EXTENSION

On-Farm Research

2021 ON-FARM RESEARCH RESULTS

University of Nebraska Lincoln

Post-Conference Publication 2022 **EC3059**

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NEBRASKA ON-FARM RESEARCH NETWORK

2022 Results Update Meetings

FEBRUARY 17, 2022

Alliance - Knight Museum and Sandhills Center- 908 Yellowstone, Alliance, NE

North Platte - West Central Research, Extension, and Education Center (WCREEC)- 402 W. State Farm Road, North Platte, NE

York - Cornerstone Event Center- 2400 N. Nebraska Ave., York, NE

Norfolk - Madison County Extension Office- 1305 S. 13th Street, Norfolk, NE

Auburn - 4-H Building at the Nemaha County Fair Grounds- 816 I St., Auburn, NE

Kearney - Buffalo County Extension Office- 1400 E. 34th (Fairgrounds), Kearney, NE

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Nebraska CornBoard

Nebraska CornGrowers ASSOCIATION

NEBRASKA SOYBEAN CHECKOFF

Nebraska Dry Bean Commission

University of Nebraska–Lincoln Institute of Agriculture and Natural Resources

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NEBRASKA ON-FARM RESEARCH NETWORK

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NEBRASKA ON-FARM RESEARCH NETWORK

In production ag it's what you think you know, that you really don't know, that can hurt you.

Nebraska Extension On-Farm Research Network Introduction

Laura Thompson
Nebraska Extension Educator and
On-Farm Research Network Director

On-farm research can provide a great avenue to accelerate learning about topics that impact farm productivity and profitability. It is research that you do on your field, using your equipment, and with your production practices. This means the research is directly applicable to your operation. The Nebraska On-Farm Research Network approaches topics that are critical to farmer productivity, profitability, and sustainability. These topics include nutrient management, pest control, irrigation strategies, conservation programs, new technologies, soil amendments, cultural practices, and hybrid and variety selection. Research comparisons are identified and designed to answer producers' production questions. Projects' protocols are developed first and foremost to meet individual cooperator needs. Multiple-year comparisons are encouraged.

We thank all the cooperators who were involved in the valuable research studies contained in this report. Your efforts lead to new discovery and validate current production practices. We also thank the Nebraska Corn Board, Nebraska Corn Growers Association, Nebraska Soybean Board, and Nebraska Dry Bean Commission for the financial support that makes this research, publication, and update meetings possible.

We invite you to become an on-farm research participant. To learn more or to discuss this report, please contact Nebraska Extension On-Farm Research Coordinator, Laura Thompson (contact information is on page 6), visit us online at onfarmresearch.unl.edu, or find us on Facebook and Twitter.

Unless otherwise noted, data in this report were analyzed using Statistixs 10.0 Analytical Software and means were separated using Tukey's HSD (honest significant difference) test.

Statistics 101

<u>Replication:</u> In statistics, replication is the repetition of an experiment or observation in the same or similar conditions. Replication is important because it adds information about the reliability of the conclusions or estimates to be drawn from the data. The statistical methods that assess that reliability rely on replication.

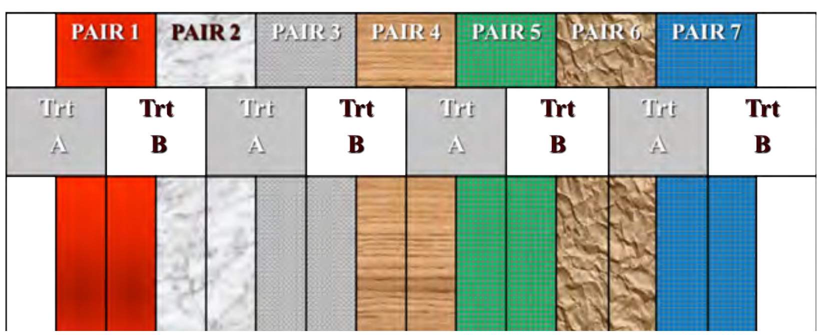
<u>Randomization:</u> Using random sampling as a method of selecting a sample from a population in which all the items in the population have an equal chance of being chosen in the sample. Randomization reduces the introduction of bias into the analysis. Two common designs that meet these criteria are shown below.

<u>What is the P-Value?</u> In field research studies we impose a *treatment* – this treatment may be a new product or practice that is being compared to a standard management. Both the **treatments** that we are testing and **random error** (such as field variability) influence research results (such as yield). You intuitively know that this error exists – for example, the average yield for each combine pass will not come out exactly the same, even if no treatments were applied. The Probability (P) -Value reported for each study assists us in determining if the differences we detect are due to error or due to the treatment we have imposed.

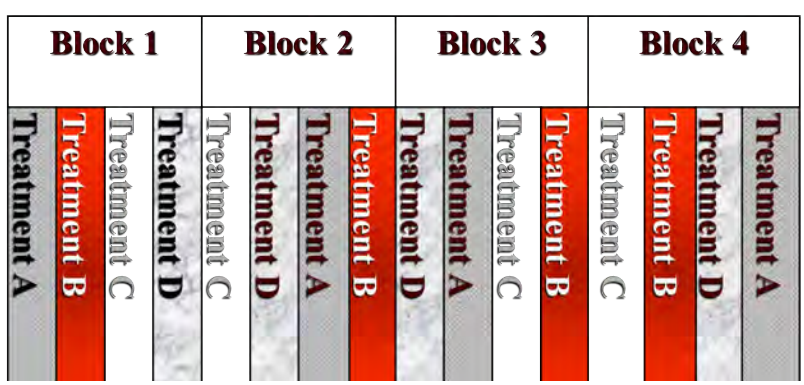
- As the P-Value decreases, the probability that differences are due to random chance decreases.
- As the P-Value increases, we are less able to distinguish if the difference is due to error or the treatment (hence, we have less confidence in the results being due to the treatment).

For these studies, we have chosen a cutoff P-Value of 10%; therefore, if the P-Value is greater than 10% we declare that there are not statistically significant differences due to the treatments. If the value is less than 10%, we declare that differences between treatments are statistically significant. When this is the case, we follow the yield values with different letters to show they are statistically different. The value of 10% is arbitrary – another cutoff could be chosen. As you increase your cutoff value, however, you increase the chance that you will declare that treatments are different when they really are not. Conversely, if you lower the P-Value, you are more likely to miss real treatment differences.

Paired comparison design



Randomized complete block design



PROFIT CALCULATION

Many of our studies include a net return calculation. It is difficult to make this figure applicable to every producer. In order to calculate revenue for our research plots we use input costs provided by the producer, application costs from Nebraska Extension's 2021 Nebraska Farm Custom Rates and an average commodity market price for 2021.

Average market commodity prices for the 2021 report are:

Wheat:	$7.05/bu
Corn:	$5.20/bu
Organic Corn:	$9.50/bu
Soybeans:	$11.80/bu
Great Northern Beans:	$30/cwt ($18/bu at 60 lb/bu)
Pinto Beans:	$45/cwt ($27/bu at 60 lb/bu)
Kidney Beans:	$50/cwt ($30/bu at 60 lb/bu)

For each study, net return is calculated as follows:
Net Return = gross income (yield × commodity price) - treatment cost.

In order to make this information relevant to your operation, you may need to refigure return per acre with costs that you expect.

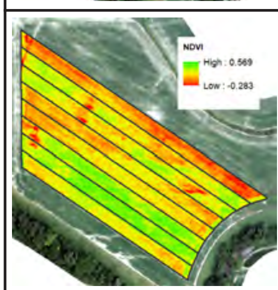
RAINFALL DATA

Rainfall data is provided for each study based on the field location. The rainfall graphs are developed using data from National Weather Service radar and ground stations that report rainfall for 1.2 × 1.2 mile grids.

FarmLogs https://farmlogs.com

AERIAL IMAGERY

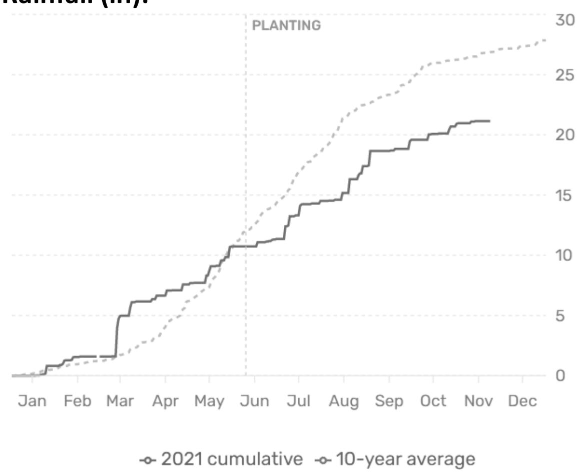
For many studies, aerial imagery was captured using a drone or airplane.

	**True Color Imagery/RGB:** True Color imagery displays the Earth in colors similar to what we might see with our own eyes. This product is a combination of the red, green, and blue wavebands of visible light and, as such, is sometimes referred to as RGB imagery.
	**Normalized Difference Vegetation Index (NDVI):** NDVI is calculated using the red and near-infrared (NIR) wavebands as follows: NDVI = (NIR-Red)/(NIR+Red). This index is often correlated with plant biomass and chlorophyll content. Higher NDVI values are indicative of greater plant biomass and/or a higher chlorophyll concentration. In the example at left, NDVI was displayed with a green to red color ramp: areas with higher NDVI values appear bright green, areas with lower NDVI values appear red and intermediary values are yellow. **Normalized Difference Red Edge (NDRE) Index:** This index is similar to NDVI, and is displayed similarly to NDVI, but is calculated with the red edge waveband in place of the red waveband as follows: NDRE = (NIR-Red Edge)/(NIR+Red Edge). NDRE is also correlated with plant biomass and chlorophyll content. This index is often preferred over NDVI when looking at high biomass crops (such as corn in the mid and late growth stages). Higher NDRE values are indicative of greater plant biomass and/or higher chlorophyll concentration.

CROP PRODUCTION

Kidney Bean Planting Population

Study ID: 1242041202101
County: Custer
Soil Type: Holdrege silt loam 0-1% slope; Coly silt loam 6-11% slopes, eroded; Hord silt loam 0-1% slope
Planting Date: 6/9/21
Harvest Date: 9/17/21-9/18/21
Row Spacing (in): 15
Variety: Pink Panther light red kidney bean
Reps: 4
Previous Crop: Corn
Tillage: No-till, roller crimped rye before drilling
Herbicides: ***Pre:*** Roundup®, Prowl® H2O, and Outlook® on 6/10/21 ***Post:*** Raptor® plus Basagran® on 7/30/21
Seed Treatment: Apron XL®, Maxim®, Rancona®, Vibrance®, Cruiser®
Foliar Insecticides: None
Foliar Fungicides: Headline® on 7/9/21, Priaxor® on 7/30/21
Fertilizer: 80 lb/ac N through pivot
Irrigation: Pivot, Total: 8-10"
Rainfall (in):



Introduction: The objective of this study was to compare three planting rates of kidney beans to determine the most economical seeding rate. The target populations in this study were 90,000, 110,000, and 130,000 plants per acres. Actual populations were determined by early season stand counts and were 85,601, 107,091, and 125,388, respectively. To estimate the treatment seeding rate and subsequent costs, 10% was added to the stand count values; this resulted in treatment seeding rates of approximately 94,000, 118,000, and 138,000 seeds/ac, and assumes all treatments had similar emergence and germination. The beans were drilled into a crimped, 3' tall rye cover crop on June 9. Despite the heavy residue, the beans had good emergence. The plots were swathed on September 8 (25' wide swath), and windrows were combined on September 17 and 18 at a temperature of 85°F.

Samples from each plot were analyzed for bean quality parameters. Harvest loss estimates were determined by taking counts in one-square-foot frames randomly chosen in the harvested area, but equally representing the left side of header, center of header, and right side of header area behind the combine.

Figure 1. Beans planted into the roller-crimped, heavy rye residue (left); Aerial image from August 20, 2021, with no visible differences due to bean populations (right). Yellow chlorotic appearance may be due to N deficiency.

Results:

Target Population (seeds/ac)	Stand Count (plants/ac)	Harvest Loss (bu/ac)	Small (%)	Split (%)	Moisture (%)	Test Weight (lb/bu)	Seeds per lb	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
90,000	85,601 C*	5.5 A	0.2 A	2.3 A	12.2 A	50 A	949 A	31 A	756.22 A
110,000	107,091 B	4.5 A	0.2 A	1.5 AB	11.9 A	52 A	924 A	30 A	738.93 A
130,000	125,388 A	4.8 A	0.2 A	1.2 B	11.9 A	53 A	926 A	30 A	724.58 A
P-Value	0.0003	0.709	0.608	0.074	0.716	0.785	0.241	0.669	0.595

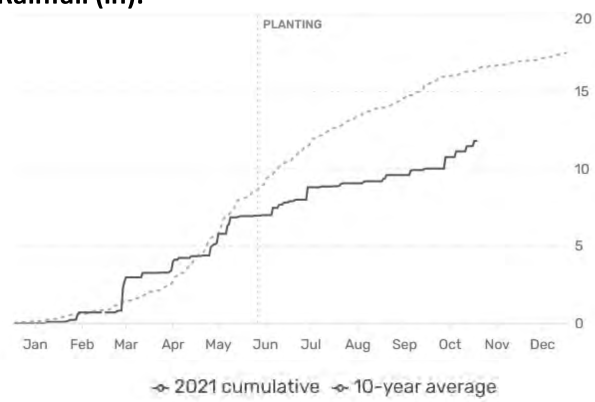
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 14% moisture.
‡Marginal net return based on $50/cwt ($30/bu at 60 lb/bu). Seed cost was $149.50 per 100,000 seeds.

Summary:

- There were no differences in harvest loss, percent of small beans, or grain moisture between the populations tested. Harvest losses were higher than desired, averaging 4.9 bu/ac for the plot.
- There were significant differences in percent of split seeds; the lowest seeding rate had a greater percent of split seeds than the highest seeding rate.
- There were no differences in test weight or seeds per pound between the seeding rates evaluated.
- There were no significant differences in yield; the lowest seeding rate (90,000 seeds/ac) resulted in the same yield as the highest seeding rate. Yields for the field are very low; yields are normally around 50 bu/ac. Local bean companies recommended around 110 lb N/ac for top yields on light red kidney beans. The heavy residue along with only 80 lb N/ac may be responsible for the field yielding approximately 40% less than expected. Note the chlorotic appearance in Figure 1 (right) which may be due to N deficiency.
- There were no statistically significant differences in marginal net return.

Pinto Bean Planting Population for Direct-Harvested Dry Beans

Study ID: 0809123202101
County: Morrill
Soil Type: Tripp very fine sandy loam 0-1% slope; Dix-Bayard complex 6-20% slopes; Mitchell silt loam 1-3% slope
Planting Date: 6/10/21
Harvest Date: 9/27/21
Row Spacing (in): 20
Variety: Gleam slow darkening pinto
Reps: 4
Previous Crop: Corn
Tillage: No-till, rolled after planting
Herbicides: ***Pre:*** 2 oz/ac Sharpen® Powered by Kixor®, and 2.5 lb/ac Actamaster® with 1.2 pt/ac MSO concentrate on 5/12/21 ***Post:*** 2.5 lb/ac Actamaster®, 2 pt/ac Basagran®, 14 oz/ac Outlook®, and 4 oz/ac Vulture® with 12.8 oz/ac HERBIMAX® on 7/12/21;
Desiccant: 1 qt/ac Gramoxone® SL 2.0, 2 oz/ac Sharpen®, 2.5 lb/ac Actamaster® Soluble Crystal Spray Adjuvant, and 1.6 pt/ac MSO seed oil on 9/19/21
Seed Treatment: Maxim®, Apron®, Rancona®, Vibrance®, Cruiser®
Foliar Insecticides: 1 lb/ac acephate 90 soluble on 8/7/21
Foliar Fungicides: 13.7 oz/ac Miravis® NEO on 7/31/21
Fertilizer: 10 gal/ac 32% UAN (36 lb N/ac), 1 qt/ac Awaken®, 2 qt/ac BlackMax® 22, 1 gal/ac Re-Nforce® K, and 3 oz/ac Revline™ on 4/10/21; 2 qt/ac BlackMax® 22, 1 qt/ac ReaX® Complete, 2 oz/ac Revline™, and 2.75 gal/ac RiseR® on 6/10/21; 2 gal/ac Thio-Sul and 20 gal/ac 32% UAN (71 lb N/ac) on 7/12/21; 1 qt/ac Awaken and 1.5 oz/ac REVLINE™ on 7/31/21
Irrigation: Pivot, Total: 10"
Rainfall (in):



Soil Tests (November 2020):

pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% DPTA Zn	Fe	Mn	Cu
8.1	1.9	4	31	447	3024	352	163	19.9	2.3	4	3	0.6

Introduction: The purpose of this study was to compare three planting rates of dry edible beans (Gleam low darkening pinto variety) planted in 20" row spacing. The target populations in this study were 60,000, 100,000, and 130,000 plants per acre. Due to planter issues these populations were not achieved. Actual populations were determined by early season stand counts and were 34,786, 56,234, and 69,952 plants/ac. To estimate the treatment seeding rate and subsequent seed costs, 10% was added to the stand count values; this resulted in treatment seeding rates of approximately 38,300, 61,900, and 76,900 seeds/ac, and assumes all treatments had similar emergence and germination. The plots were direct-harvested on September 27 with a John Deere® S780 combine and MacDon® FD75-S 35-foot FlexDraper® head. The temperature at harvest was 90°F, and the relative humidity was 13%.

