MN Wheat On-Farm Research Network 2023 Report

ON-FARM RESEARCH NETWORK
MINNESOTA WHEAT

MINNESOTA WHEAT
RESEARCH & PROMOTION COUNCIL

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Foliar Copper at Tillering

Objective
Assess the effect of adding foliar copper chelate to wheat fields that are below the critical soil test level of 0.4 ppm or have shown past copper deficiency.

Years of Study
2022-2023

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 three locations in 2023 (**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 design.
- Flag leaf tissue samples were collected from each plot at boot stage.
- At harvest, one combine pass from each plot was weighed in a weigh wagon or a calibrated grain cart. Grain was sampled to test moisture content, test weight, and protein content**.**
- ANOVA statistical analysis was conducted at the 90% confidence level.

Table 1. Agronomic information for the 2023 foliar copper locations at Argyle, Beltrami, and Gentilly, MN.

	Argyle	Beltrami	Gentilly
Variety	WB 9479	AP Murdock	SY 611
Copper Application Date	9-Jun	6-May	13-May
Planting Date	16-May	8-Jun	
Harvest Date	24-Aug	5-Aug	15-Aug
Soil Org. Matter	1.3%	3.3%	2.9
Soil Type	Sandy Loam	Loam	Sandy Loam
Previous Crop	Sugarbeet	Soybean	Dry Bean
Pre-trial Soil Test Copper		0.32	0.28

Results

Table 2. Yield, protein, moisture, and test weight data from individual and combined locations at Argyle, Beltrami, and Gentilly, MN in 2023.

Argyle	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)	Tissue Cu (ppm)
WB 9479	Control	84.3	15.4	14.2	62.4	11.0
	Copper	81.8	15.4	14.0	62.2	11.0
	LSD[1] 90% CL	NS	NS	0.03	NS	NS
	CV[2] (%)	8.2%	1.1%	0.9%	0.5%	6.9%

Beltrami	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)	Tissue Cu (ppm)
AP Murdock	Control	67.0	13.3	15.3	61.5	7.5
	Treated	69.9	13.3	15.3	61.6	7.3
	LSD 90% CL	NS	NS	NS	NS	NS
	CV (%)	6.4%	2.4%	1.3%	0.4%	7.0%

Gentilly	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)	Tissue Cu (ppm)
SY 611	Control	68.5	15.0	13.9	61.0	10.0
	Treated	64.3	14.8	14.1	61.6	9.0
	LSD 90% CL	NS	NS	NS	NS	NS
	CV (%)	5.6%	2.2%	3.0%	0.9%	28.7%

Combined	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)	Tissue Cu (ppm)
2022-2023	Control	74.6	14.0	14.2	61.8	9.5
5 locations[3]	Treated	74.2	14.1	14.1	61.9	9.1
	LSD 90% CL	NS	NS	NS	NS	NS
	CV (%)	13.5%	7.1%	6.0%	1.3%	23.6%

1 – Least Significant Difference – treatments should differ by at least this amount to be significantly different.
2- A coefficient of variation (CV) of < 10% generally indicates data are less "noisy" and more reliable than data with a CV greater than 10%.
3 – Combined locations include the 2022 Beltrami and Roosevelt data, see 2022 On-farm Annual Report.

Key Take-Aways

- Foliar copper at tillering significantly increased yield by about 4.1 bu at Beltrami in 2022 (data not shown)
- There were no significant differences in yield in 2023, or when combined across locations.
- Soil test copper level may not be the best indicator of wheat response to foliar copper applications. Fields should be evaluated on a case-by-case basis if copper deficiencies begin to appear.
- When compared to a foliar application, granular copper sulfate fertilizer applications have been shown to be more efficient at correcting copper deficiencies.

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/low protein varieties to sites with lower yielding/high protein varieties.

Years of Study

2022-2023

Treatments

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

Methods

- Prescription maps were used to apply 6 rates of urea in approximately one-acre blocks in the field. Treatments were replicated three to four times in a randomized complete block design at five locations in the spring of 2023 (**Table 3**).
- 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.
- Flag leaf tissue samples were collected from each plot at the boot stage.
- Prior to harvest, wheat heads was collected by hand sampling, walking in a line or zig-zag through each plot guided by the N application map, 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 NWROC 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.
- ANOVA statistical analysis was 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, using average prices for the year the test was conducted.

Table 3. Agronomic field information for the 2023 N Rate locations.

Location	Goodridge	Red Lake Falls	St. Hilaire-1	St. Hilaire-2	Terrebonne
Variety	MN-Rothsay	MN-Rothsay	AP Murdock	LCS Trigger	WB9590
Date Fertilized	13-May	4-May	24-Oct, 2022	12-May	17-May
Planting Date	14-May	5-May	13-May	12-May	18-May
Harvest Date	6-Sep	17-Aug	17-Aug	16-Aug	29-Aug
Soil Type	Sandy Loam	Fine Sand	Silt Loam	Loam	Sandy Loam
Application type	Spring Urea	Spring Urea	Fall NH3	Spring Urea	Spring Urea
Fall residual NO3	26 lbs	33 lbs	--	27 lbs	46 lbs
Previous Crop	Soybean	Soybean	Soybean	Soybean	Corn

