5	0.188
9	0-0-80	47.1	59.3	39.6	19.8	34	262	1.0	0.185
10	0-0-100	51.1	58.9	39.5	20.2	34	267	1.5	0.177
11	0-20-20	57.5	59.2	40.2	19.7	36	276	1.5	0.194
12	0-40-40	55.4	59.4	39.6	19.8	37	280	1.0	0.172
13	0-60-60	53.8	59.3	39.1	19.6	36	267	1.5	0.191
14	0-80-80	53.9	59.5	38.9	19.9	35	267	1.8	0.158
15	0-100-100	57.8	59.6	39.7	19.5	36	251	1.3	0.18
16	0-0-0	52.1	59.0	39.7	20.1	35	270	1.5	0.204
LSD @ 5% Level		6.7	0.8	0.9	0.5	2	37	0.7	0.0639
LSD @ 10% Level		6.1	0.7	0.8	0.4	1	30	0.6	0.058
CV (%)		9%	0.9%	1.7%	1.9%	4%	10%	35%	12%

- [1]Units P & K – 0-46-0 super phosphate and 0-0-60 potash used for P and K sources.
- [2]Yield – Bushels per acre corrected to 13% moisture for soybean.
- [3]Protein and Oil[3] content were measured on a dry matter basis.
- [4]RCI – Relative chlorophyll index-higher number = more chlorophyll.
- [5]Foliage color :1 = light green – 3 = Dark green.
- [6]Plant pop. – Plant count in millions per acre on 6-22-2022.
- Experimental Design: RCB with 4 replications.
- All plots use best management practices.
- Soybean variety – AG005xF2 seeded at 1.5 units/acre; 210,000 PLS/acre.
- Plot size = 6’ x 15’ with harvested area 5’ x 10’.
- Seeding date: 6/9/22.
- Harvest data: 10/7/22.

Conclusions – Soybean Small-plots

- Soybean yield ranged from 47.1 to 57.8 bu/ac (**Table 7**).
- The untreated plots had an average yield of 52.1 bu/ac. At the 0.05% confidence level, no differences were detected among the various fertility treatments compared to the control.
- In 2022, test weight ranged from 58.9 to 59.9 lb/bu, protein ranged from 38.9 to 40.2% and oil ranged from 19.3 to 20.1%. At the 0.05% confidence level, the fertility treatments had similar test weight, protein and oil compared to the untreated.

Large-plot Results

Table 8. Agronomic information for the 2022 on-farm locations

Location	Elbow Lake	Baudette
Crop	Wheat	Soybean
Variety	SY Valda	Croplan 008847X
Date Fertilized	15-May	23-Aug, 2021
Planting Date	17-May	10-Jun
Harvest Date	25-Aug	10-Oct
Organic Matter %	3.8%	3.0%
Soil Type	Clay Loam	Sandy Loam
Pre-trial P ppm	8 ppm	17 ppm
Pre-trial K ppm	151 ppm	112 ppm
Total Rain*	6.2"	10.2"

*Total rain between planting and harvest dates estimated with Climate Fieldview.

Table 9. Soybean yield data from Baudette, MN, 2022

Baudette	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
Soybean	Control	36.7		13.3	59.3
	+50u P+K	34.4		13.2	59.0
	LSD 90%CL	NS		NS	NS
	CV (%)	10.3%		1.9%	0.8%

* Lowercase letters (a, b) indicate a treatment is significantly different from other treatments with a different letter at the same location at the 90% confidence level.
** A coefficient of variation (CV) of < 10% generally indicates data are less "noisy" and more reliable than data with a CV > 10%.

Table 10. Wheat yield data from Elbow Lake, MN, 2022

Elbow Lake	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
Wheat	Control	83.4	13.7	13.9	60.7
	+50u P+K	87.2	13.8	13.9	60.7
	LSD 90%CL	2.1	NS	NS	NS
	CV (%)	4.2%	1.9%	1.2%	0.5%

* Lowercase letters (a, b) indicate a treatment is significantly different from other treatments with a different letter at the same location at the 90% confidence level.
** A coefficient of variation (CV) of < 10% generally indicates data are less "noisy" and more reliable than data with a CV > 10%.