Samples from each plot were analyzed for bean quality parameters. Pod height measurements were taken to determine the percent of pods 2" or greater above the soil surface. Harvest loss estimates were determined by taking counts in one-square-foot frames randomly chosen in the harvested area, but equally representing the left side of header, center of header, and right side of header area behind the combine.

Results:

Target population (seeds/ac)	Stand Count (plants/ac)	Pods > 2" Above Ground (%)	Harvest Loss (bu/ac)	Small (%)	Moisture (%)	Density (lb/bu)	Seeds per lb	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
60,000	34,786 C*	60 B	4.7 AB	6 A	23.9 A	54.8 A	1,191 B	13 B	327 B
100,000	56,234 B	68 A	5.6 A	4 A	14.9 A	54.2 A	1,220 AB	25 A	613 A
130,00	69,952 A	73 A	4.2 B	6 A	17.3 A	52.3 A	1,274 A	22 A	528 AB
P-Value	0.001	0.017	0.067	0.300	0.161	0.857	0.049	0.025	0.033

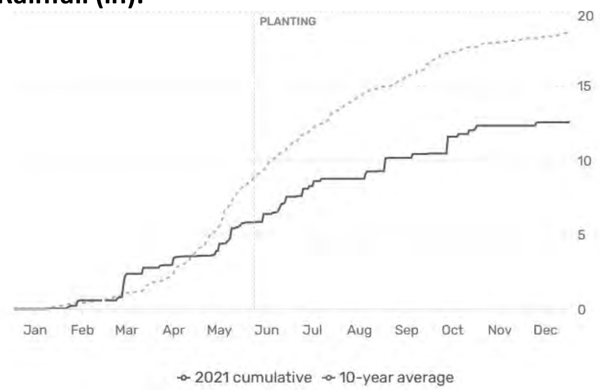
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 14% moisture and adjusted for clean yield (% splits, % small, and % foreign material removed).
‡Marginal net return based on $45/cwt ($27/bu at 60 lb/bu). Seed cost for the treated bean seed was $84.00 per 100,000 seeds.

Summary:

- The percent of pods greater than 2" above the ground increased with increasing plant population. For the 34,786 plants/ac population, only 60% of the pods were greater than 2" above the ground.
- Seeds per lb also increased with increasing plant population, with the highest plant population having 1,274 seeds/lb.
- Harvest loss varied between the populations, with the greatest harvest loss occurring at the 56,234 plants/ac population.
- There was no difference in percent small, grain moisture, or density between the populations evaluated.
- The lowest seeding rate (plant population of 34,786) resulted in significantly lower yields. Sharpen® herbicide was applied in May to control an early emergence of kochia. The herbicide label was misread and Sharpen® was used with only a one-month interval before planting rather than the five-month interval required. It is believed this resulted in approximately 60% yield loss and highlights the importance of carefully following herbicide labels. There is still a noteworthy yield response in the higher plant populations.
- Marginal net return was lower for the lowest plant population compared to the highest plant population. There was no statistical difference in net return between the 56,234 and 69,952 plant/ac populations.

Great Northern Varieties for Direct Harvest

Study ID: 0152013202102
County: Box Butte
Soil Type: Keith loam 0-1% slope; Alliance loam 1-3% slope
Planting Date: 6/7/21
Harvest Date: 9/17/21
Seeding Rate: 90,000
Row Spacing (in): 15
Variety: 4 varieties
Reps: 4
Previous Crop: Corn
Tillage: Disk
Herbicides: ***Pre:*** 30 oz/ac Prowl®, 15 oz/ac Outlook®, 32 oz/ac Roundup® ***Post:*** 4 oz/ac Raptor®, 30 oz/ac Basagran®, 15 oz/ac Select®
Seed Treatment: Apron XL®, Maxim®, Rancona®, Vibrance®, Cruiser®
Foliar Insecticides: None
Foliar Fungicides: 9 oz/ac Approach®, 1 lb/ac NU-COP® HB on 8/6/21
Fertilizer: None
Irrigation: Pivot, Total: 11"
Rainfall (in):



Soil Tests: (January 2021)

pH	OM LOI %	Nitrate – N ppm N	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% DPTA Zn	Fe	Mn	Cu
8.0	1.6	20	548	2670	314	75	17.7	1.2	4.6	0.6	0.3

Introduction: The purpose of this study was to compare four different great northern bean varieties in a direct-harvest bean production system, looking at both yield and harvest loss. Currently, most dry beans in western Nebraska are harvested in a two-step process starting with a cutting windrowing operation, and then combining. Direct-harvest is simply one pass through the field with the combine. A good upright bean variety, proper level field conditions, and a combine header suitable for direct harvest are essential to minimize harvest loss and economically justify direct harvest.

This study evaluated varieties 15215, Andromeda, Draco, and Virgo varieties. The target population for the study was 90,000 plants per acre. Because of the inaccuracy of drills, normally as a result of seed size and seed flow through the machine, actual plant populations determined by early season stand counts were 89,085 plants/ac for 15215, 73,766 plants/ac for Andromeda, 100,702 plants/ac for Draco, and 92,207 plants/ac for Virgo. Planting populations were assumed to be 10% greater at approximately 97,994 seeds/ac for 15215, 81,143 seeds/ac for Andromeda, 110,772 seeds/ac for Draco, and 101,428 seeds/ac for Virgo.

Low-hanging pods are a major cause of harvest loss in the direct-harvest process; therefore, pod height measurements were taken to determine the percent of pods greater than 2" above the ground just before harvest. The plots were direct harvested on September 17 with a Case IH 7088 combine and a MacDon® 30-foot FlexDraper® head. The temperature at harvest was 69°F and the relative humidity was 31%. Hot and dry weather conditions at harvest generally result in greater harvest loss through pod shattering.

Figure 1. Aerial imagery from August 19. The darker strips are the Virgo variety, which was later maturing.

Results:

	Stand Count (plants/ac)	Pods > 2" Above Ground (%)	Harvest Loss (bu/ac)	Small (%)	Split (%)	Damaged (%)	Moisture (%)	Density (lb/bu)	Seeds per lb	Yield (bu/ac) †	Marginal Net Return‡ ($/ac)
15215	89,085 B*	83 B	3.5 B	2 A	3 B	30.5 A	10.4 B	61 A	1,225 A	44 AB	689 A
Andromeda	73,766 C	63 D	5.9 A	1 C	2 C	13.8 BC	10.5 AB	60 B	1,145 B	43 B	692 A
Draco	100,702 A	70 C	2.9 B	1 C	2 B	8.5 C	10.8 A	59 B	1,185 AB	44 AB	686 A
Virgo	92,207 B	89 A	2.8 B	1 B	3 A	15.3 B	10.2 B	59 B	1,228 A	46 A	729 A
P-Value	<0.001	<0.001	0.001	<0.001	0.0003	<0.001	0.007	0.0004	0.014	0.050	0.113

*Values with the same letter are not significantly different at a 90% confidence level.

†Bushels per acre corrected to 14% moisture and adjusted for clean yield (% splits, % small, and % foreign material removed).

‡Marginal net return based on $30/cwt ($18/bu at 60 lb/bu). Seed cost for the bean seed was $95/100,000 seeds. Seed costs for each treatment were adjusted to represent the estimated actual seeding rate based on stand counts: $96.36/ac for Virgo, $105.23/ac for Draco, $93.09/ac for 15215, and $77.09/ac for Andromeda.

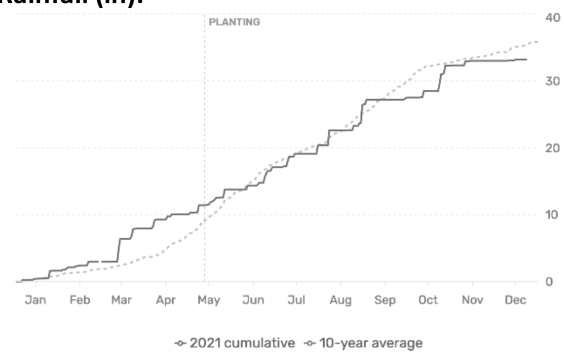
Summary:

- There were significant differences in stand counts among the treatments. Draco had the highest stand count and Andromeda had the lowest stand count.
- Virgo had the greatest percentage of pods greater than 2" above the soil. Andromeda had only 63% of pods greater than 2" above the soil. This may be due in part to the lower plant stand for this variety.
- In addition to having the fewest pods 2" above the soil, Andromeda also had the greatest harvest loss at 6 bu/ac. The other three varieties all had comparable harvest loss, around 3 bu/ac.
- Percent splits, percent smalls, moisture, damage, density, and seeds per lb varied among treatments.
- Andromeda had a significantly lower yield than Virgo. This may be due to the lower plant stands that were achieved for this variety and contributed to greater harvest loss. Virgo, Draco, and 15215 did not significantly differ in yield.
- There were no significant differences in net return between varieties evaluated.

Non-Irrigated Soybean Population Study

Study ID: 1252025202101
County: Cass
Soil Type: Marshall silty clay loam 6-11% slopes, eroded; Judson silt loam 2-6% slopes
Planting Date: 5/12/21
Harvest Date: 10/12-10/15/21
Seeding Rate: 80k, 110k, and 140k
Row Spacing (in): 15
Variety: Asgrow® AG36XF1
Reps: 6
Previous Crop: Corn
Tillage: No-till
Seed Treatment: Bayer fungicide and insecticide
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: MAP and Potash applied by variable rate

Note: Tall beans and July wind event led to lodging. Lodging appeared uniform across the different planting populations.
Irrigation: None
Rainfall (in):



Introduction: Previous on-farm research has demonstrated that soybean planting rates of 80,000 to 120,000 seeds/ac resulted in the highest profitability. The purpose of this study was to evaluate three seeding rates to determine the seeding rate that maximized yield and profit. The target seeding rates were 80,000, 110,000, and 140,000 seeds/ac. The remainder of the field was planted at 120,000 seeds/ac. Treatments were randomized and replicated in 120' wide by 400' long blocks across the field (Figure 1). A variable-rate prescription map was created and uploaded to the in-cab monitor to implement the study. Geospatial yield monitor data were collected at the end of the growing season and post-processed to remove errors. The as-planted data were evaluated and only areas that achieved within 10% of the target seeding rate were included for yield analysis. Stand counts were taken in each seeding rate on June 17. Yield, moisture, and net return were evaluated.

Figure 1. Soybean seeding rate prescription map for 2021 field site.

Results:

Target Seeding Rate (seeds/ac)	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
80,000	57,665 B*	10.3 A	65 A	732 A
110,000	72,279 B	10.4 A	64 A	697 AB
140,000	118,040 A	10.4 A	64 A	685 B
P-Value	0.010	0.696	0.489	0.076

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean and $67/unit of 140,000 seeds.

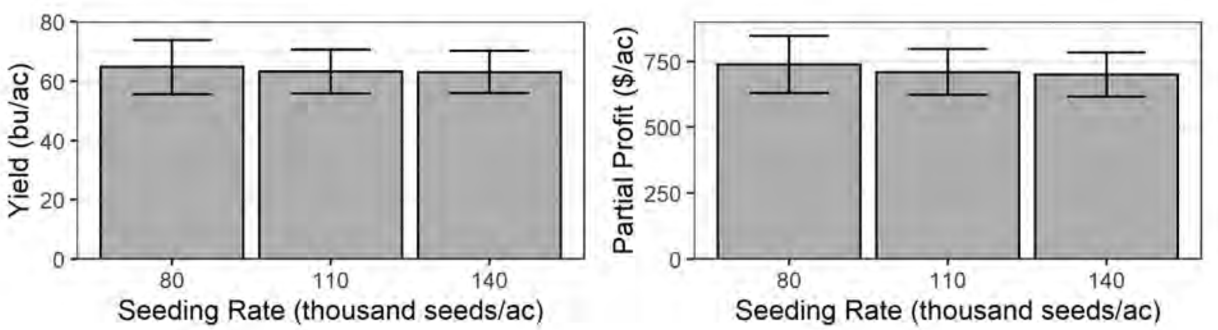


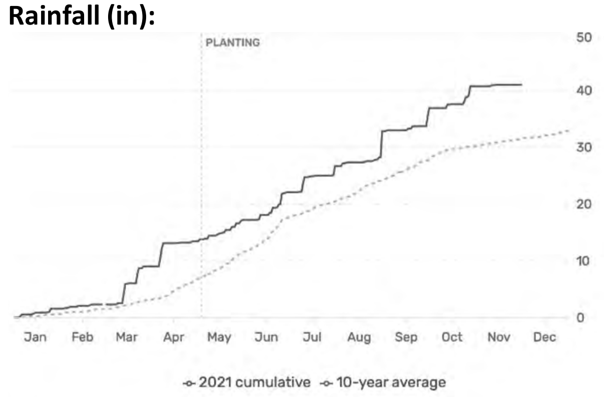
Figure 2. Soybean yield and partial profit for three seeding rates evaluated.

Summary:
- Stand counts showed that actual stands ranged from 66% to 84% of the target seeding rates.
- There was no difference in yield between the three seeding rates evaluated. Despite the lowest seeding rate (80,000 seeds/ac) only having a stand of around 58,000 plants/ac, it yielded the same as the higher seeding rates (Figure 2).
- Net return was greatest for the lowest seeding rate evaluated.

Soybean Benchmarking: Baseline vs Improved Soybean Practices

Study ID: 0926039202101
County: Cuming
Soil Type: Kennebec silt loam occasionally flooded; Kennebec silt loam 0-3% slope
Harvest Date: 10/8/21
Row Spacing (in): 30
Variety: Midland® 2990
Reps: 4
Previous Crop: Corn
Tillage: Disk
Herbicides: ***Pre:*** Treflan® ***Post:*** Enlist® and glyphosate

Irrigation: None
Rainfall (in):



Soil Tests (July 2021)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	ppm									%					ppm
6.4	6.7	18.1	0.24	3.9	7.1	612	6.9	2.3	76.1	18.7	1.5	2208	337	24	14	9	61	15	1	100

Introduction: Analysis of producer survey data revealed: (1) an average yield gap of 20-30% between current farmer yield and potential yield as determined by climate, soil, and genetics, and (2) a number of agronomic practices that, for a given soil-climate context, can be fine-tuned to close the gap and improve soybean producer profit. In Nebraska, three practices were identified as being important for improving yield and producer profit. These practices relate to planting date, seeding rate, and the use of foliar fungicides and insecticides. This study collectively tested the "baseline" practices versus the "improved" practices. Across four sites in 2019, the improved treatment resulted in an average 8 bu/ac yield increase and $46/ac profit increase compared to the baseline treatment; across six sites in 2020, the improved treatment resulted in an average of 4.5 bu/ac yield increase and $28/ac profit increase compared to the baseline treatment. Soybean cyst nematode tests for this field came back negative when tested in 2019.