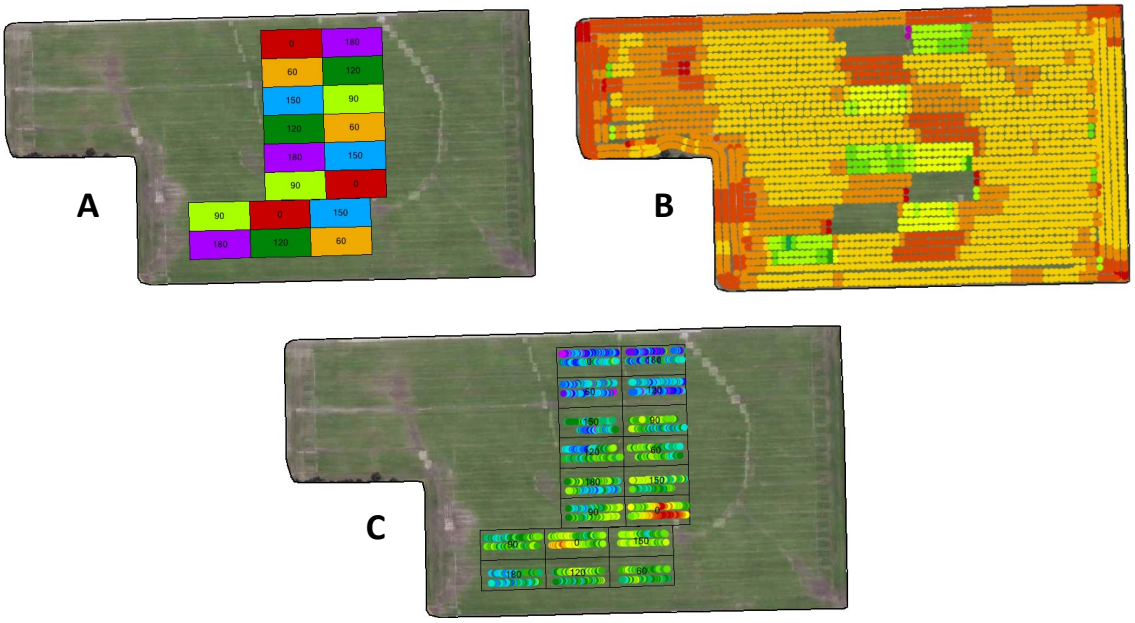

Figure 1. Example treatment layout (A), as-applied map (B), and extracted yield data (C) in East Grand Forks, MN in 2022. Plots were placed to line up with the producer's AB line. Using the prescription map to apply the N, the producer was able to fertilize and harvest the field as usual without interference.

Results

Table 4. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each treatment at Goodridge, MN, 2023.

Goodridge	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1]
MN-Rothsay	0	53.0	11.3	15.7	14	4.7	$ 396.74
	60	80.9	11.6	16.1	11	4.6	$ 570.18
	90	86.8	12.4	16.1	14	5.0	$ 596.47
	120	99.9	12.5	16.4	15	4.8	$ 677.13
	150	89.2	13.4	16.1	17	5.1	$ 579.53
	180	100.5	13.5	16.4	27	5.3	$ 646.34
	LSD 90% CL	13.1	0.7	NS	NS	0.3	$ 98.52
	CV (%)	22.1%	7.9%	4.4%	68.2%	6.8%	19.9%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)

- Yield and protein tended to increase with N rate at Goodridge.
- Residual soil nitrate remained relatively even across treatments.
- Partial profits did not differ among N rates from 90 lbs N to 180 lbs N. The overall highest profitability from N rate was at 120 lbs.
- Tissue N that tested greater than 5.0% may indicate luxury N consumption in the 150 lb and 180 lb plots.

Table 5. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each treatment at Red Lake Falls, MN, 2023.

Red Lake Falls	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	Residual N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1] $
MN-Rothsay	0	46.8	11.7	13.7	22	4.9	$ 350.32
	60	62.6	12.3	13.5	27	5.0	$ 433.29
	90	64.3	13.8	14.1	34	4.9	$ 427.98
	120	62.2	13.8	14.4	34	5.1	$ 394.84
	150	64.9	14.2	13.8	46	5.0	$ 397.02
	180	63.5	15.6	15.2	44	5.2	$ 369.32
	LSD 90% CL	9.5	1.2	NS	NS	NS	NS
	CV (%)	13.3%	11.7%	7.7%	39.1%	5.0%	11.7%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)

- Protein increased with N rate at Red Lake Falls, but yield did not increase with any added N.
- Partial profits were not significantly different from 0lb N, although the numerically highest profit was achieved at 60-90lb N.
- Low rainfall likely limited yield, as N must be in the soil water solution to be taken up by the plant, limiting response to N fertility in 2023.

Table 6. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each treatment at St. Hilaire-1, MN, 2023.

St. Hilaire-1	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1]
AP Murdock	0	69.6	13.0	13.3	18	4.5	$ 521.93
	60	85.6	13.6	13.3	38	4.9	$ 606.26
	90	83.5	13.7	13.4	31	4.8	$ 572.66
	120	88.9	14.1	13.5	76	5.0	$ 594.80
	150	86.8	14.1	13.6	38	5.0	$ 561.04
	180	87.8	14.4	13.6	128	5.1	$ 550.97
	LSD 90% CL	10.1	0.5	NS	51	0.3	NS
	CV (%)	10.5%	4.1%	2.7%	89.0%	5.0%	9.1%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)

- Protein increased with N rate at St. Hilaire-1, but yield did not increase with any added N greater than 60 lb.
- Partial profits were not significantly different from 0 lb N, although the highest apparent profit was achieved at 60 and 120 lb N.
- Tissue N was slightly lower in the 0 lb N treatment, however it was still in the N sufficiency range of 3.8-5.0% N .
- There was excessively high residual N in the 180lb treatment indicating overfertilization.

Table 7. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each treatment at St. Hilaire-2, MN, 2023.

St. Hilaire-2	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1]
LCS Trigger	0	60.2	10.0	13.8		4.8	$ 450.45
	60	67.0	11.6	14.4		5.2	$ 465.80
	90	75.8	12.1	14.3		5.3	$ 514.39
	120	69.7	12.4	14.9		5.4	$ 450.58
	150	71.6	11.8	15.0		5.4	$ 446.99
	180	66.9	12.7	14.7		5.4	$ 393.97
	LSD 90% CL	NS	1.2	0.7		NS	NS
	CV (%)	14.7%	9.7%	7.3%		4.6%	16.6%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)

- Protein increased with N rate at St. Hilaire-2, but there was no yield response to N.
- Residual soil nitrate was missed at this location due to a miscommunication about sampling.
- Partial profits were not different from each other. The overall highest profitability from N rate was at 90 lbs.
- Treatments with tissue N greater than 5.0% may indicate luxury N consumption, indicating N was likely not the yield-limiting factor, especially in the low N treatments.

Table 8. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each treatment at Terrebonne, MN, 2023.

Terrebonne	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1]
WB95590	0	59.6	13.9	13.8	14	4.9	447.20
	60	74.7	14.3	14.2	14	5.0	524.25
	90	72.9	14.7	14.1	29	5.3	492.85
	120	80.9	14.8	14.7	14	5.2	534.83
	150	78.7	14.7	14.4	37	5.1	500.45
	180	77	14.9	14.4	60	5.1	470.05
	LSD 90% CL	7.9	0.5	NS	NS	NS	NS
	CV (%)	13.2%	3.0%	2.6%	103.4%	4.4%	11.9%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)

- Protein increased with N rate at St. Hilaire-2, but there was no yield response to adding more than 60 lb N.
- Residual soil nitrate tended to increase with N rate.
- Partial profits were not different from each other, however the apparent highest profitability from N rate was at 120 lbs.
- Tissue N that was greater than 5.0% may indicate luxury N consumption, indicating that N was likely not the yield-limiting factor, especially in the low N treatments.