Large Plot Key Take-Aways

- No differences in yield, protein, moisture and test weight were observed at the Baudette on-farm trial location (**Table 9**).
- At Elbow Lake, good soil moisture and growing conditions through the summer resulted in the extra 50 units each P and K treatment yielded 3.8 bu higher than the control (**Tables 8 & 10**).
- At prices of $560/ton potash and $800/ton MAP, the total cost of spreading an extra 50 units P + 50 units K was $55.44.
    - At $6.00/bu wheat, it would take a yield increase of 9.2 bu to break-even
    - At $12.00/bu soybean, it would take a yield increase of 4.6 bu to break-even

N Rates on High-Yielding Wheat Varieties

Objective

Compare the yield, protein, and profitability response of modern high-yielding varieties to increasing N rates. In the future, compare sites with high-yielding varieties to sites with lower yielding, high-quality varieties.

Years of Study

2022

Treatments

N applied as urea at rates of 0, 60, 90, 120, 150, and 180 units N

Methods

- Prescription maps were used to apply 6 rates of urea in one-acre blocks in the field. Treatments were replicated three times in a randomized complete block design at two locations in the spring of 2022 (**Table 11**).
- Plots were established and harvested with producer or co-op spreader, and the producer's combine. Each individual plot was 140 ft wide x 400 ft long.
- Prior to harvest, wheat protein was collected by hand sampling, walking in a line, continuously collecting wheat heads from across the entire plot. Wheat heads were threshed in a small-plot combine with the help of the North Farm crew at the UMN Northwest Research and Outreach Center in Crookston, MN, and analyzed for protein content.
- Combine yield monitors were calibrated prior to harvest. The field was combined as usual, and grain yield and moisture were extracted from the yield map after harvest.
- All statistical analyses were conducted at the 90% confidence level.
- A partial-profit was calculated for each treatment to account for the cost of urea applied, protein premiums or discounts applied, and net profit from yield attained.

Table 11. Agronomic information for the 2022 locations

Location	East Grand Forks	Red Lake Falls
Variety	WB9719	WB9590
Date Fertilized	2-Jun	26-May
Planting Date	3-Jun	27-May
Harvest Date	9-Sep	1-Sep
Organic Matter %	4.8%	4.3%
Soil Type	Silty Clay Loam	Loam
Pre-trial residual NO3	40.7 lbs, 0-24"	36 lbs, 0-6"
Rain Fall	9.3"	12.4"

*Total rain between planting and harvest dates estimated with Climate Fieldview.