Baseline: Soybeans planted on May 13, at a rate of 160,000 seeds/ac, with no foliar fungicide or insecticide.

Improved: Soybeans planted on May 3, at a rate of 145,000 seeds/ac, with a foliar fungicide (10 oz/ac Affiance®) and insecticide (9 oz/ac Tundra® Supreme) application on July 28.

Results:

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Baseline	150,001 A*	56 A	12.6 A	56 B	598 A
Improved	134,217 B	57 A	12.5 A	62 A	633 A
P-Value	0.009	0.502	0.809	0.072	0.227

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $55/unit of seed (140,000 seeds), and $36/ac for fungicide, insecticide, and application.

Summary:

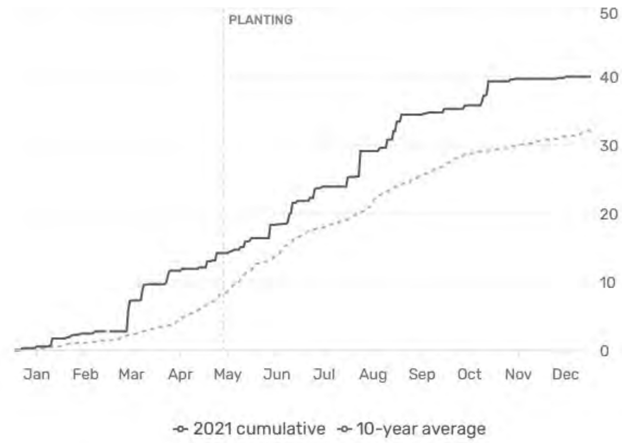
- The improved treatment (lower seeding rate, early planting, and fungicide and insecticide application) resulted in a 5 bu/ac yield increase. There was not a statistically significant difference in profit.

This study was conducted in cooperation with a regional study funded by the North Central Region Soybean Research Program.

Soybean Benchmarking: Baseline vs Improved Soybean Practices

Study ID: 1245023202101
County: Bulter
Soil Type: Yutan silty clay loam 2-6% slopes, eroded; Pohocco silty clay loam 6-11% slopes, eroded
Harvest Date: 10/5/21
Row Spacing (in): 30
Variety: Channel® 2918R2X
Reps: 4
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 32 oz/ac Roundup PowerMAX®, 8 oz/ac Cruise Control, and 8 oz/ac Antares® Prime on 5/4/21 ***Post:*** 32 oz/ac Roundup PowerMAX® and 16 oz/ac Engenia® on 6/30/21
Seed Treatment: Acceleron® and Optimize® inoculant
Fertilizer: 80 lb/ac 11-52-0 on 1/12/21

Irrigation: None
Rainfall (in):



Soil Tests (June 2021)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	ppm									%					ppm
5.8	6.6	17.7	0.08	3.2	2.9	125	7.5	0.48	30.6	8.2	0.49	1926	446	20	23	2	54	21	0	8

Introduction: Analysis of producer survey data revealed: (1) an average yield gap of 20-30% between current farmer yield and potential yield as determined by climate, soil, and genetics, and (2) a number of agronomic practices that, for a given soil-climate context, can be fine-tuned to close the gap and improve soybean producer profit. In Nebraska, three practices were identified as being important for improving yield and producer profit. These practices relate to planting date, seeding rate, and the use of foliar fungicides and insecticides. This study collectively tested the "baseline" practices versus the "improved" practices. Across four sites in 2019, the improved treatment resulted in an average 8 bu/ac yield increase and $46/ac profit increase compared to the baseline treatment; across six sites in 2020, the improved treatment resulted in an average of 4.5 bu/ac yield increase and $28/ac profit increase compared to the baseline treatment. Soybean cyst nematode tests for this field came back negative.
Baseline: Soybeans planted on May 15, at a rate of 160,000 seeds/ac, with no foliar fungicide or insecticide.

Improved: Soybeans planted on May 12, at a rate of 130,000 seeds/ac, with a foliar fungicide (8 oz/ac Delaro®) and insecticide (3 oz/ac lambda-cyhalothrin) application on July 17.

Results:

	Stand Count (plants/ac)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Baseline	126,667 A*	74 A	818 A
Improved	105,083 B	72 A	777 A
P-Value	0.006	0.232	0.169

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybeans, $52.19/unit of 140,000 seeds, $15/ac for fungicide and insecticide, and $2.79/ac for application of fungicide and insecticide.

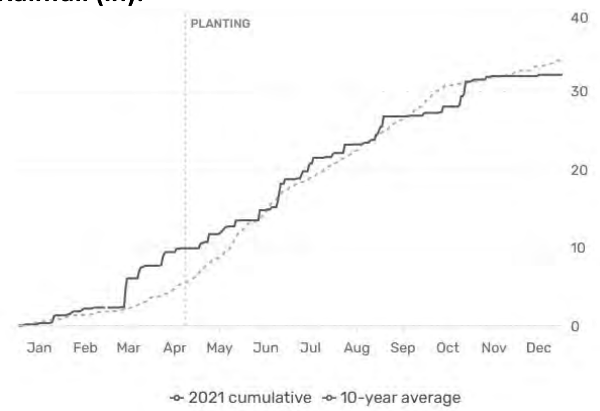
Summary: In 2021, the improved treatment (lower seeding rate, early planting, and fungicide and insecticide application) did not result in a yield increase. For this study, the planting dates were only 3 days apart rather than the desired 2 week difference. Additionally, the early planting date was not as early as other studies, which had the early planting date in late April or early May. This likely contributed to the lack of response for the improved treatment.

This study was conducted in cooperation with a regional study funded by the North Central Region Soybean Research Program.

Soybean Benchmarking: Baseline vs Improved Soybean Practices

Study ID: 1126131202101
County: Otoe
Soil Type: Wymore silty clay 2-6% slopes; Zook silty clay loam occasionally flooded
Harvest Date: 10/14/21
Row Spacing (in): 30
Variety: Pioneer® 41T07
Reps: 4
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 1 pt/ac 2,4-D, 2 pt/ac glyphosate, and 1.875 lb/ac sulfentrazone with 1.875 lb/ac AMS on 4/19/21 ***Post:*** 3 pt/ac glufosinate, 7 oz/ac clethodim, and 1.875 lb/ac AMS on 6/7/21
Fertilizer: None

Irrigation: None
Rainfall (in):



Soil Tests (June 2021 - average of study area)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	ppm									%					ppm
5.6	6.4	19.6	0.68	3.6	5.7	100	11.8	1.72	59.2	20.7	0.72	2213	244	131	29	1	56	10	3	24

Introduction: Analysis of producer survey data revealed: (1) an average yield gap of 20-30% between current farmer yield and potential yield as determined by climate, soil, and genetics, and (2) a number of agronomic practices that, for a given soil-climate context, can be fine-tuned to close the gap and improve soybean producer profit. In Nebraska, three practices were identified as being important for improving yield and producer profit. These practices relate to planting date, seeding rate, and the use of foliar fungicides and insecticides. This study collectively tested the "baseline" practices versus the "improved" practices. Across four sites in 2019, the improved treatment resulted in an average 8 bu/ac yield increase and $46/ac profit increase compared to the baseline treatment; across six sites in 2020, the improved treatment resulted in an average of 4.5 bu/ac yield increase and $28/ac profit increase compared to the baseline treatment. Soybean cyst nematode tests for this field came back negative.

Baseline: Soybeans planted on May 23, at a rate of 150,000 seeds/ac.

Improved: Soybeans planted on April 22, at a rate of 130,000 seeds/ac. The improved treatment was to have received a foliar fungicide and insecticide application; it was inadvertently omitted from this trial this year.

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Baseline	130,559 A*	12.3 A	70 A	767 A
Improved	99,521 B	12.2 A	73 A	815 A
P-Value	0.013	0.916	0.423	0.350

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean and and $55/unit of 140,000 seeds.

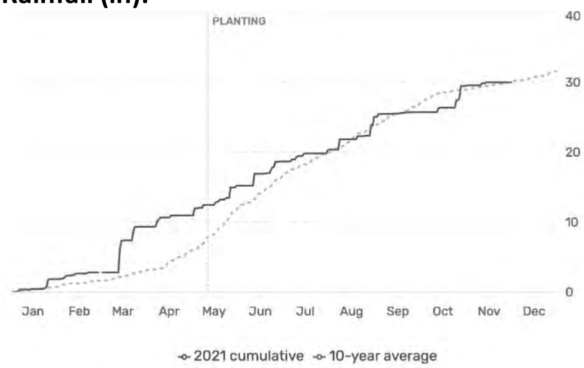
Summary: Early season stand counts showed plant stands were approximately 77 to 87% of the planted rate. In 2021, the improved treatment (lower seeding rate and early planting) did not result in a statistically significant yield increase compared to the baseline treatment. For this study, the foliar fungicide and insecticide application was inadvertently omitted; therefore, this study only compares the impact of seeding rate and planting date. There was no difference in net return.

This study was conducted in cooperation with a regional study funded by the North Central Region Soybean Research Program.

Group 2.1 vs Group 3.1 Soybean Maturity

Study ID: 0802159202102
County: Seward
Soil Type: Hastings silt loam 1-3% slope
Planting Date: 5/11/21
Harvest Date: 9/15/21 and 9/27/21
Seeding Rate: 135,000
Row Spacing (in): 30
Variety: Pioneer® P21A28X, P31A95BX
Reps: 3
Previous Crop: Corn
Tillage: No-Till
Herbicides: ***Pre:*** 22 oz/ac Roundup PowerMAX®, 1 pt/ac 2,4-D LV 6, and 6 oz/ac Zidua® PRO with 2.55 lb/ac AMS ***Post:*** 32 oz/ac Roundup PowerMAX®, 6 oz/ac Select Max®, 32 oz/ac Symbol™/Release, and 6 oz/ac Cadet® with 2.55 lb/ac AMS
Seed Treatment: Lumisena™, Gaucho®, EverGol®, Pioneer Premium Seed Treatment 2030 and PPST 120+

Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: None
Irrigation: None
Rainfall (in):



Introduction: With early planting of soybean (in April or as close to May 1 as possible), a longer-season variety may help take advantage of the longer growing season. However, some growers are also obtaining high yields with mid-group 2 varieties. The goal of this study was to determine if growers need to plant a longer-season maturity soybean to achieve optimum yields when planting early. This study compared a group 2.1 (Pioneer® P21A28X) and group 3.1 (Pioneer® P31A95BX) soybean. Due to rain delays, the soybeans this year were planted later than desired, on May 11. The 2.1 maturity group soybeans were harvested on September 15 and the 3.1 maturity group soybeans were harvested on September 27.

Results:

	Stand Count (plants/ac)	Pods/plant	Nodes/plant	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Group 2.1 (Pioneer® 21A28X)	123,333 A*	39 A	17 A	12.6 A	65 B	711 B
Group 3.1 (Pioneer® 31A95BX)	123,833 A	45 A	18 A	12.3 A	71 A	778 A
P-Value	0.858	0.191	0.270	0.565	0.088	0.098

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $51.99/ac for Pioneer® P21A28X, and Pioneer® P31A95BX.

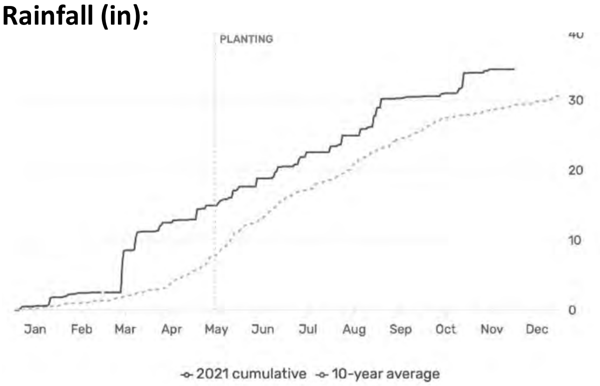
Summary:

- Rain delays led to later than desired planting date; therefore, the impact of soybean maturity on early planted soybeans cannot be determined for this study.
- There were no differences in stand count, pods per plant or nodes per plant between the varieties evaluated.
- The 3.1 maturity group soybean (Pioneer® P31A95BX) had a 6 bu/ac higher yield and $68/ac greater profit than the 2.1 maturity group soybean (Pioneer® P21A28X). A key rainfall in late August helped the 3.1 maturity beans compared to the 2.1 maturity that were already at physiological maturity.
- Previous on-farm research studies in 2018, 2019, and 2020 found no difference in yield between group 2 and group 3 soybeans across ten site-years.

Group 2.0 vs Group 2.5 vs Group 2.8 vs Group 3.1 Soybean Maturity

Study ID: 0802159202101
County: Seward
Soil Type: Hastings silt loam 0-1% slope; Fillmore silt loam frequently ponded
Planting Date: 5/14/21
Harvest Date: 9/29/21 and 10/1/21
Seeding Rate: 135,000
Row Spacing (in): 30
Variety: Pioneer® P20A22X, P25A04X, P28A42X, P31A95BX
Reps: 3
Previous Crop: Corn
Tillage: Ridge-Till
Herbicides: ***Pre:*** 22 oz/ac Roundup PowerMAX®, 1 pt/ac 2,4-D LV 6, and 6 oz/ac Zidua® PRO with 2.55 lb/ac AMS ***Post:*** 22 oz/ac Roundup PowerMAX®, 22 oz/ac XtendiMax® with VaporGrip® Technology, 6 oz/ac Select Max®, with CVA Elite, and Volt-Edge™

Seed Treatment: Lumisena™, Gaucho®, EverGol®, Pioneer PPST 2030 and PPST 120+
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: None
Irrigation: Gravity, Total: 8.80"
Rainfall (in):



Introduction: With early planting of soybean (in April or as close to May 1 as possible), a longer-season variety may help take advantage of the longer growing season. However, some growers are also obtaining high yields with mid-group 2 varieties. The goal of this study was to determine if growers need to plant a longer-season maturity soybean to achieve optimum yields when planting early. Three group 2 soybeans (Pioneer® P20A22X, Pioneer® P25A04X, and Pioneer® P28A42X) and a group 3 soybean (Pioneer® P31A95BX) were evaluated. Due to rain delays and logistics of moving equipment to this field located in a different part of the county, the soybeans were planted later than desired, on May 14. Rep 1 was harvested on September 29 and Reps 2 and 3 were harvested on October 1 after a rain delay.

Results:

	Stand Count (plants/ac)	Pods/plant	Nodes/plant	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Group 2.0 (Pioneer® 20A22X)	114,833 A*	42 A	16 C	13.6 A	77 B	858 B
Group 2.5 (Pioneer® 25A04X)	119,500 A	43 A	18 AB	13.5 A	83 A	920 A
Group 2.8 (Pioneer® 28A42X)	112,667 A	45 A	17 BC	13.9 A	86 A	960 A
Group 3.1 (Pioneer® 31A95BX)	112,667 A	49 A	19 A	13.5 A	73 B	804 B
P-Value	0.090	0.322	0.008	0.630	0.001	0.001

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $51.98/ac for Pioneer® P20A22X, $56.44/ac for Pioneer® P25A04X, $57.72/ac for Pioneer® P28A42X and Pioneer® P31A95BX.