Table 9. Yield, protein, harvest moisture, residual soil nitrate, flag leaf tissue N, and calculated partial profit for each N rate treatment over seven locations in 2022 and 2023.

Combined	Treatment Units N	Yield (bu/ac)	Protein (%)	Moisture (%)	N 0-24" (lbs)	Tissue N (%)	Partial Profit (ac)[1]
2022-2023	0	60.3	12.0	14.1	17	4.75	$ 458.78
7 Locations[2]	60	74.9	12.7	14.4	22	4.92	$ 535.21
	90	76.4	13.3	14.3	27	5.03	$ 527.43
	120	78.6	13.5	14.6	35	5.08	$ 525.20
	150	76.4	13.6	14.5	40	5.13	$ 489.26
	180	80.6	14.4	14.7	63	5.21	$ 504.23
	LSD 90% CL	5.72	0.5	0.3	9	0.14	$ 43.83
	CV (%)	18.6%	10.0%	8.1%	88.2%	5.6%	18.9%

1 - Partial Profit = (bushels x $7.50) +/- (protein premium/discount, $0.05/fifth) - (urea applied x $550/ton)
2 Data also included East Grand Forks and Red Lake Falls locations from 2022, see 2022 Annual On-farm Research Report.

Key Take-Aways

- The dry latter half of the season may have interfered with N response in 2023. Roots likely scavenged soil moisture and N from soil below 24”, which may have supplemented low N treatments.
- Most of the treatments tested high for tissue N, indicating N was likely not a large yield-limiting factor overall.
- The highest profitability among all locations was achieved at 60lbs N, further indicating that the soil provided much of the N needed to maximize yield.
- With additional locations and varieties, in future seasons we hope to examine differences in N fertility needs among varieties that are typically high protein vs low protein.

Pivot Bio Wheat Seed Treatment

Objective
Assess the effect of using PivotBio RETURN biological seed treatment to replace 25 units of N fertilizer.

Years of Study
2023

Treatments
Control: 100% producer N rate
Reduced N: Producer N rate - 25 units N
Pivot Bio: Producer N rate - 25 units N + RETURN + water dechlorinator (if using treated/rural water)

Methods
- Fertilizer strips were broadcast by the producer's co-op and incorporated prior to planting to apply the 100% N and Reduced N fertilizer treatments.
- Wheat seed was treated with RETURN using a mobile seed treater just prior to planting. All locations were planted within 2 weeks of treatment.
- Treated seed was planted in the Pivot Bio treatment strips, and the producer's regular seed was planted in the Control and Reduced N strips.
- Plots were established and harvested with producer equipment. Plots were one round of either the spreader or air seeder wide by the full length of the field. Treatments were replicated three to four times in a randomized complete block design.
- Tissue samples were collected from each plot at boot stage.
- At harvest, one combine pass from each plot was weighed using a weigh wagon or grain cart and the grain was sampled to test moisture content, test weight, and protein content.
- Residual soil N was sampled from each plot after harvest.
- ANOVA statistical analysis was conducted at the 90% confidence level.

Table 10. Agronomic information for the 2023 locations.

Location	Mentor	Stephen	St. Hilaire	Terrebonne
Variety	LCS Cannon	WB9479	LCS Trigger	WB9590
Previous Crop	Soybean	Dry Bean	Soybeans	Soybean
Planting Date	22-May	12-May	12-May	18-May
Harvest Date	30-Aug	16-Aug	15-Aug	28-Aug
2022 Residual N lbs	29 lbs	30 lbs	42 lbs	39 lbs
Field N Rate	122 lbs	185 lbs	135 lbs	140 lbs
Seed Treatment	Vibrance + Imida	Stamina F4	None	None
N Application Method	Broadcast Urea + 25u UAN Top-dress	Broadcast Urea	Spring NH3	Broadcast Urea

Results

Table 11. Yield, protein, moisture, test weight, and residual N soil test data from individual and combined locations in 2023.

Location	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)	N 0-24" (lbs)	Tissue N (%)
Mentor	100% N	61.9	13.5	14.2	63.3	64.5	5.1
	-25 lbs N	62.8	13.3	14.0	63.3	40.0	5.1
	-25lbs N + PB	59.1	13.2	14.1	63.5	41.8	5.0
	LSD 90% CL	NS	NS	NS	NS	NS	NS
	CV (%)	5.8%	1.5%	5.9%	0.6%	37.9%	2.8%
Stephen	100% N	82.4	13.9	14.1	62.2	30.3 a	5.6
	-25 lbs N	79.8	13.4	14.0	61.9	23.3 b	5.4
	-25lbs N + PB	83	13.6	14.2	62.4	24.5 c	5.5
	LSD 90% CL	NS	NS	NS	NS	4.1	NS
	CV (%)	7.4%	3.9%	4.3%	0.7%	29.3%	2.6%
St. Hilaire	100% N	80.7	12.1	14.9	60.0	51.7	--
	-25 lbs N	81.4	11.7	15.0	60.5	36.0	--
	-25lbs N + PB	82.5	11.7	14.9	60.7	19.8	--
	LSD 90% CL	NS	NS	NS	NS	NS	--
	CV (%)	4.3%	1.9%	2.8%	1.1%	60.3%	--
Terrebonne	100% N	76.6	15.4	15.6	61.6	31.3	5.4
	-25 lbs N	70.9	15.4	15.4	61.5	41.0	5.4
	-25lbs N + PB	68.6	15.5	15.4	61.3	22.7	5.4
	LSD 90% CL	NS	NS	NS	NS	NS	NS
	CV (%)	8.7%	2.1%	1.3%	0.8%	45.2%	0.9%
Combined	100% N	74.9	13.7	14.6	61.9	44.9	5.4
	-25 lbs N	73.4	13.4	14.5	61.9	34.6	5.3
	-25lbs N + PB	73.6	13.4	14.6	62.0	27.5	5.3
	LSD 90% CL	NS	NS	NS	NS	NS	NS
	CV (%)	13.6%	9.4%	5.6%	1.9%	50.1%	4.2%

Key Take-Aways

- There were no significant yield differences across locations.
- At St. Hilaire, there was no response to N rate, indicating the producer's N rate may have been too high and did not elicit a N deficiency in the Reduced N treatment.
- These locations represent only 1 year of research in a low N-response season (See N Rate data in previous section). Additional years and locations will give better insight into when, where, and how much the wheat could be expected to respond to biological inoculation with RETURN.