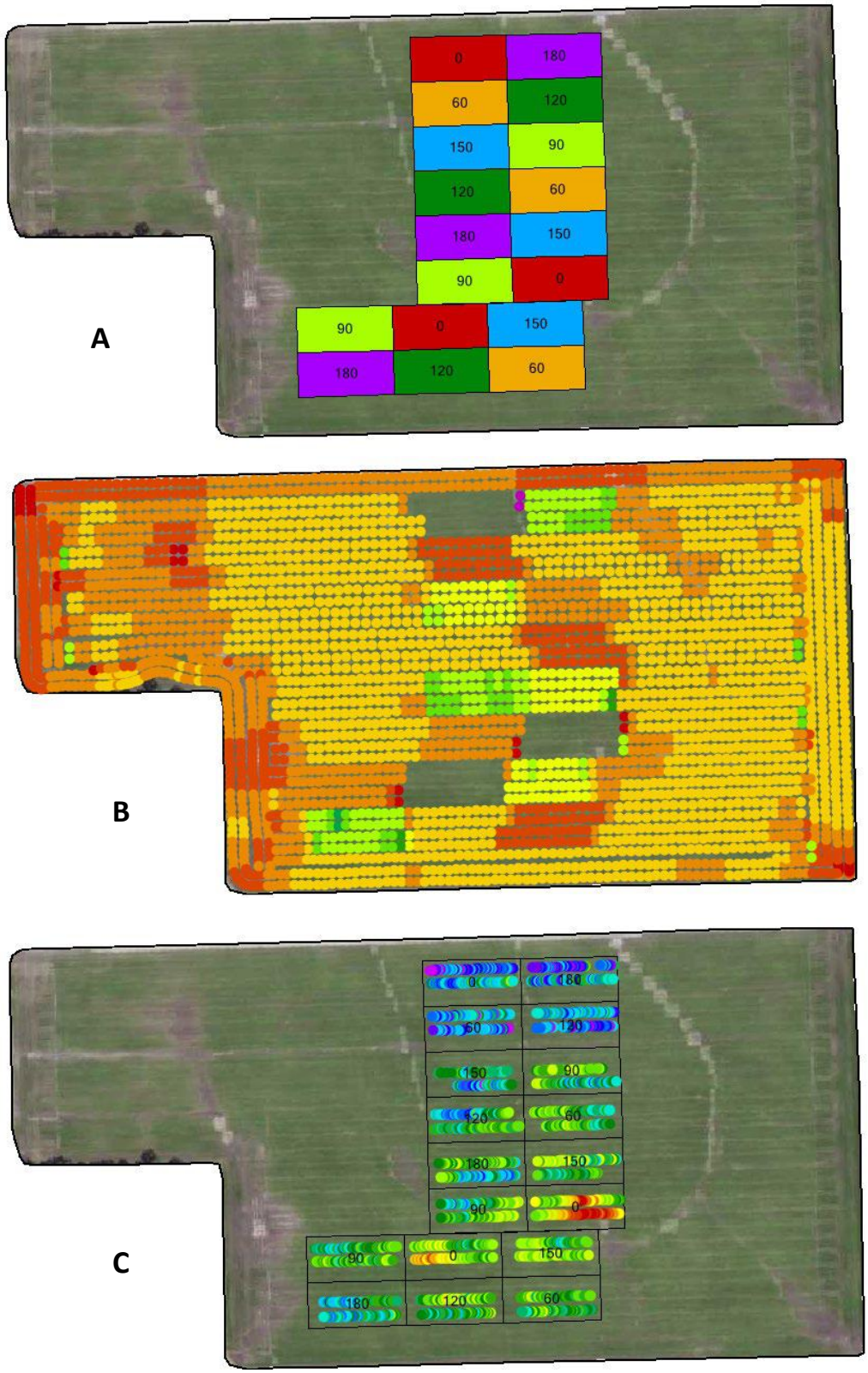

Figure 2. Treatment layout (A), as-applied map (B), and extracted yield data (C) in EGF, MN. Plots were placed to line up with the producer's AB line. Using the prescription map to apply the trial, the producer was able to apply and harvest the field as usual without interference.

Results

Table 12. Yield, protein, harvest moisture, residual soil nitrate, and calculated partial profit for each treatment at East Grand Forks, MN, 2022, variety WB 9719.

Units N	Yield (bu/ac)[1,2]	Protein (%)	Moisture (%)	0-24" Residual N (lbs)	Partial Profit (ac)[3]
0	57.7 b	12.9	13.9	17 c	$ 461.27 ab
60	68.3 ab	13.3	14.2	19 c	$ 494.29 a
90	68.4 ab	13.8	13.9	38 bc	$ 468.57 ab
120	69.4 a	13.0	14.3	39 bc	$ 450.65 ab
150	65.5 ab	12.6	13.8	51 b	$ 393.40 b
180	73.1 a	14.9	14.1	81 a	$ 428.22 ab
LSD 90% CL	6.2	NS	NS	13.6	$ 44.89
CV (%)[4]	8.1%	8.9%	4.2%	58.6%	8.5%

1 Yield and partial profit exclude Rep 3

2 Means with the same lowercase letter (a, b) are not significantly different from each other at the 90% confidence level.

3 Partial Profit = (bushels x $8) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $800/ton)

4 A coefficient of variation (CV) <10% indicates data are less "noisy" and more reliable than data with CV >10%.

- The highest yielding treatment received 180 lb N, while the lowest yielding treatment was the 0 lb N control.
- Residual soil nitrate increased with applied N rate
- The most profitable application was 60 lb N, while the least profitable treatment was 150 lb N
- It is unclear why protein content began decreasing at the 120 lb and 150 lb N rates at this site

Table 13. Yield, protein, harvest moisture, residual soil nitrate, and calculated partial profit for each treatment at Red Lake Falls, MN, 2022, variety WB 9590.