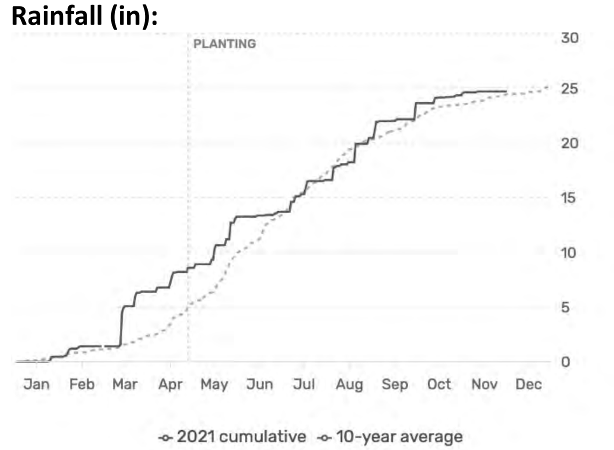
Summary:

- Rain delays and equipment logistics led to later than desired planting date; therefore, the impact of soybean maturity on early planted soybeans cannot be determined for this study.
- Average pods per plant were the same between the varieties tested; however, average nodes per plant were higher for the Pioneer® P31A95BX soybean than the Pioneer® P28A42X and Pioneer® P20A22X.
- There were no differences in stand counts between the four varieties evaluated.
- Yield and profit were greater for the 2.5 and 2.8 group soybeans compared to the 2.0 and 3.1 group soybeans. This is similar to the results from the 2020 growing season where group 2.5 and 2.7 soybeans (Pioneer® P25A04X and Pioneer® P27A17X) had higher yields than group 2.1 and 3.1 soybeans (Pioneer® P21A28X and Pioneer® P31A22X). Because the site was irrigated, water limitations were not a factor for any of the varieties evaluated.

Fertility& Soil Management

Altura™ vs 10-34-0 in Strip-Till Fertilizer Application on Corn

Study ID: 0709047202104
County: Dawson
Soil Type: Hord silt loam 0-1% slope; Cozad silt loam 0-1% slope
Planting Date: 4/27/21
Harvest Date: 11/5/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1353Q
Reps: 7
Previous Crop: Corn
Tillage: Strip-till, Ridge-till
Herbicides: ***Pre:*** Burndown: 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer® 5 Extra, 1 qt/ac atrazine 4L, and 20 oz/ac Moccasin™ II Plus on 5/4/21
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac bifenthrin 2EC and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Irrigation: Gravity, Total: 12"
Rainfall (in):



Introduction: This is the second year of a three-year study that evaluates the impact of Altura™ fertilizer versus 10-34-0 fertilizer. The treatment strips are maintained in the same place each year and soil tests are collected annually to detect changes in soil fertility over time. Altura™ is a 7-21-0-0.2 Zn fertilizer with 6% organic material derived from leonardite, 1% gluconic acid, and 0.2% zinc.

The two treatments were applied with strip-till on April 13, 2021:

Check: 15 gal/ac 32% UAN, 5 gal/ac 12-0-0-26S, 0.25 gal/ac ReaX™ Zinc, and 15 gal/ac 10-34-0
(10-34-0 provided 17 lb N/ac and 59 lb P/ac)
Altura™: 15 gal/ac 32% UAN, 5 gal/ac 12-0-0-26S, 0.25 gal/ac ReaX™ Zinc, and 5 gal/ac Altura™ 7-21-0-0.2 Zn
(Altura™ provided 4 lb N/ac and 11 lb P/ac).

Additional fertilizer on the field was the same for both treatments and included an in-furrow starter fertilizer application of 1 gal/ac Altura™, 1 gal/ac ReaX™ K, and 0.25 gal/ac ReaX™ Zinc with in-furrow starter on April 27, 2021, 10 gal/ac 32% UAN with burndown herbicide on April 30, 2021, and 34 gal/ac 32% UAN, 8 gal/ac 12-0-0-26S, and 1 gal/ac ReaX™ K side-dressed on June 15, 2021.

Results:

Table 1. Soil tests before and after application of Altura™.

	Soil pH	OM LOI %	Nitrate lb N/A	Mehlich P-III ppm P	SO_4-S ppm	Ammonium Acetate (ppm) K	Ca	Mg	Na	Sum of Cations meq/100g	DPTA (ppm) Zn	Fe	Mn	Cu
					Before application – April 2020									
Check	6.7	2.8	26	21	3	353	1879	341	60	13	1.4	17.8	6.3	0.6
Altura™	6.6	2.7	26	19	4	385	2865	436	61	19	1.7	24.2	8.4	0.7
					After year 1 – March 2021									
Check	6.4	3.1	98	23	19	448	2300	424	82	17	2.8	18.5	9.1	0.8
Altura™	6.7	2.7	156	20	26	432	2701	390	72	18	2.1	20.0	11.4	0.9

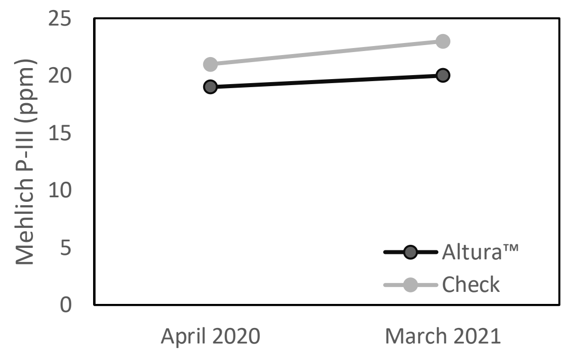


Figure 1. Soil test P from before the study and after year one of Altura™ application.

Table 2. Stand counts, yield, and profit for the Altura™ treatment and check.

	Early Season Stand Count (plants/ac)	**Harvest Stand Count (plants/ac)**	**Moisture (%)**	**Yield (bu/ac)†**	**Marginal Net Return‡ ($/ac)**
Check	27,333 A*	26,333 A	17.0 A	238 A	1,205 A
Altura™	27,571 A	27,143 A	17.0 A	228 B	1,150 B
P-Value	0.839	0.394	0.736	0.0003	0.0002

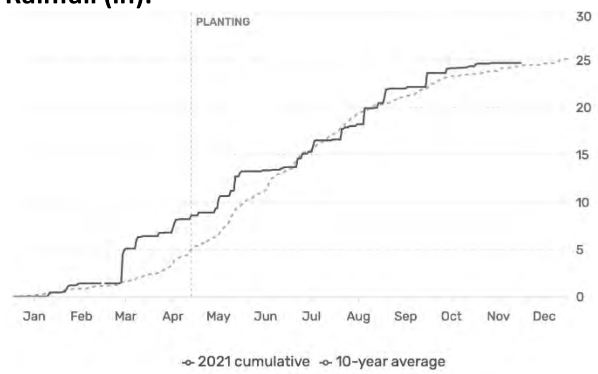
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $35/ac for 10-34-0, and $36.70/ac for Altura™.

Summary:

- There were no differences in early season or harvest stand counts.
- The corn yield was 10 bu/ac greater for the check treatment compared to the Altura™. This resulted in an increase of $55/ac for the check treatment compared to the Altura™.
- In year one of the study there were no significant differences in yield or net return between the check and Altura™ treatment.
- Soil tests do not show an increase in soil P with an additional 5 gal/ac Altura™ in the strip-till application after year one of the study.

ReaX™ Mn in Starter Fertilizer on Corn

Study ID: 0709047202106
County: Dawson
Soil Type: Cozad silt loam 0-1% slope; Cozad silt loam 0-3% slope
Planting Date: 4/27/21
Harvest Date: 11/5/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1353Q
Reps: 7
Previous Crop: Corn
Tillage: Strip-till, Ridge-till
Herbicides: ***Pre:*** Burndown: 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer® 5 Extra, 1 qt/ac atrazine 4L, and 20 oz/ac Moccasin® ll Plus on 4/30/21
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac bifenthrin 2EC and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Irrigation: Gravity, Total: 12"
Rainfall (in):



Introduction: The purpose of this study is to evaluate the impact of ReaX™Mn in starter fertilizer. ReaX™Mn is a 4% Mn powdered manganese. Soil tests indicated Mn levels ranged from 7.4 to 13.6 ppm. The producer's goal was to increase Mn levels to 20 ppm. This is the second year of a three-year study, which maintains the same treatment strips to assess yield and soil test changes with use of ReaX™ Mn over time.

The two treatments were applied with starter at planting on April 27, 2021:

Check: 1 gal/ac Altura™, 1 gal/ac ReaX™K, and 0.125 gal/ac ReaX™Zn.

ReaX™Mn: 1 gal/ac Altura™, 1 gal/ac ReaX™K, 0.125 gal/ac ReaX™Zn, and 0.5 gal/ac ReaX™Mn.

Additional fertilizer on the field was the same for both treatments and included a strip-till application of 15 gal/ac 32% UAN (53 lb N/ac), 5 gal/ac 12-0-0-26S, 2 gal/ac Altura™, 0.25 gal/ac chelated zinc, and 15 gal/ac 10-34-0 on April 13, 2021, a burndown spray on April 30, 2021, that included 10 gal/ac 32% UAN (36 lb N/ac), and a side-dress application of 34 gal/ac 32% UAN (121 lb N/ac), 8 gal/ac 12-0-0-26S, and 1 gal/ac ReaX™K on June 15, 2021.

Results:

Table 1. Soil tests before and after application of ReaX™ Mn.

	Soil pH	OM LOI %	Nitrate lb N/A	Mehlich P-III ppm P	SO_4-S ppm	Ammonium Acetate (ppm) K	Ca	Mg	Na	Sum of Cations meq/100g	DPTA (ppm) Zn	Fe	Mn	Cu
							Before application – April 2020							
Check	6.1	3.0	29	16	3	393	1997	397	56	15	2.0	30.7	17.0	0.6
ReaX™ Mn	6.1	3.2	31	20	4	424	1519	339	61	12	1.7	30.8	13.9	0.6
							After year 1 – March 2021							
Check	5.9	3.0	108	23	21	495	1696	306	77	15	2.1	30.0	22.4	0.7
ReaX™ Mn	5.8	3.3	103	20	26	468	1602	294	77	16	2.1	34.4	22.6	0.9

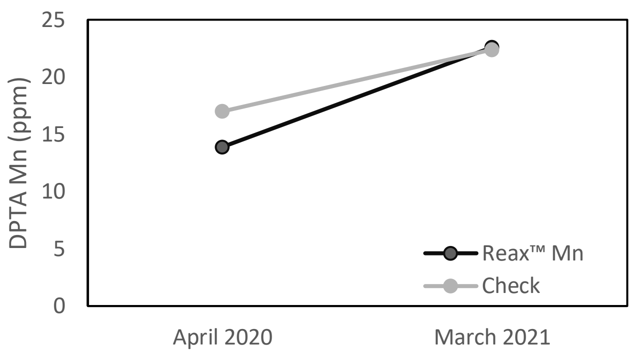


Figure 1. Soil test Mn from before the study and after year one.

Table 2. Stand counts, yield, and profit for the ReaX™ Mn treatment and check.

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	29,191 A*	28,476 A	17.0 A	236 A	1,202 A
ReaX™ Mn	29,333 A	27,952 A	17.0 A	236 A	1,190 A
P-Value	0.893	0.419	0.182	0.864	0.200

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $27/ac for the check, and $37.50/ac for ReaX™ Mn.

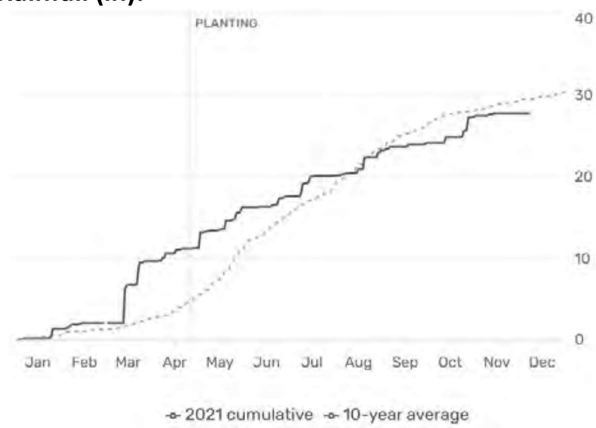
Summary:

- The ReaX™ Mn with starter fertilizer did not result in statistically significant differences in early season or harvest stand counts.
- In both the first and second year of the study, there were no differences in grain yield or marginal net return.
- After the first year of the study, soil test Mn was the same for the ReaX™ Mn treatment and check. Additional soil samples will be collected to determine the impact after this year, which is year two of the study.

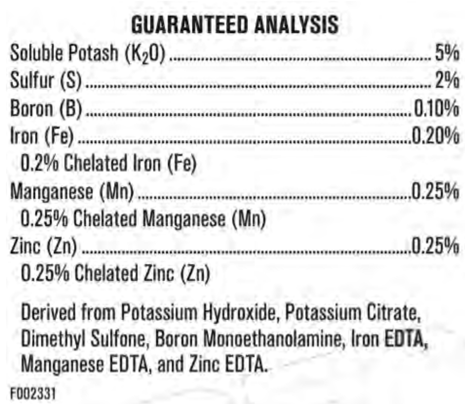
Impact of Verdesian Take Off® LS and Toggle® with Starter Fertilizer In-Furrow

Study ID: 1050081202101
County: Hamilton
Soil Type: Hastings silt loam 0-1% slope
Planting Date: 4/25/21
Harvest Date: 10/9/21
Seeding Rate: 32,000
Row Spacing (in): 36
Hybrid: DEKALB®63-91RIB
Reps: 4
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 5.5 oz/ac Corvus®, 48 oz/ac atrazine, and 32 oz/ac Roundup® on 5/6/21
Seed Treatment: Acceleron® 250
Foliar Fungicides: Delaro® Complete on 7/16/21
Fertilizer: 190 lb N/ac as anhydrous ammonia in fall 2020; 4 gal/ac starter fertilizer 7-23-4-0.25 Zn

Note: Wind event on 7/9/21 resulted in 9% green snap
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Introduction: This study evaluated the impact of Verdesian Take Off® LS and Acadian Plant Health™ Toggle® applied in-furrow at planting with Begin starter fertilizer. The check was Begin starter fertilizer alone. Take Off® LS was applied at 16 oz/ac and is designed to improve nutrient use efficiency, promote faster germination and emergence, and increase yield. Take Off® LS contains potash, sulfur, boron, iron, manganese, and zinc. Toggle® was applied at 8 oz/ac and is designed to increase root growth, enhance nutrient uptake, and increase yield potential. Toggle® is derived from marine plant extract. The product information for Take Off® LS is provided below.



GUARANTEED ANALYSIS

Soluble Potash (K_2O) 5%
Sulfur (S) 2%
Boron (B) 0.10%
Iron (Fe) 0.20%
0.2% Chelated Iron (Fe)
Manganese (Mn) 0.25%
0.25% Chelated Manganese (Mn)
Zinc (Zn) 0.25%
0.25% Chelated Zinc (Zn)

Derived from Potassium Hydroxide, Potassium Citrate, Dimethyl Sulfone, Boron Monoethanolamine, Iron EDTA, Manganese EDTA, and Zinc EDTA.

F002331

https://vlsci.com/wp-content/uploads/2020/10/Take-Off-LS-Specimen-label-REV-05-18-A1-GHS.pdf

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Begin Starter (check)	31,000 A*	17.7 A	273 A	1,417 A
Begin Starter + Take Off LS + Toggle	30,625 A	17.6 A	268 A	1,387 A
P-Value	0.245	0.358	0.282	0.222

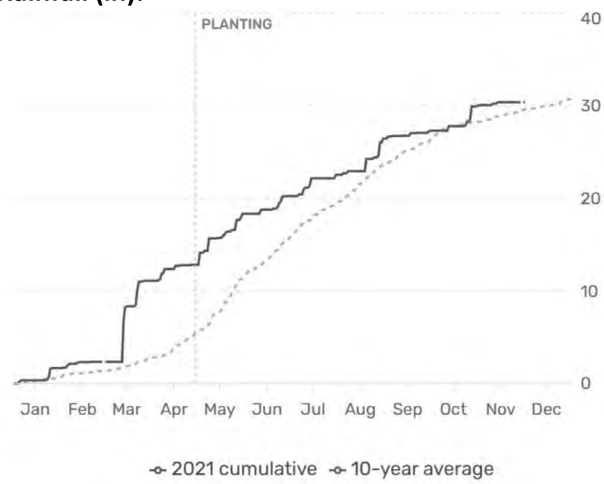
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $4.45/ac for Take Off® LS and Toggle®.

Summary: There were no differences in stand counts, grain moisture, yield, or profit between the Take Off® LS, Toggle®, and the check.