Johnson-Su Bioreactor Seed Treatment

Objectives

1. Demonstrate methods to economically create and use a Johnson-Su Bioreactor on a commercial crop farm that could be used for wheat and soybean and soybean production
2. Determine if N and P fertilizer can be reduced by using compost extract applied in-furrow at planting
3. Evaluate fungal and bacterial species diversity and quantity in compost extract
4. Educate regenerative and conventional farmers about the principles and methods behind the compost extract application to wheat and soybean and how to replicate the process on their own farm

Years of Study

2023-2024

SARE North Central Sustainable Agriculture Research and Education

UNIVERSITY OF MINNESOTA

Large Plot Treatments

Crookston

0 N, 50% N, and 100% N, with compost extract

Red Lake Falls - Wheat

Control – Farmer fertilizer rate, no extract

Compost extract + 50% N + 0 P

Compost extract + 0N + 0P

Red Lake Falls – Sunflower

Control – No extract

Treatment – In-furrow liquid compost extract at 6 gal/acre

Small Plot Treatments

- 0, 60, 120, 180 lbs N; with compost extract (wheat only)
- 0, 120, 180 lbs N; no compost extract (wheat only)
- 0, 20, 40, 60 lbs P_2O_5; with compost extract (wheat and soybeans)
- 0, 40, 60 lbs P_2O_5; no compost extract (wheat and soybeans)

Figure 2. Johnson-Su Bioreactors built in March 2023 (left) and filtered vermicast slurry applied to wheat seed (right).

Methods

- Johnson-Su Bioreactors were built in March 2023 at Trinity Creek Ranch in Red Lake Falls for use in 2024 after composting process is completed.
- Vermicast was bought from Fed N Happy worm farm to use in place of Johnson-Su compost for the 2023 season. Vermicast was tested by BiomeMakers to identify all species of bacteria and fungi present in the mixture.
- A slurry of the vermicast was made using a mixing cone and water pump and filtered down to an 80-mesh inline filter before it was applied to the wheat seed or in-furrow.
- A microbiome analysis was conducted on the vermicast by BiomeMakers to determine the number of different species of fungi and bacteria present in the seed treatment.
- Vermicast was mixed at a rate of 2lbs/gallon to make the initial slurry and applied at a target rate of 9oz/cwt to wheat seed, and at a rate of 2 lbs dry vermicast per 6 gal/acre liquid in-furrow extract in the sunflower large-plot and soybean small plots.
- On-farm plots were established and harvested with producer equipment. Plots were one round of either air seeder wide by the full length of the field. Treatments were replicated three to four times in a randomized complete block.
- Tissue samples were collected from each plot at boot stage.
- At harvest, one combine pass from each plot was weighed using a weigh wagon or a grain cart and the grain was sampled to test moisture content, test weight, and protein content.
- Residual soil N and phospholipid fatty acid (PLFA) soil health samples were collected in each plot after harvest at the wheat on-farm plots and selected wheat and soybean small plot treatments.
- ANOVA statistical analysis was conducted at the 90% confidence level.

Table 12. Agronomic information for the 2023 locations at Crookston and Red Lake Falls, MN.

Location	Crookston	RLF - Wheat	RLF - Sunflower
Variety	AP Murdock	Shelly	P64ME01
Planting Date	5/22/2023	5/16/2023	23-May
Harvest Date	30-Aug	31-Aug	17-Nov
Previous Crop	Soybean	Soybean	Soybean
Field Rate Fertilizer	120 lbs Urea	50 lbs Map	9-12 gal UAN at side-dress
	0 lbs P	55lbs ESN	0 lbs P
	0 lbs K	66 lbs Urea	0 lbs K

BiomeMakers Micorbiome Analysis of Vermicast

- 137 species fungi
- 848 species bacteria
- 985 microbial species total

Table 13. Yield, protein, moisture, and test weight from individual locations in 2023.

Crookston	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
Wheat	100% N + Extract	30.1	15.4	15.0	60.4
AP Murdock	50% N + Extract	30.1	15.2	15.3	60.6
	0 N + Extract	30.8	14.7	15.0	60.3
	LSD 90% CL	NS	0.3	NS	NS
	CV (%)	4.9%	2.9%	2.6%	0.6%
Red Lake Falls	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
Wheat	100% NP	72.7	10.8	15.6	59.3
MN-Rothsay	50% N + Extract	63.9	10.4	15.7	59.5
	0 N + Extract	50.4	10.1	15.7	59.4
	LSD 90% CL	3.4	0.3	NS	NS
	CV (%)	15.8%	3.6%	2.5%	0.6%
Red Lake Falls	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
Sunflower	Control	2728	--	9.9	29.4
P64ME01	In-furrow Extract	2806	--	9.9	29.3
	LSD 90% CL	64	--	NS	NS
	CV (%)	2.1%	--	1.8%	1.7%

Table 14. Selected means of flag leaf tissue analysis and PLFA soil test.

Location	Treatment	Tissue N (%)	Tissue P (%)	Tissue K (%)	Tissue S (%)	Bacteria (%)	Total Fungi (%)	%AMF[1] Total Fungi	Fungi: Bacteria[2]
Crookston	0 N	5.3	0.27	1.70	0.39	39.77	1.62	0.82	0.04
	100% N	5.2	0.28	1.85	0.43	37.16	5.50	2.99	0.15
	50% N	5.4	0.28	1.73	0.42	39.31	2.80	1.53	0.06
Red Lake Falls	100% NP	4.7	0.41	1.60	0.36	28.44	5.86	3.21	0.22
Wheat	CE+0 N	4.2	0.39	1.58	0.29	29.67	5.55	3.22	0.19
	CE+50% N	4.4	0.40	1.68	0.31	26.97	4.24	2.80	0.16

1 – Percent of total fungal mass present that is made of Arbuscular Mycorrhizal Fungi (AMF)

2 – Target Fungi:Bacteria ratio is closer to 1:1

Key Take-Aways

- In this first season, differences in N rate treatments were too great to measure any potential biological response. A better choice of treatments would have been similar to the treatments used in the Pivot Bio wheat inoculation trial (see previous section).
- There was a small but significant yield increase with the in-furrow application in sunflowers, which aligns with anecdotal evidence that extract efficacy increases in the order of foliar application < seed treatment < in-furrow application.

Rock Rolling Wheat After Planting

Objective
Assess the impact of rock-rolling on wheat emergence and yield.