Units N	Yield (bu/ac)[1,2]	Protein (%)	Moisture (%)	0-24" Residual N (lbs)	Partial Profit (ac)[3]
0	70.5 b	11.8 c	13.8	8	$ 563.62
60	76.6 ab	13.0 abc	14.1	17	$ 586.88
90	80.5 ab	12.8 bc	14.0	8	$ 602.60
120	83.2 ab	14.0 ab	13.8	22	$ 608.37
150	79.9 ab	14.4 a	14.1	34	$ 567.12
180	87.4 a	14.4 a	13.8	35	$ 611.10
LSD 90% CL	7.7	0.9	NS	NS	NS
CV (%)[4]	8.1%	8.9%	2.9%	68.4%	5.6%

1 - Yield and partial profit exclude Rep 1

2 - Means with the same lowercase letter (a, b) are not significantly different from each other at the 90% confidence level.

3 - Partial Profit = (bushels x $8) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $800/ton)

4 A coefficient of variation (CV) <10% indicates data are less "noisy" and more reliable than data with CV >10%.

- The highest yielding treatment received 180 lb N, while the lowest yielding treatment was the 0 lb N control.
- Residual soil nitrate, grain protein content, and residual nitrate increased with applied N rate

Planting Green in the Frozen North

Objectives

Evaluate the effect of green seeding soybean into rye on soybean establishment, yield, and field management.

- Demonstrate that soybean can be successfully seeded into a living rye cover crop.
- Quantify the effect of a winter rye cover crop on soybean establishment and yield.
- Quantify the effect of a winter rye cover crop on IDC and weed pressure in soybean, soil fertility and soil health metrics.

Principal Investigators (in alphabetical order)

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Project Partners

Years of Study

Fall 2021- Fall 2022

Treatments

- No cover crop control (current tillage practice without a fall-seeded cereal rye cover crop)
- Rye terminated 7-14 days prior to planting
- Rye terminated within 24 hours of planting
- Rye terminated 7-14 days after planting

Methods

- Treatments were replicated 3 times at 5 locations between Appleton to Gentilly, MN (**Table 14**).
- Strip widths varied but were wide enough to allow for one combine pass in soybeans that excluded sprayer track damage.
- Plots were established and harvested using producer equipment.
- Soybeans were seeded in spring 2022 and cover crops terminated before, at or after soybean planting.

Table 14. Dates that the 2021 winter rye cover and 2022 soybean crop were seeded and soybean seeding rate in five Minnesota farmer fields

Town	Rye seeded ('21)	Soybean seeded ('22)	Soybean seeding rate (per acre)
Appleton	Oct 30-31	May 10	140,000
Browns Valley	Oct 31	May 23	165,000
Tintah	Sep 8	Jun 8	140,000
Barrett	Oct 31	May 27	165,000
Gentilly	Sep 7	Jun 7	175,000

Results

- Results are presented by location. Each trial location grew different soybean varieties and had different soybean seeding dates, seeding rates different dates of rye termination
- Here we summarize the effect of cover crop termination timing on rye biomass, soybean stand count, seed moisture, test weight, and yield.

Browns Valley

- Aerial seeding of rye into a standing silage corn crop in the fall of 2021 allowed some seed to drift into the no-rye plots (**Table 15**).
- The before-planting rye termination plots accumulated significantly less rye biomass than the at-planting plots and the at planting plots significantly more than the after-planting rye plots.
- There was a numerical trend with the lower rye biomass accumulation, the greater the soybean stand count, with the after-planting rye termination plots averaging 21,511 fewer plants/A than the other treatments.
- Soybean yields were similar for all but the lower yielding after-planting rye termination timing.
- Soybean moisture and test weights were similar among treatments.

Table 15. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at the Browns Valley, MN farm

Rye termination timing	Rye biomass (lb/A)	Soybean stand (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	1280 a	104,221 b	41.7 b	11.6	57.7
At planting	3091 b	103,576 b	41.2 b	11.6	57.7
After planting	4676 c	83,248 a	34.5 a	11.6	47.3
No rye	N/A	106,480 b	39.4 b	11.7	57.20
LSD 90% CL	44	10,492	2.61	NS	NS
CV (%)	14.66	6.65	4.19	0.81	15.76

Tintah

- Termination timing had a significant effect on rye biomass, with greater biomass with each successive timing (**Table 16**).
- Rye biomass also appeared to have an effect on soybean stand count; the no-rye and before-planting termination timing treatments had significantly higher soybean stand counts than the plots in which rye was terminated at or after soybean planting.
- The yields in the no-rye and before-planting termination timing plots were similar and greater than when rye was terminated at planting. Yield was lowest when rye termination took place after soybean planting.
- Oddly, soybean test weights were significantly lower in plots with no rye or when rye was terminated before planting than when rye was terminated at planting.