Impact of Cultivace FREE pHOS 24 Starter Fertilizer

Study ID: 0718185202101
County: York
Soil Type: Hastings silt loam 0-1% slope; Uly-Hobbs silt loam 11-30% slopes
Planting Date: 4/29/21
Harvest Date: 10/14/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1185Q
Reps: 6
Previous Crop: Corn
Tillage: Spring tillage, Row cultivation
Herbicides: ***Pre:*** 2 qt/ac Medal® ll ATZ and 5 oz/ac Cavallo™ at planting on 4/29/21
Seed Treatment: 4 oz/ac Ethos® XB and 4 oz/ac Batallion™ in furrow on 4/29/21
Foliar Insecticides: 8 oz/ac Lorsban™ on 7/16/21
Foliar Fungicides: 15.2 oz/ac Xyway™ LFR® applied in-furrow on 4/29/21

Fertilizer: 190 lb N/ac as anhydrous ammonia and 200 lb/ac MESZ®
Irrigation: Pivot, Total: 6"
Rainfall (in):



Soil Tests: (October 2020)

pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% Base Saturation H	K	Ca	Mg	Na
6.6	3.4	5.7	22	390	2023	306	41	13.8	0	7	73	18	1
6.8	3.2	6.2	14	355	2193	317	46	14.7	0	6	74	18	1

Introduction: The purpose of this study is to evaluate the impact of FREE pHOS 24 starter fertilizer compared to a standard 10-34-0 starter. FREE pHOS 24 has an analysis of 8-24-0-0.25 Zn. Both starter fertilizers were applied at a rate of 3 gal/ac in-furrow at planting. The FREE pHOS 24 starter fertilizer provided 7.7 lb P_2O_5/ac and the 10-34-0 starter provided 11.9 lb P_2O_5/ac.

Results:

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
10-34-0	31,000 A*	30,300 A	1 A	3 A	16.7 A	272 B	1,408 A
FREE pHOS 24	31,300 A	31,000 A	2 A	1 A	16.7 A	276 A	1,399 A
P-Value	0.745	0.184	0.749	0.338	0.476	0.012	0.193

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $7.74/ac for 10-34-0, and $37.50/ac for FREE pHOS 24.

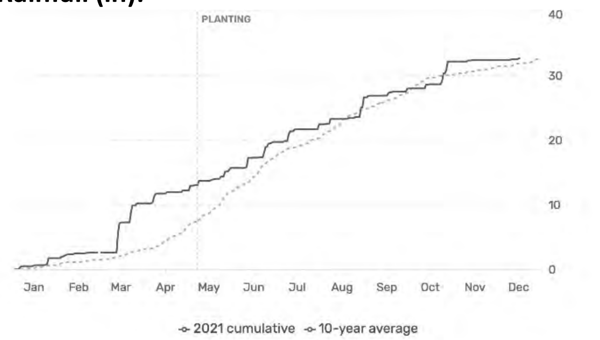
Summary:

- There were no differences in stand count and stalk quality between the two starter fertilizers evaluated.
- Yield was 4 bu/ac higher with the FREE pHOS 24 fertilizer compared to the 10-34-0 starter fertilizer; however, there were no differences in profit.

Impact of CultivAce FREE pHOS 24 Starter Fertilizer

Study ID: 0085141202101
County: Platte
Soil Type: Boel fine sandy loam 0-2% slope; Boel fine sandy loam occasionally flooded
Planting Date: 5/7/21
Harvest Date: 10/22/21
Seeding Rate: 35,000
Row Spacing (in): 30
Hybrid: DEKALB® 63-91
Reps: 5
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 2 qt/ac Degree Xtra®, 7 oz/ac Sterling Blue®, 3 oz/ac Balance® Flexx, and 1 pt/ac atrazine on 5/10/21
Seed Treatment: Acceleron® Elite
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 50 lb/ac potash, 75 lb/ac 11-52-0, and 30 lb/ac 12-40-0-10s-1Zn Mesz® on 12/11/20; 125 lb/ac urea and 50 lb/ac Potash on 4/8/21; 8 gal/ac UAN 32% (28 lb N/ac) and 2 gal/ac thiosulfate dribbled on top behind planter on 5/7/21; 41 gal/ac UAN 32% (146 lb N/ac) and 5 gal/ac Thiosulfate applied with 360 Y-DROP® on 6/10/21
Irrigation: Gravity
Rainfall (in):



Soil Tests (June 2021)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	ppm									%					ppm
5.7	6.8	8.1	0.34	1.5	56.5	275	11.7	7.62	45.2	6.7	1.1	895	108	19	24	9	55	11	1	77

Introduction: The purpose of this study is to evaluate the impact of FREE pHOS 24 starter fertilizer compared to no in-furrow starter fertilizer. FREE pHOS 24 was applied in-furrow at a rate of 3 gal/ac and has an analysis of 8-24-0-0.25 Zn. The FREE pHOS 24 starter provided 7.7 lb P_2O_5/ac. All fertilizer listed above, including UAN and thiosulfate at planting, was applied to both treatments.

Results:

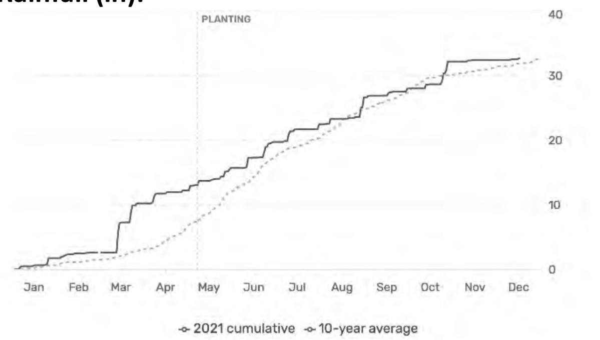
	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	16.1 A*	240 A	1,249 A
FREE pHOS 24	16.0 A	242 A	1,219 B
P-Value	0.721	0.394	0.021

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $37.50/ac for FREE pHOS 24 starter fertilizer.

Summary: The use of the FREE pHOS 24 starter fertilizer did not result in a statistically significant yield increase. Due to the additional cost of the product, the check had a significantly higher net return.

Impact of CultivAce FREE pHOS 24 Starter Fertilizer vs Kugler

Study ID: 0085141202102
County: Platte
Soil Type: Boel fine sandy loam 0-2% slope; Boel fine sandy loam occasionally flooded
Planting Date: 5/7/21
Harvest Date: 10/22/21
Seeding Rate: 35,000
Row Spacing (in): 30
Hybrid: DEKALB® 63-91
Reps: 5
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 2 qt/ac Degree Xtra®, 7 oz/ac Sterling Blue®, 3 oz/ac Balance® Flexx, and 1 pt/ac atrazine on 5/10/21
Seed Treatment: Acceleron® Elite
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 50 lb/ac potash, 75 lb/ac 11-52-0, and 30 lb/ac 12-40-0-10s-1Zn Mesz® on 12/11/20; 125 lb/ac urea and 50 lb/ac Potash on 4/8/21; 8 gal/ac UAN 32% (28 lb N/ac) and 2 gal/ac thiosulfate dribbled on top behind planter on 5/7/21; 41 gal/ac UAN 32% (146 lb N/ac) and 5 gal/ac thiosulfate applied with 360 Y-DROP® on 6/10/21
Irrigation: Gravity
Rainfall (in):



Soil Tests (June 2021)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	ppm									%					ppm
5.7	6.8	8.1	0.34	1.5	56.5	275	11.7	7.62	45.2	6.7	1.1	895	108	19	24	9	55	11	1	77

Introduction: The purpose of this study is to compare 3 gal/ac CultivAce FREE pHOS 24 starter fertilizer (8-24-0-0.25 Zn) applied in-furrow to the grower's traditional in-furrow starter fertilizer, which consists of 4.75 gal/ac Kugler LS 624 (6-24-6) gallons, 1 pt/ac zinc, and 1 pt/ac Kugler KS MicroMax. The FREE pHOS 24 starter fertilizer provided 7.7 lb P_2O_5/ac and the Kugler starter provided 12.8 lb P_2O_5/ac.

Results:

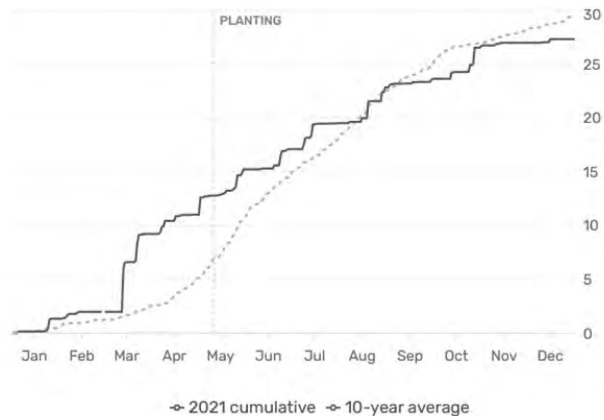
	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
FREE pHOS 24 Starter Fertilizer	16.3 A*	247 A	1,245 A
Kugler Starter Fertilizer	16.3 A	245 A	1,252 A
P-Value	0.480	0.262	0.359

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $37.50/ac for FREE pHOS 24 starter, and $23.50/ac for the Kugler starter fertilizer.

Summary: There was no difference in moisture, yield, or net return between the grower's traditional starter fertilizer (Kugler) and FREE pHOS 24.

Evaluating Nitrogen Rate and Timing on Corn

Study ID: 1111185202102
County: York
Soil Type: Butler silt loam 0-1% slope; Hastings silty clay loam 3-7% slopes; Hord silt loam 1-3% slope
Planting Date: 5/11/21
Harvest Date: 10/21/21
Seeding Rate: 29,300
Row Spacing (in): 36
Hybrid: Pioneer® P1309WHR
Reps: 3
Previous Crop: Soybean
Tillage: Stalk Chopped 5/12/21
Herbicides: ***Post:*** 1.5 qt/ac Resicore®, 32 oz/ac Roundup®, and 32 oz/ac atrazine on 5/17/21. 1 qt/ac Resicore®, 32 oz/ac Roundup®, 3 oz/ac drift control, and 16 oz/100 gal water of AGpHRx™ on 6/5/21.
Seed Treatment: Lumivia™ 250, Maxim® Quattro, Lumiflex™, Lumiante™, L-20012R
Foliar Insecticides: None
Foliar Fungicides: None
Note: Wind event pre-tassel resulting in 20% damage.
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Soil Tests (December 2020):

					Ammonium Acetate (ppm)				CEC	% Base Saturation				
pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
6.4	6.8	3.3	9.5	31	365	2070	299	46	15.7	11	6	66	16	1
6.9		3.6	8.5	74	510	3613	482	66	18.7	0	7	69	22	2
6.9		3.7	8.4	65	533	2489	476	54	18.0	0	8	69	22	1
6.4	6.8	3.7	10.0	48	458	1968	346	44	16.5	15	7	60	17	1

Introduction: This study evaluated various rates and timings of nitrogen application. The treatments were as follows:

Spring 140 lb/ac: 110 lb/ac N as anhydrous and 30 lb/ac N with herbicide
Spring 190 lb/ac: 160 lb/ac N as anhydrous and 30 lb/ac N with herbicide
Split 140 lb/ac: 50 lb/ac N as anhydrous, 30 lb/ac N with herbicide, and 60 lb/ac N side-dressed at V8
Split 190 lb/ac: 100 lb/ac N as anhydrous, 30 lb/ac N with herbicide, and 60 lb/ac N side-dressed at V8

Spring anhydrous application was on April 1, 2021. The N with herbicide was applied on May 17, 2021. The side-dress application at V8 was June 14, 2021. For reference, with a yield goal of 240 bu/ac, the University of Nebraska-Lincoln N recommendation for this field was 145 lb/ac N if spring or split-applied.

Soil samples were collected from the same area of the field throughout the season. Two soil cores were pulled from the anhydrous band in three rows for a total of six cores per sample. Soil sampling was collected from one replication only.

Results:

	Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	lbs N/ bu grain	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
140 lbs/ac spring	27,333 A*	2.50 A	12 A	0.60 B	15.5 A	235 A	1,178 A
190 lbs/ac spring	29,000 A	2.50 A	2 A	0.81 A	15.5 A	236 A	1,166 A
140 lbs/ac split	28,667 A	1.67 A	3 A	0.59 B	15.5 A	237 A	1,171 A
190 lbs/ac split	27,833 A	3.33 A	4 A	0.81 A	15.5 A	236 A	1,150 A
P-Value	0.464	0.974	0.441	<0.0001	1	0.955	0.305

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $0.30/lb N as anhydrous ammonia, $0.40/lb N as UAN, and $8/ac for the side-dress UAN application at V8.

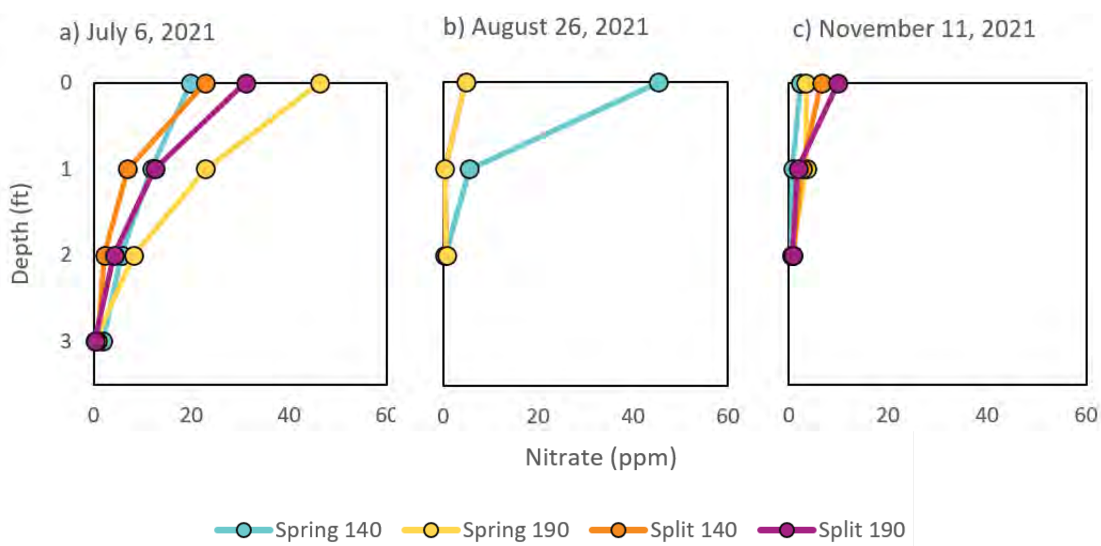


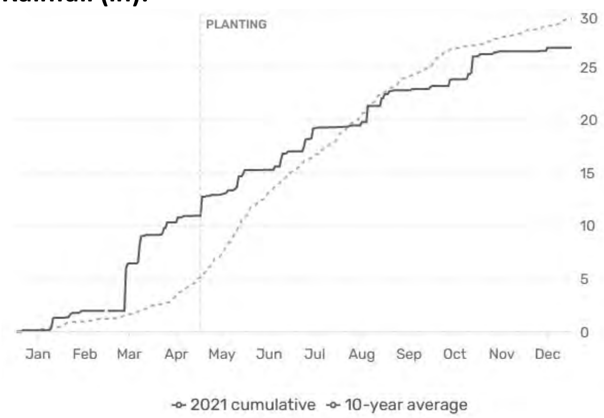
Figure 1. Nitrate (ppm) soil samples for July 6, August 26, and November 11 at depths of 0-12", 12-24", 24-36", and 36-72" for four nitrogen rate and timing treatments.

Summary:

- There were no differences in stalk quality, yield, moisture, or net return for the nitrogen rates and timings evaluated. The 140 lb/ac N rate yielded as well as the 190 lb/ac N rate.
- The treatments with 140 lb/ac N resulted in better nitrogen use efficiency, using approximately 0.6 lb of N to produce a bushel of grain. In contrast, the treatments with 190 lb/ac N used approximately 0.8 lb of N to produce a bushel of grain.
- Soil test results showed low nitrate in the lower profile over the course of the growing season.