Years of Study
2022-2023

Treatments
Control – Not rolled
Treatment - Wheat rolled after planting, prior to emergence

Methods
- Treated strips were rolled with a rock roller after planting and before emergence.
- At harvest, one combine pass from each plot was weighed using a weigh wagon or grain cart and the grain was sampled to test moisture content, test weight, and protein content.
- ANOVA statistical analysis was conducted at the 90% confidence level.

Table 15. Agronomic information for the 2023 locations.

Location	Crookston	Dorothy	Red Lake Falls
Crop Year	2023	2023	2022
Planting Date	6-May	13-May	7-Jun
Previous Crop	Sugarbeet	Soybean	Soybean
Variety	AP Murdock	AP Smith	MN-Torgy
Rolling Date	6-May	13-May	6-Jun
Drill Type	Press drill	Single disc	Single disc
Harvest Date	4-Aug	24-Aug	8-Sep

Results

Table 16. Yield, protein, moisture, and test weight from individual and combined rolling locations in 2023.

Crookston	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
2023	Control	63.3	14.6	12.5	61.9
	Rolled	66.5	14.5	12.3	62.2
	LSD 90% CL	1.4	NS	NS	NS
	CV (%)	5.4%	1.0%	1.7%	1.7%

Dorothy	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
2023	Control	81.1	14.6	14.4	61.7
	Rolled	82.2	14.6	14.5	60.8
	LSD 90% CL	NS	NS	NS	NS
	CV (%)	3.2%	1.6%	2.4%	1.2%

Red Lake Falls	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
2022	Control	64.7	13.9	16.5	61.1
	Rolled	64.5	13.9	16.0	61.5
	LSD 90% CL	NS	NS	NS	NS
	CV (%)	4.6%	1.5%	6.9%	1.3%

Combined	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
2022-2023	Control	69.3	14.3	14.6	61.5
	Rolled	70.6	14.3	14.4	61.5
	LSD 90% CL	NS	NS	NS	NS
	CV (%)	12.1%	2.6%	12.0%	1.5%

Key Take-Aways

- There was a 3.2 bu yield increase at Crookston in 2023, but no effect on yield at the other two locations.
- Soil sealing/crusting was noted at both the Crookston and Red Lake Falls locations, and it was theorized that the crusting may have helped to keep some soil moisture from evaporating during the dry season.
- While there are only 3 locations tested thus far, they suggest that there is little effect from rock-rolling on wheat yield.
- Two of three locations noted increased soil crusting after rolling, soil crusting can affect seedling emergence and rainwater infiltration depending on the environment and the season.

Soil Health Partnership – Long Term Diverse Cover Crop Rotation

Objective

To quantify the soil health impact of cover crops integrated annually into a soybean-wheat-corn-sunflower rotation through soil health sampling and in-season field evaluations.

This began as a nationwide study conducted through the National Corn Grower's Association's Soil Health Partnership (SHP), a program designed to conduct long-term soil health impact assessments with producers nationwide. After the SHP was discontinued in 2020, The MN Corn Research and Promotion Council kindly opted to finish funding the research project through their Corn Innovation Grant program.

Years of Study

2019-2023

Treatments

Control – No Cover Crop
Treatment – Diverse cover crop mix interseeded into each main crop of a 4-crop rotation over 5 years.

Methods

- Cover crops were interseeded in-season into corn, soybean, and sunflower stands with an interseeder/side-dresser, or after wheat harvest.
- Haney and Cornell soil health tests were/will be sampled in the spring of 2019 and 2024. Complete inorganic nutrients were sampled in each spring prior to fertilization and planting.
- Cover crop stand, weed counts, and biomass were collected in-season.
- At harvest, one combine pass from each plot was weighed using a weigh wagon or a grain cart and the grain was sampled to test moisture content, test weight, and protein content.
- ANOVA statistical analysis was conducted at the 90% confidence level.

Figure 3. Cover crop mix interseeded into corn 6-13-23, photo taken 7-21-23.

Table 17. Agronomic information and cover crop mixes for Red Lake Falls, MN, 2019-2023.

Year	2019	2020	2021	2022	2023
Crop	Corn	Soybean	Wheat	Sunflower	Corn
Planting Date	5/17/2019	5/25/2020	4/24/2021	6/7/2022	5/12/2023
Main Crop Variety	Pioneer 7632 AM	Pioneer P03A17X	MN-Torgy	Pioneer P64ME01	Pioneer 8588 AM
Seeding Rate	32K	165K	120 lbs	22K	32K
CC Planting Date	6/29/2019	7/10/2020	8/14/2021	8/14/2021	6/13/2023
Cover Crop Mix	Balansa Clover - 0.5#	Teff Grass - 0.5#	Brown Flax - 3#	Forage Pea - 1#	Annual Ryegrass - 4#
	Red Clover - 0.5#	Buckwheat - 0.5#	Hairy Vetch - 1#	Buckwheat - 1#	Balansa Clover - 0.25#
	Faba Bean - 5#	Brown Flax - 2#	Lentils - 2#	Cow Pea - 2#	Buckwheat - 1#
	Cowpea - 3#	Phacelia - 0.5#	Buster Forage Radish - 1.5#	Brown Flax -2#	Cowpea - 6#
	Sunn Hemp - 0.6#	Rape - 0.5#	Purple Top Turnip - 0.5#	Hairy Vetch - 1#	Brown Flax - 2#
	Barley - 2#	Red Clover - 1#	Cereal Rye - 80#	Kale - 0.5#	Kale - 0.5#
	Teff Grass - 0.5#	Safflower - 1#	-	Lentils - 5#	Forage Radish - 0.5#
	Kale - 0.3#	-	-	White Proso Millet - 1#	Mammoth Red Clover - 1#
	Rape - 0.3#	-	-	Yellow Mustard - 0.25#	-
	Radish - 0.3#	-	-	Mammoth Red Clover - 0.5#	-
	Turnip - 0.3#	-	-	Purple Top Turnip - 0.5#	-
	Phacelia - 0.1#	-	-	-	-
	Flax - 2#	-	-	-	-
	Cereal Rye - 20#	-	-	-	-
CC Seed Cost $/acre	$20.00	$9.13	$15.77	$20.00	$23.00

Results

Table 18. Yield, moisture, and test weight data from 2019 corn, 2020 soybean, 2021 wheat, 2022 sunflower and 2023 corn plots at Red Lake Falls, MN.