Table 16. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at the farm in Tintah, MN

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	1370 a	111,320 b	44.4 c	10.8	58.4 a
At planting	3413 b	95,040 a	40.0 b	10.7	59.3 b
After planting	4470 c	87,560 a	36.5 a	10.9	59.0 ab
No rye	N/A	109,120 b	45.6 c	10.8	58.3 a
LSD (90% CL)	957	11,257	1.60	NS	0.71
CV (%)	38.30	7.04	2.42	0.99	0.70

Barrett

- Rye biomass was significantly lower when terminated before soybean than when terminated either at or after soybean planting (**Table 17**).
- The soybean stand did not differ among treatments.
- Soybean yield was statistically similar regardless of rye termination timing, and lower than when grown without the rye cover crop.
- Soybean moisture was lowest in plots in which rye was terminated after soybean planting and highest in plots without rye or when rye was terminated before soybean planting.

Table 17. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at the farm near Barrett, MN

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	1128 a	130,357	45.9 a	10.8 b	57.3
At planting	2211 b	128,421	46.9 a	10.7 ab	57.2
After planting	2664 b	139,392	45.3 a	10.6 a	56.7
No rye	N/A	147,781	54.9 b	10.8 b	56.8
LSD (90% CL)	585	NS	3.1	0.2	NS
CV (%)	36.35	9.35	4.5	1.27	0.64

Gentilly

- The exceptional drought and early wheat harvest in 2021 allowed for timely rye seeding and the abnormally wet 2022 spring led to delayed soybean planting at the northernmost location (near Gentilly), allowing considerable rye growth.
- Each successive rye termination timing allowed for significantly more biomass to accumulate when compared to the previous timing (**Table 18**). Rye biomass was perhaps responsible for the lower soybean stand count, as the greater the biomass accumulation, the numerically lower the soybean stand.
- Surprisingly, soybean yields were statistically similar and greater in the plots with no-rye, at-planting and after-planting rye termination treatments than in the plots in which rye was terminated before planting.
- Soybean moisture content was significantly similar and higher in the rye plots than in the no-rye plots.
- Soybean test weight was significantly higher in the plots in which rye was terminated after-planting than at-planting.

Table 18. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at a farm near Gentilly, MN

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	2061 a	196,698 **ab**	35.7 a	12.2 b	60.7 ab
At planting	4384 b	175,015 a	41.4 b	12.5 b	60.2 a
After planting	4965 b	168,045 a	40.9 b	12.5 b	60.9 b
No rye	N/A	215,283 b	44.2 b	11.5 a	60.8 ab
LSD (90% CL)	1165	29,186	4.9	0.6	0.7
CV (%)	37.53	9.75	7.63	2.85	0.77