Evaluating Spring-Applied Anhydrous Ammonia Nitrogen Rate on Corn

Study ID: 1111185202103
County: York
Soil Type: Hastings silty clay loam 3-7% slopes, eroded; Uly-Hobbs silt loam 11-30% slopes; Hastings silt loam 0-1% slope; Hord silt loam 1-3% slope
Planting Date: 5/1/21
Harvest Date: 10/21/21
Seeding Rate: 29,300
Row Spacing (in): 36
Hybrid: Pioneer® P1366
Reps: 3
Previous Crop: Soybean
Tillage: Stalk Chopped 4/19/21
Herbicides: ***Post:*** 1.5 qt/ac Resicore®, 32 oz/ac Roundup®, and 32 oz/ac atrazine on 5/17/21. 1/ac qt Resicore®, 32 oz/ac Roundup®, and 3 oz/ac drift control on 6/5/21.
Seed Treatment: Lumivia™ 250, Maxim® Quattro, Lumiflex™, Lumiante™, L-20012R
Foliar Insecticides: None
Foliar Fungicides: None
Note: Wind event at pre-tassel resulted in 20% damage.
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Soil Tests: (December 2020)

pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% Base Saturation H	K	Ca	Mg	Na
6.8		3.8	5.2	20	442	2452	386	42	16.8	0	7	73	19	1
6.6		3.8	5.4	3	430	2742	548	56	19.6	0	6	70	23	1
6.0	6.7	3.5	5.2	6	458	1741	246	32	14.9	19	8	58	14	1
6.0	6.6	3.8	15.8	47	603	1958	306	23	18.5	24	8	53	14	1
6.4	6.9	3.8	3.5	4	500	2639	452	60	19.8	7	6	67	19	1

Introduction: This study evaluated three different rates of nitrogen fertilizer, the grower's typical nitrogen rate and a rate 50 lb/ac higher and lower. Nitrogen was knifed in as anhydrous ammonia the second week of April 2021. Three rates were applied: 130 lb/ac N, 180 lb/ac N, and 230 lb/ac N. For reference, the University of Nebraska-Lincoln nitrogen algorithm would recommend 141 lb/ac of N for this field using an expected yield of 220 bu/ac. There was a wind event pre-tassel that resulted in approximately 20% damage.

Results:

	Moisture (%)	lbs N/bu grain	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
130 lb/ac	18.3 A*	0.68 C	192 B	957 B
180 lb/ac	19.0 A	0.87 B	208 A	1,026 A
230 lb/ac	19.0 A	1.09 A	211 A	1,028 A
P-Value	0.111	<0.0001	0.007	0.024

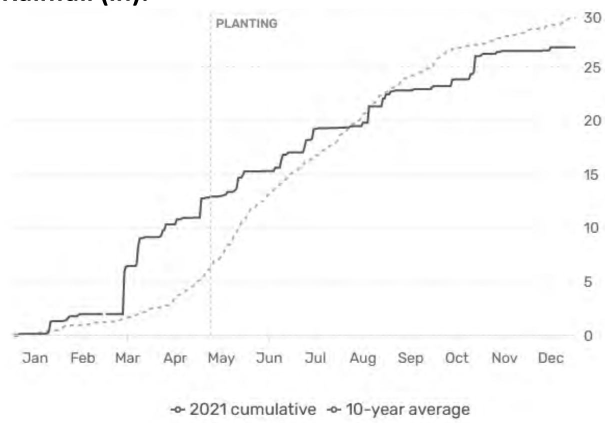
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $0.30/lb N as anhydrous, and $0.40/lb N as UAN.

Summary:
- There were no statisitcally significant differences in grain moisture.
- The 130 lb/ac rate resulted in lower yield and net return compared to the 180 and 230 lb/ac treatments.
- The 230 lb/ac rate did not result in a yield or profit increase above the 180 lb/ac treatment.
- The grower's 180 lb/ac rate resulted in a nitrogen use efficiency of 0.87 lb to produce a bushel of grain.

Evaluating Spring-Applied Anhydrous Ammonia Nitrogen Rate on Corn

Study ID: 1111081202101
County: Hamilton
Soil Type: Hord silt loam rarely flooded
Planting Date: 5/8/21
Harvest Date: 10/23/21
Seeding Rate: 29,300
Row Spacing (in): 36
Hybrid: Pioneer® P32B16
Reps: 3
Previous Crop: Soybean
Tillage: Stalk chopped 5/5/21, Ridge-till 6/10/21
Herbicides: ***Post:*** 1.5 qt Resicore®, 32 oz Roundup®, and 32 oz atrazine on 5/13/21
Seed Treatment: Lumivia™ 250, Maxim® Quattro, Lumiflex™, Lumiante™, L-20012R
Foliar Insecticides: None
Foliar Fungicides: None

Note: Wind event at pre-tassel resulted in 20 bu/ac yield reduction
Irrigation: Pivot, Total: 6.5”
Rainfall (in):



Soil Tests: (December 2020)

pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% Base Saturation H	K	Ca	Mg	Na
6.6	6.6	3.0	11.8	5	358	2096	272	29	13.8	0	7	76	16	1
6.1	6.1	3.6	9.5	9	340	2013	277	34	15.3	12	6	66	15	1
6.5	6.5	4.0	9.3	26	450	2112	249	26	15.6	11	7	68	13	1

Introduction: This study evaluated three different rates of nitrogen fertilizer, the grower’s typical nitrogen rate and a rate 50 lb/ac higher and lower. Nitrogen was knifed in as anhydrous ammonia the third week of April 2021. Three rates were applied: 70 lb/ac N, 120 lb/ac N, and 170 lb/ac N. All treatments also received 30 lb/ac N as UAN with the burndown herbicide on May 13, 2021. The total N rates for each treatment were 100 lb/ac, 150 lb/ac, and 200 lb/ac. For reference, the University of Nebraska-Lincoln nitrogen algorithm would recommend 155 lb/ac of N for this field using an expected yield of 240 bu/ac. There was a wind event pre-tassel that reduced yields by approximately 20 bu/ac.

Results:

	Harvest Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	lb N/ bu grain	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
100 lb-N/ac	26,833 A*	45.00 A	4 AB	0.46 C	17.0 A	217 B	1,095 A
150 lb-N/ac	27,333 A	40.17 A	8 A	0.67 B	17.5 A	224 AB	1,119 A
200 lb-N/ac	27,333 A	20.00 A	0 B	0.87 A	17.7 A	231 A	1,140 A
P-Value	0.940	0.219	0.035	<0.0001	0.145	0.036	0.132

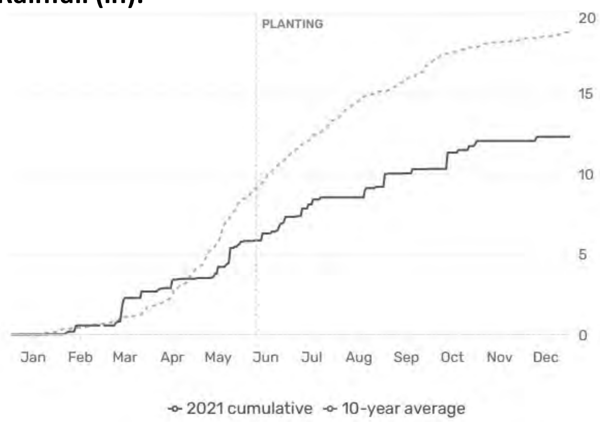
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $0.30/lb N as anhydrous, and $0.40/lb N as UAN.

Summary:

- There were no statisitcally significant differences in stand count, stalk rot, or grain moisture.
- The lowest N rate (100 lb/ac) resulted in the best nitrogen use efficiency, using only 0.46 lb N to produce a bushel of grain. However, the 100 lb/ac rate resulted in a loss of yield compared to the 200 lb/ac treatment.
- There were no statistically significant differences in marginal net return between the three N rates evaluated.

Impact of Verdesian N-Charge® Inoculant on Dry Edible Beans

Study ID: 0152013202101
County: Box Butte
Soil Type: Keith sandy loam 0-1% slope; Keith loam 3-6% slopes
Planting Date: 6/9/21
Harvest Date: 9/28/21
Seeding Rate: 89,000
Row Spacing (in): 15
Hybrid: Virgo Great Northern Variety
Reps: 6
Previous Crop: Corn
Tillage: Disk
Herbicides: ***Pre:*** 30 oz/ac Prowl®, 15 oz/ac Outlook®, and 32 oz/ac Roundup® ***Post:*** 4 oz/ac Raptor®, 30 oz/ac Basagran®, and 15 oz/ac Select®
Seed Treatment: Apron XL®, Maxim®, Rancona®, Vibrance®, Cruiser®
Foliar Insecticides: None
Foliar Fungicides: 9 oz/ac Aproach®, 1 lb/ac NU-COP® HB on 8/6/21
Fertilizer: None
Irrigation: Pivot, Total: 11"
Rainfall (in):



Soil Tests (January 2021):

			Ammonium Acetate (ppm)					% DPTA			
pH	OM LOI %	Nitrate – N ppm N	K	Ca	Mg	Na	CEC me/100g	Zn	Fe	Mn	Cu
8.3	1.5	11.9	436	2420	264	76	15.7	2.7	2.3	0.4	0.2

Introduction: This study evaluated Verdesian N-Charge® inoculant on dry edible bean production. The active ingredient is *Rhizobium leguminosarum* biovar *phaseoli*. The dry inoculant was thoroughly blended with seed in the planter box at a rate of 2.5 oz per 50 lb of seed before planting. The dry edible beans were direct harvested on September 28 at a temperature of 85°F and a relative humidity of 26%. This is the second year this producer has evaluated the Verdesian N-Charge® inoculant. Year one was located on a different field.

Results:

	Stand Count (plants/ac)	Harvest Loss (bu/ac)	% Small	Moisture (%)	Density (lb/bu)	Seeds per lb	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
No inoculant	91,723 A*	4.9 A	1.9 A	10.0 A	52.0 B	1,248 A	53 A	953 A
Verdesian N-Charge® Inoculant	85,673 B	5.6 A	1.6 A	9.4 B	57.8 A	1,256 A	54 A	965 A
P-Value	0.096	0.391	0.187	0.087	0.083	0.716	0.681	0.716

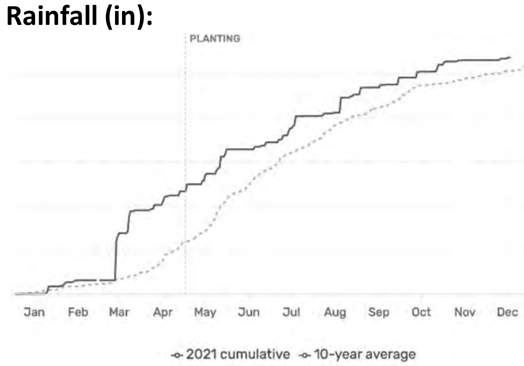
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 14% moisture and adjusted for clean yield (% splits, % smalls, and % foreign material removed).
‡Marginal net return based on $30/cwt ($18/bu at 60 lb/bu). The inoculant cost $1.79/ac.

Summary:

- Beans with the inoculant had a lower stand count of 85,673 plants/ac compared to 91,723 plants/ac for the non-treated beans. The same effect was observed in year one of the study.
- The use of the inoculant did not result in statistically significant differences in harvest loss, percent of pods greater than 2" above the ground, percent small beans, seeds per lb, yield, or marginal net return. Similarly, in year one of the study there were no differences in yield or net return.
- The non-inoculated beans had a greater moisture and lower density than the inoculated beans.

Impact of Pivot Bio PROVEN® 40 at Two Nitrogen Rates on Corn

Study ID: 1121019202102
County: Buffalo
Soil Type: Hord silt loam 0-1% slope; Wood River silt loam 0-1% slope
Planting Date: 4/25/21
Harvest Date: 10/7/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Hoegemeyer® 8518 AM™
Reps: 5
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 1.5 qt/ac Degree Xtra®, 3 oz/ac mesotrione, 32 oz/ac Roundup PowerMAX® with 1% crop oil concentrates (COC) and 8.5 lb AMS/100 gal water ***Post:*** 1.25 qt/ac Harness® MAX, 1 pt/ac atrazine, 22 oz/ac Roundup PowerMAX®, and 8.5 lb AMS/100 gal water
Foliar Insecticides: None
Foliar Fungicides: 10 oz/ac Headline AMP® chemigated at R1
Fertilizer: 40-40-0-0-1 Zn applied during strip-till; 3 gal/ac 10-34-0 applied in-furrow at planting; 42 gal/ac or 32 gal/ac of UAN 32% was side-dressed as per the treatments shown below
Irrigation: Pivot
Rainfall (in):



Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. Pivot Bio PROVEN® 40 is an N-fixing bacterial inoculant that is expected to fix ~40 lb N/ac over the growing season. Biological N fixation for cereal crops has potential to increase N efficiency and decrease N losses. The objective of this study was to evaluate Pivot Bio PROVEN® 40 on corn yield and net return. Pivot Bio PROVEN® 40 was applied at a rate of 12.8 oz/ac in-furrow with starter fertilizer and was compared to an untreated check. The product was evaluated at the grower's full N rate (269 lb N/ac) and a reduced N rate (N reduced at side-dress application for a total of 234 lb N/ac).

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
No Pivot Bio PROVEN® 40, Full N	31,267 A	18.6 A	249 A	1,240 B
No Pivot Bio PROVEN® 40, Reduced Side-dress N	31,133 A	18.7 A	252 A	1,264 A
Pivot Bio PROVEN® 40, Reduced Side-dress N	31,067 A	18.7 A	251 A	1,247 AB
P-Value	0.941	0.867	0.334	0.075

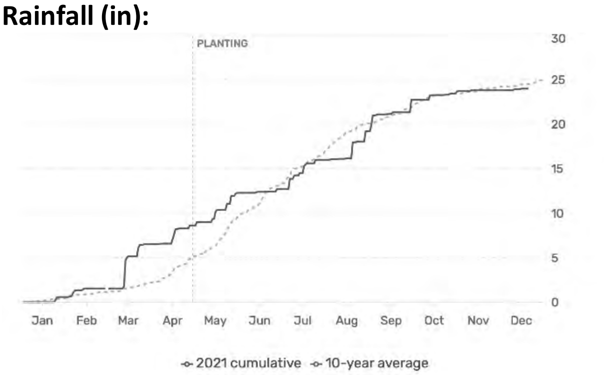
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $56/ac for the full side-dress rate, $45.50/ac for the reduced side-dress rate without Pivot Bio PROVEN® 40, and $59.50/ac for the reduced side-dress rate with Pivot Bio PROVEN® 40.

Summary:

- There were no differences in stand count, grain moisture, or yield between the three treatments evaluated. The reduced N rate yielded as well as the full N rate, showing potential to reduce N application on this field. The use of Pivot Bio PROVEN® 40 at a reduced N rate did not impact yield. If the reduced side-dress N rate was sufficient for crop N needs, there would likely be little benefit for Pivot Bio PROVEN® 40. Repeating the study with lower N rates would be beneficial in determining the potential impact of Pivot Bio PROVEN® 40.
- Net return for the reduced N rate with no Pivot Bio PROVEN® 40 was $24.30/ac more profitable than the full N rate.

Impact of Pivot Bio PROVEN® 40 and Ag Concepts® AgZyme®

Study ID: 1262047202101
County: Dawson
Soil Type: Rusco silt loam 0-1% slope; Wood River complex 0-1% slope
Planting Date: 4/29/21
Harvest Date: 10/19/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Channel® 211-66 VT2
Reps: 10
Previous Crop: Soybean
Tillage: Strip-till
Herbicides: ***Pre:*** 10 oz/ac Verdict®, 1 pt/ac atrazine, 8 oz/ac dicamba, 32 oz/ac Roundup®, and 1 pt/ac methylated seed oil (MSO) ***Post:*** 64 oz/ac Keystone® NXT, 3 oz/ac mesotrione, 5 oz/ac Status®, 32 oz/ac Roundup®, and 8.5 lb AMS/100 gal water
Foliar Fungicides: 14 oz/ac Quilt Xcel® with 0.5% crop oil concentrates (COC) applied at R1
Fertilizer: 40-40-0-0-1 Zn applied during strip-till; 3 gal/ac 10-34-0 in-furrow at planting; 42 gal/ac UAN 32% (149 lb N/ac) side-dress
Irrigation: Pivot
Rainfall (in):



Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. Three different products were evaluated in this study, plus an untreated check:

- Ag Concepts® AgZyme® was applied at 12.8 oz/ac with in-furrow starter fertilizer. The product information notes the product will activate the microbial potential of the soil to increase nutrient uptake.
- Pivot Bio PROVEN® is a N-fixing bacterial inoculant that is expected to fix ~20-30 lb N/ac over the growing season (https://krex.k-state.edu/dspace/handle/2097/41689). The product was applied at a rate of 12.8 oz/ac with in-furrow starter fertilizer.
- Pivot Bio PROVEN® 40 is an N-fixing bacterial inoculant that is expected to replace up to ~40 lb N/ac over the growing season. For this treatment, Pivot Bio PROVEN® 40 was applied at a rate of 12.8 oz/ac with in-furrow stater fertilizer and side-dress UAN was reduced by 35 lb N/ac.
- The check was in-furrow starter fertilizer.