Corn 2019	Treatment	Yield (bu/ac)	Moisture (%)	TW (lbs/bu)
Pioneer 7632AM	Control	138.6	22.5	48.0
	Cover Crop	147.0	23.2	47.2
	LSD 90% CL	NS	0.4	NS
	CV (%)	10.1%	2.9%	1.9%

Soybean 2020	Treatment	Yield (bu/ac)	Moisture (%)	TW (lbs/bu)
Pioneer P03A17X	Control	32.7	11.2	57.0
	Cover Crop	30.1	11.3	57.0
	LSD 90% CL	NS	NS	NS
	CV (%)	11.8%	4.6%	0.5%

Wheat 2021	Treatment	Yield (bu/ac)	Protein (%)	Moisture (%)	TW (lbs/bu)
MN-Torgy	Control	41.0	15.3	15.0	60.7
	Cover Crop	43.0	15.4	14.2	60.7
	LSD 90% CL	NS	NS	0.6	NS
	CV (%)	5.8%	1.6%	3.6%	0.7%

Sunflower 2022	Treatment	Yield (bu/ac)[1]	Moisture (%)	TW (lbs/bu)
P64ME01	Control	2176	16.7	28.8
	Cover Crop	1368	20.5	29.9
	LSD 90% CL	219.3	1.6	1.1
	CV (%)	25.3%	12.0%	2.8%

Corn 2023	Treatment	Yield (bu/ac)[2]	Moisture (%)	TW (lbs/bu)
Pioneer 8588 AM	Control	111.6	19.7	52.8
	Cover Crop	132.1	19.7	53.8
	LSD 90% CL	5.8	NS	0.5
	CV (%)	10.7%	2.6%	1.2%

1 - Major cover crop and weed competition severely impacted yield in cover crop plots

2 - Yield difference may be due to nutrient tie up from greater sunflower residue in control plots

Key Take-Aways

- Cover crop had no effect on yield in 2019-2021. In 2022, cereal rye competition stunted sunflower stand and reduced yield, which showed a carryover effect into 2023, when corn yielded higher where there had been less sunflower residue from the previous year.

Planting Green in the Frozen North – Rye Cover Crop Termination Timing

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Farmer partners in Gentilly, Fisher, Fertile, Barrett, Tintah & Granite Falls

Project sponsors: USDA NC-SARE, Minnesota Wheat Research & Promotion Council

Purpose of Study:

MN farmers face difficult choices when deciding to prioritize either long-term soil health goals or the immediate benefits of tillage for residue management and seedbed preparation. Despite the reported soil health benefits of cover crops, a short growing season makes delays to spring field work risky. Research on cover cropping suggests that early season cover crops can stabilize yields by mitigating excess and limited soil moisture, improving field trafficability, and reducing wind erosion. Reliable advice on agronomic outcomes of cover cropping is critically needed by MN farmers interested in adopting reduced-tillage and cover cropping systems. To meet this need, we partnered with MN farmers to design replicated, production-scale research and demonstration trials that were sown to cereal rye in Fall 2022 (**Figure 4, Table 19**). Soybeans were seeded in spring 2023 and cover crops terminated before, at or after soybean planting; 2023 is the second of four seasons for this work. See the report summarizing the results from 2022 here: https://z.umn.edu/2021-22_Planting_Green

On-farm Experimental Design:

Treatments were arranged as large strips wide enough to accommodate farmers' equipment in a randomized complete block design with three replications. Nutrient cycling, soil health, rye biomass at termination, weed density and biomass, IDC and other disease ratings, soybean stand count, yield, moisture & test weight data were collected from each plot.

Treatments: 1) Current tillage practice without a fall-seeded rye cover crop (CC),
2) CC terminated 1-2 weeks before soybean planting,
3) CC terminated at soybean planting,
4) CC terminated 1-2 weeks after soybean planting.

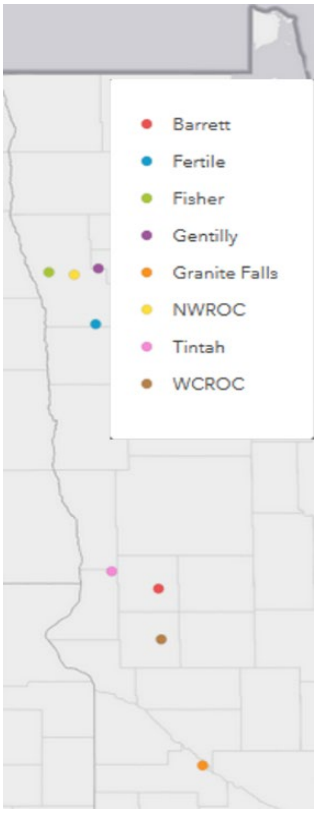

Figure 4. Locations of on-farm and small plot research trials seeded to rye in fall 2022 and to soybean in 2023.

Each trial location grew different soybean varieties and had different soybean seeding dates and rates and therefore different dates of rye termination and so results are presented by location.

Table 19. Locations of on-farm strip trials, 2022 cash crop, any tillage that took place between 2022 crop harvest and rye seeding, rye seeding date and method, 2023 soybean seeding date, soil texture and May-September 2023 precipitation totals.

MN Town/ County	2022 cash crop	Tillage	Rye seeded (2022)	Soybean seeded (2023)	Soil texture	May-Sept. rainfall (inches)*
Gentilly/Polk	wheat	Vertical till for no rye & NT for rye plots	Sept. 22 Drilled	May 19 & 20	loam	9-10
Fertile/Polk	wheat	Fall CP all treatments	Sept. 26 Bdcst & incorporated	May 26	very fine sandy loam	10-11
Fisher/Polk	wheat	No-till all treatments	Sept. 20 Drilled	May 11	silty clay loam	9-10
Granite Falls/Yellow Medicine	corn grain	CP/FC in no-rye,	Sept. 2 Bdcst	May 24	loam, clay loam	11-12
Tintah/Traverse	corn silage	No-till all treatments	Sept. 13 Drilled	May 17	silty clay loam, loam	14-15
Barrett/Grant	corn grain	VT no rye plots, NT for rye plots	Sept. 2 Bdcst	May 17	clay loam	11-12

*Rain estimates were provided by the Midwest Regional Climate Center's cli-MATE application tools environment maps of gridded accumulated precipitation for the period of May 1-September 30, 2023 (see **Figure 5**).