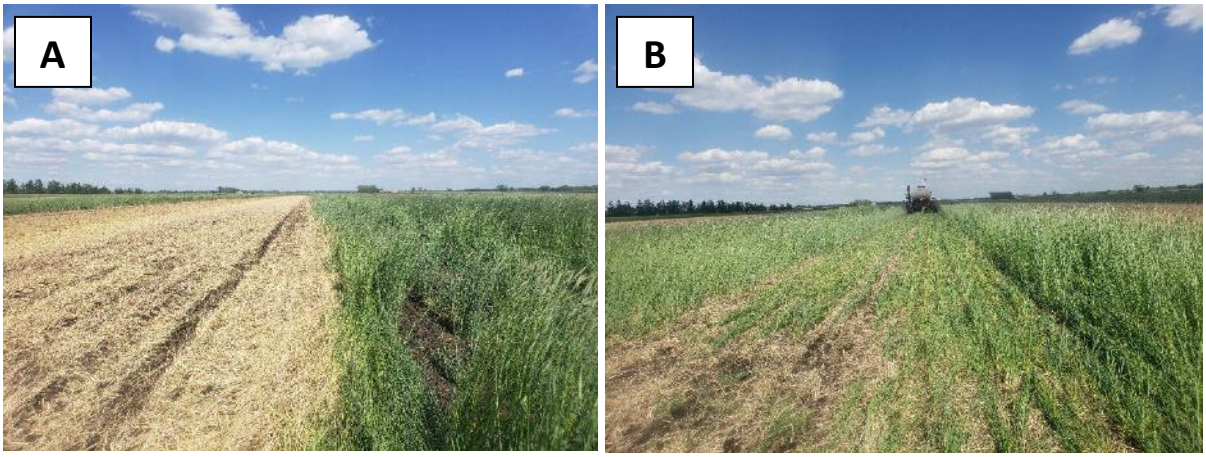

Figure 3. (A) Rye terminated May 26th (left) vs Rye terminated June 7th, prior to planting on June 8th (right). (B) Seeding soybeans into rye at Gentilly on June 8th, 2022, using single disc openers.

Appleton

- The first rye termination near Appleton took place at soybean planting. A significant additional 105 lb/A of rye biomass were added in the 13 days between soybean planting and the after-planting termination timing (**Table 19**).
- A numerical trend was observed in that the greater the cover crop biomass, the lower the soybean stand count. But this slight trend did not result in any statistical differences among treatments for soybean yield, moisture and test weight.
- There were no treatment differences in soybean yield, moisture or test weight.

Table 19. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at a farm near Appleton, MN

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting		Treatment not included at this location			
At planting	146.4 a	115,837	39.9	10.9	56.2
After planting	383.6 b	114,869	36.8	10.5	56.9
No rye		116,483	46.4	10.0	55.9
LSD (90% CL)	1.6	NS	NS	NS	NS
CV (%)	10.34	1.70	10.64	8.13	1.74

Figure 4. Rye overseeded into corn in 2021 at Appleton, MN.

Key Take-aways

- This document summarizes crops grown in farmer cooperators' fields in two abnormal growing seasons. The rye cover crop was seeded after an abnormally early harvest of the 2021 wheat crop (Gentilly) due to exceptional drought conditions or into standing corn crops (Barrett, Browns Valley, Tintah, Appleton) and then in spring 2022, soybean was seeded a month (or greater) later than normal due to very wet soil conditions. Only time will reveal how 'typical' the results of this 2021-22 study were.

Rye biomass & soybean stand count

- Delaying cover crop termination until 1-2 weeks after soybean planting produced more cover crop biomass at four of the five trial locations.
- At most of the locations, planting soybean into a living cover crop that was then terminated either immediately after planting or 2 weeks later resulted in numerically lower soybean stand counts when compared soybeans grown in plots in which the rye was terminated before planting or in plots without rye.

Soybean yield, moisture & test weight

- At one location, there were no differences in yield among cover crops treatments; at another, all of the treatment yields were similar with the surprising exception of lower yield in plots terminated before soybean planting. At two locations, regardless of termination timing rye plots yielded significantly less than the no-rye plots. In another location, yield in the no-rye plots was statistically similar to yield in rye plots terminated before soybean planting, with each later termination timing yielding significantly less than plots of earlier termination timing.
- Soybean moisture and test weight were not affected by cover crops treatments at 3 of the trial locations. At one location soybean moisture was higher when a cover crop was grown than when not; at another, soybean moisture was lower in rye plots that were terminated after planting than in the no rye or other rye termination timings. At one location test weight was higher and at another lower when rye was terminated at planting.

Stay tuned. Watch for news about this project as additional tests are currently being run and data analyzed. Look for more research results on the effects of different combinations of cover crop seeding rate, tillage strategies and cover crop termination timing on nutrient cycling, soil health metrics, iron deficiency chlorosis and weed management at the UMN Research & Outreach Centers (ROC) in Crookston and Morris, MN.

Rye was seeded at 3 on-farm locations surrounding each of the two ROCs in fall 2022 in anticipation of planting soybean "green" for further study in 2023. This project will run both on ROCs and on cooperators' farms through 2025.

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