This objective of this study was to evaluate Ag Concepts® AgZyme®, Pivot Bio PROVEN®, and Pivot Bio PROVEN® 40 on corn yield and net return.

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	33,733 A*	15.1 A	281 A	1,462 AB
AgZyme®	32,333 A	15.1 A	285 A	1,468 AB
Pivot Bio Proven®	32,933 A	15.1 A	277 A	1,424 B
Pivot Bio Proven® 40 with reduced sidedress	33,133 A	14.8 B	285 A	1,477 A
P-Value	0.189	0.006	0.130	0.056

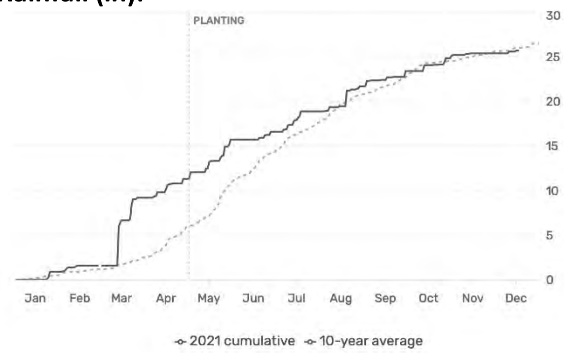
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $12/ac for AgZyme, $14/ac for Pivot Bio PROVEN®, and $2.30/ac for Pivot Bio PROVEN 40 treatment ($14/ac for Pivot Bio PROVEN® 40 but 32% UAN was reduced by 10 gal and cost $1.17/gal).

Summary:

- There were no differences in stand count or yield among the four treatments evaluated. Because Pivot Bio PROVEN® 40 was not evaluated at the full nitrogen rate and the no Pivot Bio PROVEN® 40 treatment was not evaluated at a reduced nitrogen rate, it is not possible to make a conclusion about the product impact.
- Net return was greater for the Pivot Bio PROVEN® 40 with reduced sidedress rate compared to the Pivot Bio PROVEN® with full sidedress rate.

Impact of Pivot Bio PROVEN® In-Furrow at One Nitrogen Rate on Corn

Study ID: 1121019202103
County: Buffalo
Soil Type: Holdrege-Hall silt loam 0-1% slope; Coly silt loam 6-11% slopes
Planting Date: 5/1/21
Harvest Date: 10/18/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Dekalb® DKC61-41 VT2
Reps: 7
Previous Crop: Soybean
Tillage: Strip-till
Herbicides: ***Pre:*** 1.5 qt/ac Degree Xtra®, 3 oz/ac Mesotrione, 32 oz/ac Roundup PowerMAX® with 1% COC and 8.5 lb AMS/100 gal water ***Post:*** 1.25 qt/ac Harness® MAX, 1 pt/ac Atrazine, 22 oz/ac Roundup PowerMAX®, 3 oz/ac Stinger®, and 8.5 lb AMS/100 gal water
Foliar Insecticides: None
Foliar Fungicides: 10 oz/ac Headline AMP® chemigated at R1
Fertilizer: 40-40-0-0-1 ZN applied during strip-till; 3 gal/ac 10-34-0 applied in-furrow at planting; 42 gal/ac UAN 32% (149 lb N/ac) side-dressed; total N application was 269 lb N/ac
Irrigation: Pivot
Rainfall (in):



Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environment concerns and reduce profit. Pivot Pio PROVEN® is a N-fixing bacterial inoculant that is expected to fix ~20-30 lb N/ac over the growing season (https://krex.k-state.edu/dspace/handle/2097/41689). Biological N fixation for cereal crops has potential to increase N efficiency and decrease N losses. This objective of this study was to evaluate Pivot Bio PROVEN® on corn yield and net return. Pivot Bio PROVEN® was applied at a rate of 12.8 oz/ac in-furrow with 3 gal/ac 10-34-0 starter fertilizer and was compared to a check of 3 gal/ac 10-34-0 starter and no Pivot Bio PROVEN®.

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	31,143 B	17.8 A	246 A	1,278 A
Pivot Bio PROVEN®	32,143 A*	17.7 A	248 A	1,275 A
P-Value	0.029	0.267	0.333	0.776

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $14/ac for Pivot Bio PROVEN®.

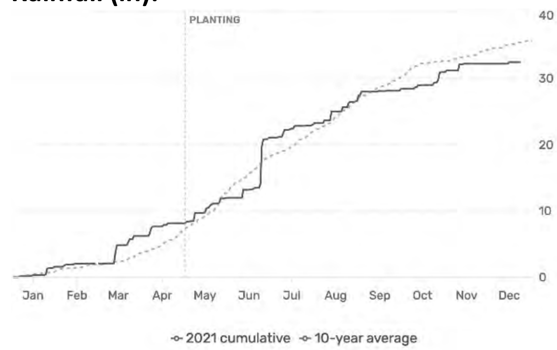
Summary:

- Stand counts were 1,000 plants/ac higher for the Pivot Bio PROVEN® treatment compared to the untreated check.
- There were no differences in yield, moisture, or net return.

Impact of Pivot Bio PROVEN® In-Furrow at One Nitrogen Rate on Corn

Study ID: 1251147202101
County: Richardson
Soil Type: Wabash silty clay occasionally flooded; Zook silty clay loam occasionally flooded
Planting Date: 5/1/2021
Harvest Date: 10/5-8/2021
Seeding Rate: 27,000
Row Spacing (in): 30
Hybrid: Hoegemeyer™ 8490
Reps: 6
Previous Crop: Soybean
Tillage: No-Till

Irrigation: None
Rainfall (in):



Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environment concerns and reduce profit. Pivot Pio PROVEN® is a N-fixing bacterial inoculant that is expected to fix ~20-30 lb N/ac over the growing season (https://krex.k-state.edu/dspace/handle/2097/41689). Biological N fixation for cereal crops has potential to increase N efficiency and decrease N losses. The objective of this study was to evaluate Pivot Bio PROVEN® on corn yield and net return. Pivot Bio PROVEN® was applied at a rate of 12.8 oz/ac in-furrow with starter fertilizer and was compared to an untreated check.

Results:

	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	188 A*	975 A
Pivot Bio Proven®	192 A	983 A
P-Value	0.331	0.721

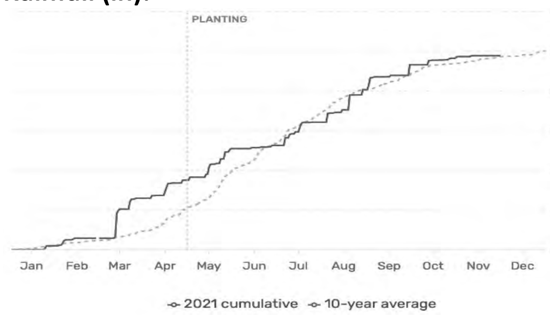
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $15/ac for Pivot Bio PROVEN®.

Summary:

- The use of Pivot Bio PROVEN® did not result in an increase in yield or net return.
- Soil texture varies in the field; therefore, future analysis of these data is planned to examine the possiblity of a spatially variable response to Pivot Bio PROVEN®.

Impact of Pivot Bio PROVEN® at Two Nitrogen Rates on Corn

Study ID: 0709047202101
County: Dawson
Soil Type: Cozad silt loam 0-1% slope
Planting Date: 4/30/21
Harvest Date: 11/10/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Channel® 214-22 STX
Reps: 4
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Burndown:*** 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer® 5 Extra, 3 pt/ac Fearless Xtra® on 5/6/21
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac bifenthrin 2EC and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Irrigation: Gravity, Total: 12"
Rainfall (in):



Soil Tests: (December 2020)

				Ammonium Acetate (ppm)				CEC	% DPTA			
pH	**OM LOI %**	**Nitrate – N ppm N**	**Mehlich P-III ppm P**	**K**	**Ca**	**Mg**	**Na**	**me/100g**	**Zn**	**Fe**	**Mn**	**Cu**
6.7	3.6	8	68	943	1580	304	105	13	1.1	32.1	11.5	1
7.7	2.1	5	17	303	3668	376	206	23	0.5	7.9	-	0.6

Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. Pivot Bio PROVEN® is a N-fixing bacterial inoculant that is expected to fix ~20-30 lb N/ac over the growing season (https://krex.k-state.edu/dspace/handle/2097/41689). Biological N fixation for cereal crops has potential to increase N efficiency and decrease N losses. The objective of this study was to evaluate Pivot Bio PROVEN® on corn yield and net return. Pivot Bio PROVEN® was applied at a rate of 12.8 oz/ac in-furrow with starter fertilizer and was compared to an untreated check. The product was evaluated at the grower's full N rate (225 lb N/ac) and a reduced N rate (190 lb N/ac). For reference, with a yield goal of 240 bu/ac, the UNL N recommendation for this field was 175 lb/ac N if primarily applied in the spring. Fertilizer applications were as follows:

a) 15 gal/ac 32-0-0 (53.25 lb N/ac), 5 gal/ac 10-34-0 (5.8 lb N/ac), 2 gal/ac Altura™, and 0.25 gal/ac ReaX™ Zinc applied during strip-till on 4/14/21
b) 1 gal/ac Altura™, 1 gal/ac ReaX™ K, 0.25 gal/ac ReaX™ Zinc, with in-furrow starter on 4/30/21
c) 10 gal/ac 32-0-0 (35.5 lb N/ac) on 5/6/21
d) 25 gal/ac 32-0-0 (reduced treatment, 88.75 lb N/ac) or 35 gal/ac 32-0-0 (full treatment, 124.25 lb N/ac), 5 gal/ac 12-0-0-26S (6.66 lb N/ac), and 1 gal/ac ReaX™ K on 6/17/21.

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
No Pivot Bio PROVEN®, Full N (225 lb/ac)	31,667 A*	16.6 A	232 A	1,166 A
Pivot Bio PROVEN®, Full N (225 lb/ac)	32,583 A	16.5 AB	239 A	1,186 A
No Pivot Bio PROVEN®, Reduced N (190 lb/ac)	33,083 A	16.3 C	235 A	1,193 A
Pivot Bio PROVEN®, Reduced N (190 lb/ac)	32,667 A	16.4 BC	236 A	1,181 A
P-Value	0.263	0.007	0.412	0.583

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $210/ton of 32% UAN, and $150/gal Pivot Bio PROVEN®.

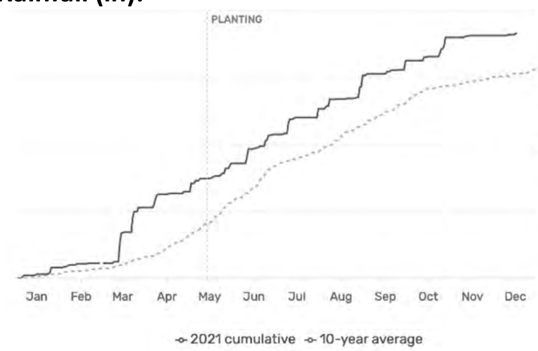
Summary:

- There were no significant differences in stand count, yield, or net return between the treatments.
- The reduced N rate with 190 lb N/ac yielded as well as the full N rate, showing potential to reduce N application on this field. Additional years of data are needed.

Evaluating PSNT Side-dress Rate and Pivot Bio PROVEN®

Study ID: 0996037202101
County: Colfax
Soil Type: Moody silty clay loam 2-6% slopes; Nora-Crofton complex 6-11% slopes
Planting Date: 5/13/21
Harvest Date: 11/20/21
Seeding Rate: 30,500
Row Spacing (in): 30
Hybrid: Pioneer® P1244AM
Reps: 4
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** 8 oz/ac 2,4-D LV6, 8 oz/ac dicamba, 40 oz/ac glyphosate, and 96 oz/ac Stalwart® 3W on 4/26/21 ***Post:*** 5 oz/ac Status® and 32 oz/ac Roundup PowerMAX® on 6/14/21
Seed Treatment: LumiGEN®
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: Variable-rate 11-52-0 (average of 77 lb/ac), 25 lb/ac sulfur 85%, and variable-rate 0-0-60 (average of 78 lb/ac) on 4/16/21; 5 gal/ac 7-22-5 applied in-furrow and 18.5 gal/ac UAN 32% with ammonium thiosulfate (7.5:1) in 2x2x2 placement on 5/13/21 at planting.
Irrigation: None
Rainfall (in):



Soil Samples: (December 2020)

Soil pH 1:1	Soluble Salts 1:1 mmho/cm	OM LOI-%	KCl Nitrate ppm N	M-3 P ppm	-Ammonium Acetate- K ppm	Ca ppm	Mg ppm	NA ppm	M-3 Sulfate ppm S	------------DTPA------------ Zn ppm	Fe ppm	Mn ppm	Cu ppm	Hot Water Boron ppm	Sum of Cations Me/100g	% Base ---Saturation--- H	K	Ca	Mg	Na
7.4	0.20	2.5	6.2	55	114	2807	524	12	6.9	0.93	17.1	7.6	0.56	0.48	18.7	0	2	75	23	0
6.8	0.16	3.4	5.4	83	180	2153	427	12	7.0	1.35	32	6.8	0.55	0.59	14.8	0	3	73	24	0
6.2	0.14	3.6	5.9	59	214	1746	339	11	9.3	1.59	43.7	10.5	0.51	0.49	16.6	27	3	52	17	0
6.1	0.15	3.7	7.0	48	224	1666	309	12	9.2	1.09	43.9	7.6	0.45	0.51	14.3	20	4	58	18	0
6.7	0.20	3.4	5.7	142	364	2019	493	27	12.7	1.81	30	7.9	0.78	0.54	15.3	0	6	66	27	1
5.8	0.14	3.6	6.3	36	190	1664	320	12	11.7	0.88	47.7	10.9	0.48	0.48	14.9	23	3	56	18	0

Introduction: The purpose of this study was to compare side-dress rate recommendations obtained using the pre-sidedress nitrate test (PSNT) and compare the impact of Pivot Bio PROVEN®. There was a cover crop preceeding the corn crop, which consisted of rye, Austrian winter peas, hairy vetch, and rapeseed drilled in October 2020. It was terminted with the pre-plant herbicide, and the rye was 4-6" tall at termination.

Prior to planting, approximately 8 lb N/ac was applied as 11-52-0. At planting, 65 lb N/ac was applied; 3 lb N/ac was applied in-furrow with the 7-22-5 starter and an additional 62 lb N/ac was applied with a 7.5:1 blend of 32% UAN along with ammonium thiosulfate applied in a 2x2x2 fertilizer placement, where fertilizer is applied to both sides of the row.

Sidedress nitrogen rates were determined using the Iowa State University Extension and Outreach recommendation for PSNT (https://store.extension.iastate.edu/product/5259). The soil nitrate samples were taken on June 13, 2021, at a depth of 0-10". Soil nitrate was 16 ppm. It should be noted that the Iowa State University PSNT method uses a soil sampling depth of 0-12". Using the Iowa State University PSNT method, the appropriate sidedress rate was 72 lb N/ac ([25 ppm - 16 ppm] * 8). This was rounded to 80 lb N/ac for the PSNT sidedress rate. This was compared to plus 30 lb N/ac and minus 30 lb N/ac sidedress rates. Sidedressing was done on June 29, 2021, with homemade Y-drops. The fertilizer was UAN treated with ANVOL® nitrogen stabilizer.