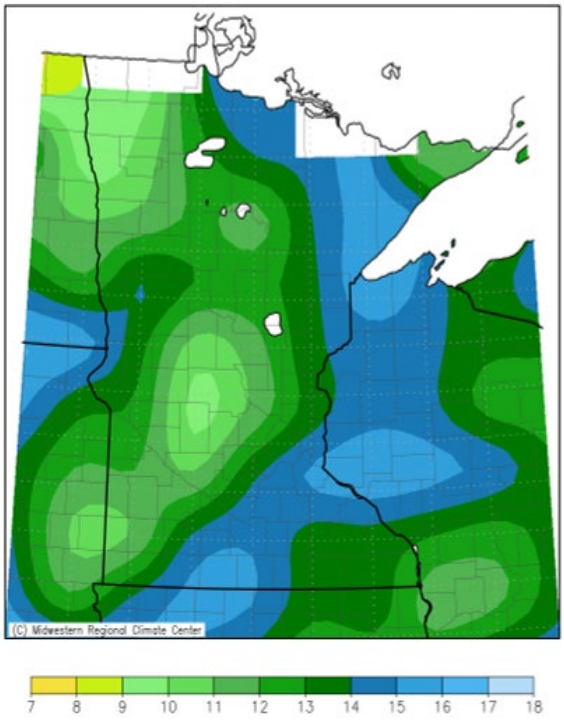

Figure 5. Accumulated precipitation (in inches), May 1-September 30, 2023. Rainfall totals were 6-8 inches lower than the 30 year normal in Granite Falls, 4-6 inches lower than normal in Barrett, Fertile, Fisher and Gentilly and 2-4 inches lower than normal in Tintah. than Source: Midwestern Regional Climate Center cli-MATE: MRCC Application Tools Environment. Generated Nov 16, 2023.

2022-23 Northwest Minnesota On-farm Summary

Gentilly, MN.

Unlike in 2022, when soybean planting and therefore rye termination was delayed, the more typical start to the 2023 growing season meant that instead of the soybean crop contending with thousands of pounds of rye, there was only up to 75 pounds per acre, regardless of termination timing (**Table 19**). While significantly more biomass accumulated with each successive termination timing, very little biomass overall was unlikely to be of biological significance and had no impact on test weight or oil content.

There were differences observed among termination timing treatments in soybean yield, moisture and protein content (**Table 20**). The no rye and rye terminated before soybean planting treatments were statistically similar and yielded between 2.2 and 2.6 bu more than when rye was terminated at soybean planting and between 6.1 and 6.5 bu more when rye was terminated after soybean planting. The at and after soybean planting treatments also differed, with lower yield observed when termination was further delayed. The same statistical groupings were observed with grain moisture, with significantly similar and higher grain moisture observed in no rye plots or when rye was terminated before soybean planting. Soybean moisture declined with each successive rye termination timing. While there were significant differences observed among treatments for soybean protein content, it is not clear why or whether the differences are biologically relevant.

The growing season had unseasonably hot temperatures at times and there were long periods in which no rain fell (**Table 19, Figure 5**). As the yield and moisture results closely mirror rye biomass, perhaps these hot and dry periods occurred often and early enough that when combined with soil moisture removed via rye, it had a significant impact on the crop. An article from Michigan State Extension suggests that an 'aggressive' rye cover can take up 0.8-1.2 inches per week in April and May (later in our climate).

Table 20. The effect of rye termination timing on rye biomass, yield, moisture, protein, oil and test weight at a farm near Gentilly, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Yield (bu/A)	Moisture (%)	Protein (%)	Oil (%)	Test weight (lb/bu)
Before planting	8 a[z]	40.7 c	14.4 c	35.7 a	17.1	59.0
At planting	28 b	38.5 b	14.2 b	35.9 b	16.9	59.3
After planting	72 c	34.6 a	14.1 a	36.1 c	17.0	59.3
No rye	N/A	41.1 c	14.4 c	35.9 b	16.1	59.3
LSD (90% CL)	15	1.2	0.1	0.2	NS	NS
CV (%)	34	2.0	0.4	0.4	4.6	0.3

[z] Treatment means within a column that are followed by different letters are significantly different at *P* = 0.10.

Fertile, MN.

Prohibitively windy conditions early in the growing season in Fertile prevented timely termination of rye before soybean planting, so this treatment was not evaluated. Each remaining successive rye termination timing allowed for significantly more biomass to accumulate when compared to the previous timing (**Table 21**). However, unlike in 2022 when wet soils delayed soybean planting, much less biomass accumulated in 2023, leading to no negative impacts on the soybean stand.

Soybean yield, moisture and test weight were all impacted by rye termination treatments. The yield was greatest in plots that did not have rye. The no rye plots included in the study however, trended lower than the soybeans grown outside the study area that were cultivated in the spring to prepare the seedbed before soybean planting. The rye plots terminated at soybean planting yielded significantly less than no rye plots and the rye plots terminated after planting significantly less still.

The no rye and at-planting rye termination plots had statistically similar and lower grain moisture than plots in which rye was terminated after soybean planting (**Table 21**). Perhaps the latest terminated soybeans received less sunlight and heat at the soil surface in the beginning of the season and so may have had maturity delayed in comparison to the soybeans that were less stunted due to earlier termination.

Test weight of soybeans harvested from the plots in which rye was terminated after soybean planting was significantly lower than from the no-rye plots and rye plots terminated at soybean planting. Test weight appeared to be one casualty of waiting a bit too long to terminate the rye cover crop given the hot, dry field conditions.

Table 21. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture, protein, oil, and test weight at a farm near Fertile, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Soybean stand (plants/A)	Yield (bu/A)	Moisture (%)	Protein (%)	Oil (%)	Test weight (lb/bu)
Before planting	N/A						
1 week after planting	65 a	143,440	21.2 b	10.9 a	33.0	18.6	59.3 b
2 weeks after planting	106 b	143,440	17.1 a	14.0 b	33.1	19.1	55.9 a
No rye	N/A	146,080	25.1 c	10.9 a	33.0	18.7	58.8 b
LSD (90% CL)	14	NS	3.0	1.1	NS	NS	1.2
CV (%)	19	9	8.1	5.1	2.0	1.6	1.2

[z] Treatment means within a column that are followed by different letters are significantly different at $P = 0.10$.

Fisher, MN.

The plots at the Fisher location were planted no-till into either no rye or living rye that was terminated either at, 1 week after or 2 weeks after soybean planting. The previous crop was wheat that had been harvested with a stripper-header and so wheat stems remained standing in spring (**Figure 6**). There were differences in rye biomass accumulation among termination treatments, with plots of each successive termination timing accumulating significantly more biomass than the plots that were terminated before. Soybean yield was not significantly different between the no rye control and rye terminated at planting, but the no rye control was 1.6 bu/A greater than rye terminated 1 week after planting and 3.2 bu/A greater than rye terminated 2 weeks after planting (**Table 22**).

Table 22. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture, protein, oil and test weight at a farm near Fisher, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Soybean stand (plants/A)	Yield (bu/A)	Moisture (%)	Protein (%)	Oil (%)	Test weight (lb/bu)
At planting	37.5 a	158,840	62.9 ab	9.4	33.0	18.4	58.8
1 week after planting	100.2 b	160,160	62.1 b	9.4	33.2	18.3	58.8
2 weeks after planting	174.6 c	160,600	60.5 c	9.4	33.3	18.4	59.0
No rye	N/A	165,000	63.7 a	9.3	33.1	18.4	58.5
LSD (90% CL)	31.4	NS	1.5	NS	NS	NS	NS
CV (%)	25.4	4	1.5	1.1	0.6	0.6	0.4

[z] Treatment means within a column that are followed by different letters are significantly different at *P* = 0.10.

Figure 6. Rye interseeded into stripper headed wheat stubble at Fisher, MN, photo taken 4-17-2023.

2022-23 West-central Minnesota On-farm Summary

Tintah, MN.

The Tintah on-farm location was dry in both 2022 and 2023. Between 119 and 1,777 pounds of rye biomass per acre accumulated nonetheless, with each subsequent delay in termination timing resulting in significantly more rye biomass than the timing previous (**Table 23**).

The dry summer and rye had a significant impact on both soybean stand count and yield. Particularly pronounced in the plots that were terminated after planting were leafhoppers that fed on rye. When the rye was terminated, leafhoppers moved from rye to feed on stunted soybeans, likely contributing to yield loss.

The plots that had no rye or in which rye was terminated before soybean planting had the highest and statistically similar stand counts. Stand count decreased significantly with each successive rye termination timing treatment, with an average of ~54,000 plants per acre in the plots in which rye was terminated after planting. To maximize soybean yield potential, UMN Extension agronomists tell us that at least 100,000 plants per acre are required. Soybean yield of plots without rye or in which rye was terminated before soybean planting were statistically similar to one another and 7.0 to 7.6 bu/A greater than when rye was terminated at soybean planting and 13.0 to 13.6 bu/A greater than when rye was terminated after soybean planting.

Table 23. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at a farm near Tintah, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	119 a	91,080 c	41.8 c	14.0	54.9
At planting	870 b	77,000 b	34.8 b	13.8	54.8
After planting	1,777 c	53,680 a	28.8 a	14.2	54.8
No rye	N/A	99,000 c	42.4 c	14.0	55.1
LSD (90% CL)	86	13,966	4.4	NS	NS
CV (%)	8	11	7.5	2.3	1.2

[z] Treatment means within a column that are followed by different letters are significantly different at *P* = 0.10.

Barrett, MN.

In Barrett, the before and at planting rye termination timings had statistically similar and less biomass than the after planting termination plots (**Table 24**). Rye biomass did not impact soybean stand in Barrett. Soybean yield was not impacted by rye termination timing, but both moisture and test weight were. The driest soybeans were those in which rye was terminated at planting and the wettest were those in which rye was terminated before planting. Test weights in the no rye plots and those plots in which rye was terminated at and after planting were all statistically similar and greater than in plots in which rye was terminated before planting. We would be interested in discussing potential reasons for the moisture and test weight results.

Table 24. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at a farm near Barrett, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	26 a[z]	145,200	51.5	12.6 c	56.5 a
At planting	31 a	143,264	50.7	12.2 a	57.4 b
After planting	115 b	151,008	53.8	12.4 b	57.6 b
No rye	N/A	158,106	56.1	12.4 b	57.6 b
LSD (90% CL)	22	NS	NS	0.2	0.5
CV (%)	45	11	5.1	1.0	0.5

[z] Treatment means within a column that are followed by different letters are significantly different at *P* = 0.10.

Granite Falls, MN.

Significantly more rye biomass accumulated at the Granite Falls location with each subsequent delay in terminating the rye cover crop (**Table 25**). Soybean stand count, yield, moisture and test weight did not differ among rye termination timing treatments. While this location began the growing season unseasonably hot and dry, both the root channels created by the rye cover crop that could have impacted water infiltration and the 3.1 and 1.9 inches of rain that fell on June 24 and August 13, respectively, may have helped to mitigate stress on the crop caused by the rye cover crop.

Table 25. The effect of rye termination timing on rye biomass, soybean stand count, yield, moisture and test weight at a farm near Granite Falls, MN in 2023

Rye termination timing	Rye biomass (lb/A)	Soybean stand count (plants/A)	Yield (bu/A)	Moisture (%)	Test weight (lb/bu)
Before planting	482 a	121,968	44.5	12.0	54.4
At planting	1697 b	129,067	45.8	12.0	54.9
After planting	2422 c	125,195	44.8	12.1	54.5
No rye	N/A	114,224	44.1	12.3	51.1
LSD (90% CL)	410	NS	NS	NS	NS
CV (%)	22	13	3.2	1.9	3.3

[z] Treatment means within a column that are followed by different letters are significantly different at *P* = 0.10.

Summary

In a dry year, waiting to terminate a rye cover crop increases the risk of yield loss. At three of the six locations (two in northwest and one in west-central MN), soybean yields were significantly lower if rye was terminated after planting. The two northwest locations also had significantly lower yield when rye was terminated at soybean planting.

Surprisingly, the Granite Falls location that received between 6 and 8 inches less rain throughout the growing season compared to normal did not see lower yields with rye termination delays and the Tintah location that received 2 to 4 inches less rain than normal did. Oddly, the sites with the worst yield hit due to late CC termination were not always the sites with the largest amount of rye biomass, suggesting that rye water uptake alone cannot explain the effect. Precipitation in 2023 was highly variable, and timely rains at some sites were likely the key to stable yields irrespective of CC treatment.

Terminating rye before soybean planting only lowered soybean yields in one of the six sites in 2023 and 2 of four locations in 2023, so this practice appears less risky overall. When waiting to terminate *until planting*, yield losses were observed at 3 of 6 locations in 2023 and 2 of 5 in 2022. The greatest risk of delaying termination came when rye was terminated *after planting* in which yield losses were observed at 3 of 6 locations in 2023 and 3 of 5 in 2022. There is a great need to be nimble and have a back-up plan for terminating a living cover crop in spring.

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ON-FARM RESEARCH NETWORK LEADERSHIP TEAM

WHO WE ARE

Minnesota Wheat's On-Farm Research Network (OFRN) conducts producer-funded, producer-driven research that investigates producer-selected research topics in a large plot environment.

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