An additional treatment compared Pivot Bio PROVEN® on the minus 30 lb N/ac sidedress treatment. Pivot Pio PROVEN® is an N-fixing bacterial inoculant that is expected to fix ~20-30 lb N/ac over the growing season (https://krex.k-state.edu/dspace/handle/2097/41689). Biological N fixation for cereal crops has potential to increase N efficiency and decrease N losses. Pivot Bio PROVEN® was applied at a rate of 12.8 oz/ac in-furrow with the 7-22-5 starter fertilizer. The four treatments are as follows:

- PSNT: 80 lb N/ac; 153 lb N/ac total
- PSNT + 30: 110 lb N/ac; 183 lb N/ac total
- PSNT - 30: 50 lb N/ac; 123 lb N/ac total
- PSNT - 30 with Pivot Bio PROVEN®: 50 lb N/ac; 123 lb N/ac total.

For reference, with a yield goal of 250, the UNL N recommendation for this field was 137 if split applied.

Results:

Table 1. Harvest stand counts, grain moisture, yield, and net return for three nitrogen rates based on the pre-sidedress nitrate test (PSNT) and Pivot Bio PROVEN®.

	Harvest Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	N Efficiency (lb N/bu grain)	Marginal Net Return‡ ($/ac)
PSNT (153 lb total N/ac)	28,594 A*	15.3 A	230 B	0.66 B	1,135 B
PSNT+30 (183 total N/ac)	28,750 A	15.2 A	243 A	0.75 A	1,191 A
PSNT-30 (123 lb total N/ac)	29,375 A	15.0 B	213 C	0.58 C	1,055 C
PSNT-30 w/Pivot Bio PROVEN® (123 lb total N/ac)	29,031 A	15.3 A	214 C	0.58 C	1,045 C
P-Value	0.704	0.008	<0.0001	<0.0001	<0.0001

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $0.41/lb N, and $15/ac for Pivot Bio PROVEN®.

Table 2. In-season soil and tissue samples and end-of-season corn stalk nitrate test for one replication.

	V6 Tissue (% N) June 2021	VT Tissue (% N) July 2021	Corn Stalk N (ppm) Oct. 2021
PSNT (153 lb total N/ac)	4.35 (S) ‖ §	2.80 (S)	238 (L)
PSNT+30 (183 total N/ac)	-	2.89 (S)	172 (L)
PSNT-30 (123 lb total N/ac)	-	2.62 (L)	254 (L)
PSNT-30 w/Pivot Bio PROVEN® (123 lb total N/ac)	4.40 (S)	2.62 (L)	105 (L)
P-Value	-	-	-

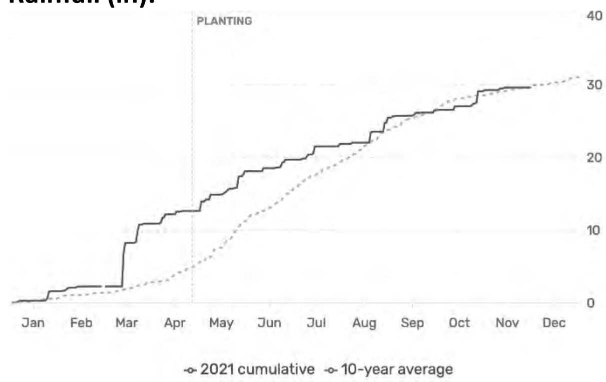
‖Only two tissue tests were taken for the June V6 tissue sample (one for without Pivot Bio PROVEN® treatments and one for the Pivot Bio PROVEN® treatment) as this was before sidedress applications occurred, so all treatments had the same N rate.
§Sufficiency level as indicated by Ward Laboratories. S indicates sufficient, L indicates Low, D indicates deficient.

Summary:

- There was no difference in harvest stand counts between the N rates and products evaluated.
- The highest N rate (PSNT + 30 for a total of 183 lb N/ac) resulted in the greatest yield and profit. The PSNT reduced yield and profit compared to the PSNT + 30 rate.
- The use of Pivot Bio PROVEN® at the PSNT - 30 rate did not increase yields compared to the PSNT - 30 without Pivot Bio PROVEN®.
- VT tissue samples showed lower N with the lowest N rate (123 lb N/ac). There was no difference in VT tissue samples between the lowest N rate with Pivot Bio PROVEN® and the lowest N rate without Pivot Bio PROVEN®.

Impact of CENTURO™ Inhibitor with Fall and Spring Anhydrous Ammonia Application

Study ID: 0118185202102
County: York
Soil Type: Hastings silt loam 0-1% slope
Planting Date: 4/26/21
Harvest Date: 10/15/21
Seeding Rate: 32,500
Row Spacing (in): 30
Hybrid: DEKALB® DKC 60-80RIB
Reps: 4
Previous Crop: Soybean
Tillage: No-Till
Herbicides: ***Pre:*** 3 qt/ac Lexar® on 4/30/21 ***Post:*** None
Foliar Insecticides: None
Foliar Fungicides: 15 oz/ac Xyway™ LFR® with starter
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Soil Test (December 2020):

				Ammonium Acetate (ppm)				CEC	% Base Saturation				
pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
7.2	3.3	10.7	20	338	2023	231	37	13.1	0	7	77	15	1
7.0	3.5	11.5	11	277	2276	298	41	14.8	0	5	77	17	1
7.0	3.2	10.9	10	241	1991	220	37	12.6	0	5	79	15	1
7.0	3.5	9.9	9	306	2399	320	42	15.6	0	5	77	17	1

Introduction: CENTURO™ by Koch™ Agronomic Services LLC contains a product with known efficacy for inhibiting nitrification. The chemical compound pronitridine in CENTURO™ temporarily inhibits populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_{4+}) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as in clays and organic matter); in comparison nitrate (NO_{3-}), which is negatively charged, can be converted to N_2O or N_2 gases in waterlogged conditions, or can leach below the root zone with rain in well drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The purpose of this study was to evaluate the impact of CENTURO™ applied with anhydrous ammonia on crop yield and soil ammonium and nitrate. Anhydrous ammonia was applied at 150 lb/ac N at two different times; the fall application date was November 7, 2020, and the spring application date was March 9, 2021. The study compared both application timings with no inhibitors versus with CENTURO™ applied at 10 gal/ton anhydrous ammonia. The field also received 5 gal/ac N from 10-34-0 at planting and 20 lb/ac N as 32% UAN through fertigation on June 5, 2021. The field was planted on April 26, 2021. Total N application on this field was 175 lb N/ac. For reference, with an expected yield of 280 bu/ac, the University of Nebraska-Lincoln N recommendation for this field was 240 lb N/ac if fall applied and 222 lb N/ac if spring applied.

Crop yield and soil ammonium and nitrate were measured. Soil samples were taken for ammonium-N and nitrate-N on five dates, starting on April 1, 2021 (Figure 1). Soil samples were collected at 1' depth starting in the band and at 7" and 15" on either side of the band for a total of five soil cores for each treatment, replication, and sampling date. On November 11, end of the season, deep soil nitrate samples (1', 2', and 3' depths) were collected for one replication. Stand count, stalk quality, yield, and net return were evaluated.

Results:

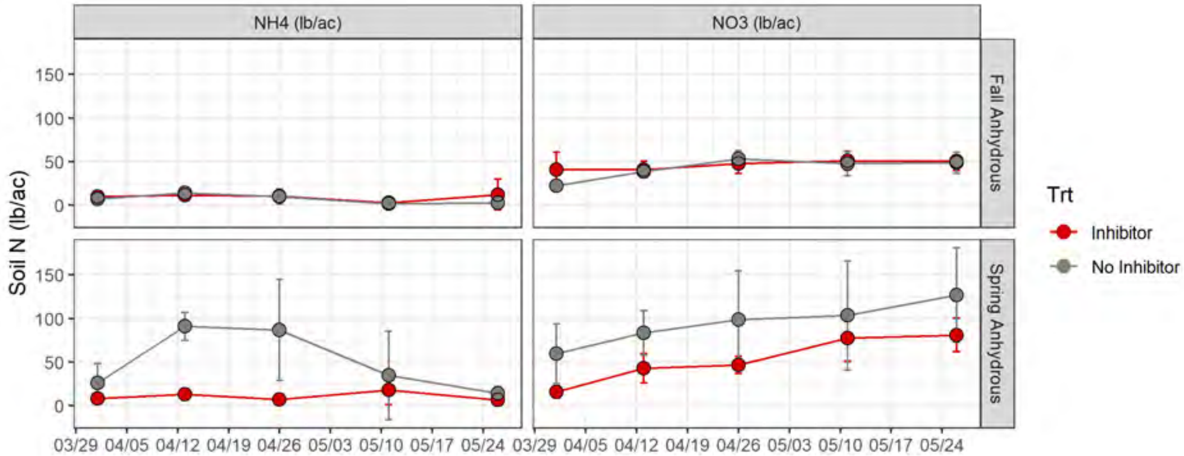


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across five dates, separated by landscape positions.

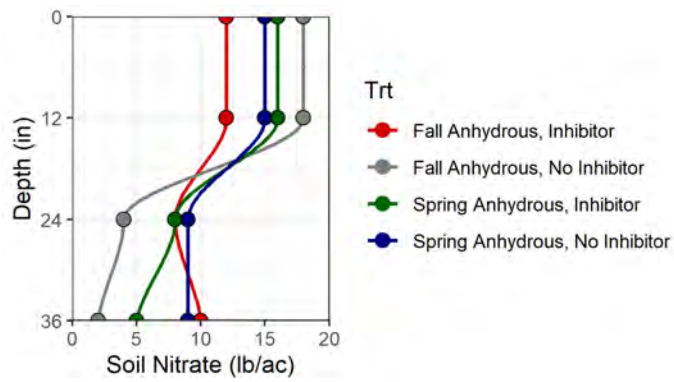


Figure 2. November 11 soil nitrate (lb/ac) at one, two, and three-foot depths at one replication.

	Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Fall, no inhibitor	29,667 A*	1.67 B	4 A	16.5 A	286 A	1,457 A
Fall, CENTURO™	30,667 A	0.83 B	0 A	16.6 A	290 A	1,468 A
Spring, no inhibitor	30,667 A	7.50 A	0 A	16.5 A	290 A	1,477 A
Spring, CENTURO™	29,333 A	1.67 B	0 A	16.6 A	295 A	1,492 A
P-Value	0.349	0.052	0.455	0.362	0.330	0.497

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $475/ton anhydrous ammonia, and $10/ac CENTURO™. This resulted in a treatment cost of $29.25/ac for the no inhibitor treatment and $39.25/ac for the CENTURO™ treatment.

Summary:

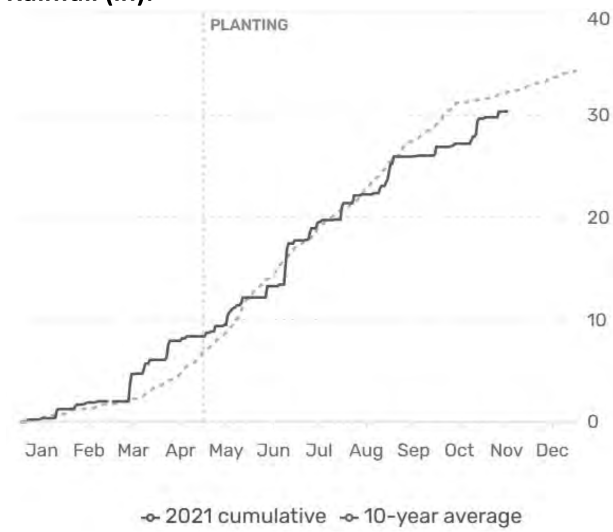
- The spring no inhibitor treatment had greater stalk rot than the other treatments.
- There were no differences in stand count, green snap, grain moisture, yield, or net return for the nitrogen timings and inhibitors evaluated.
- This is the second year of this study. In year one, there was also no difference in yield for the nitrogen timings and inhibitors evaluated.
- For the fall application timing, there were no soil ammonium or nitrate differences between the with and without inhibitor treatments. For the spring application time, the no inhibitor treatment tended to have greater ammonium and nitrate than the CENTURO™ treatment.

This research was supported in part by an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of CENTURO™ and FunctioN™ Inhibitors with Fall Anhydrous Ammonia

Study ID: 1247127202101
County: Nemaha
Soil Type: Yutan silty clay loam 2-6% slopes, eroded; Kennebec silt loam rarely flooded
Planting Date: 4/29-30/21
Harvest Date: 10/15/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: DEKALB® DKC70-27RIB
Reps: 7
Previous Crop: Soybean
Tillage: Strip-till
Fertilizer: 190 lb/ac N as anhydrous ammonia strip-till dual-placed with dry homogenized fertilizer contributing 12 lb/ac N, 40 lb/ac P, 30 lb/ac K, 10 lb/ac S, and 1 lb/ac Zn on 12/22/20

Note: Wind damage resulted in green snap and breakage, approximately 5-10%
Irrigation: None
Rainfall (in):



Soil Tests (March 2021):

				Nitrate – N	Mehlich P-III	Ammonium Acetate (ppm)				M-3 Sulfate	CEC	% Base Saturation				
Landscape	pH	BpH	OM LOI %	lb/ac	ppm P	K	Ca	Mg	Na	(ppm)	me/100g	H	K	Ca	Mg	Na
Hill	5.7	6.4	3.6	7	19	201	2282	372	16	7.7	20.9	28	2	55	15	0
Hill	5.8	6.4	3.9	12	32	199	2187	329	13	7.6	19.9	29	3	54	14	0
Bottom	5.6	6.3	3.6	5	27	196	1894	239	15	10.4	19.0	37	3	50	10	0
Bottom	5.7	6.4	3.5	21	25	218	1945	232	14	6.9	18.5	34	3	53	10	0

Introduction: CENTURO™ by Koch Agronomic Services LLC and FunctioN™ by Rosen's Inc. are products with known efficacy for inhibiting nitrification. The chemical compound in CENTURO™ is pronitridine, whereas the chemical compound in FunctioN™ is dicyandiamide (DCD). Both products inhibit populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_{4+}) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as in clays and organic matter); in comparison nitrate (NO_{3-}), which is negatively charged, can be converted to N_2O or N_2 gases in waterlogged conditions, or can leach below the root zone with rain in well-drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The goal of this study was to evaluate these two nitrification inhibitor products in two contrasting areas of the field, a hilltop with silty clay loam soils, and a bottom with silt loam soils. Anhydrous ammonia was applied at 190 lb N/ac on Dec. 22, 2020, with strip-till following a previous crop of soybeans. Both products were applied at the recommended rate: CENTURO™ was applied at 5 gal/ton anhydrous ammonia and FunctioN™ was applied at 1 qt/ac. Crop yield and soil ammonium and nitrate were measured. Soil samples were taken for ammonium-N and nitrate-N on five dates, starting on March 25, 2021. Soil samples were collected at 1' depth starting in the band and then at 7" and 15" on either side of the band for a total of 5 soil cores for each treatment, replication, and sampling date. Yield data were analyzed for each landscape position separately (Table 1).

A total of 202 lb N/ac was applied on the field. For reference, with a yield goal of 240 bu/ac, the University of Nebraska-Lincoln N recommendation for this field was 204 lb N/ac if applied in the fall.

Results:

Table 1. Early season stand counts, moisture, yield, and marginal net return for check, CENTURO™ and FunctioN™ by landscape position.

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
		Hill (3 replications)		
Check	32,512 A*	16.3 A	232 B	1205.70 A
CENTURO™	33,672 A	16.4 A	238 A	1228.80 A
FunctioN™	33,672 A	16.2 A	234 AB	1208.90 A
P-Value	0.637	0.363	0.044	0.110
		Bottom (4 replications)		
Check	32,221 A	16.6 A	245 A	1272.90 A
CENTURO™	32,511 A	16.7 A	244 A	1260.50 A
FunctioN™	33,092 A	16.6 A	242 A	1250.90 A
P-Value	0.794	0.221	0.585	0.324

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $8.65/ac for FunctioN, and $10.50/ac for CENTURO™.

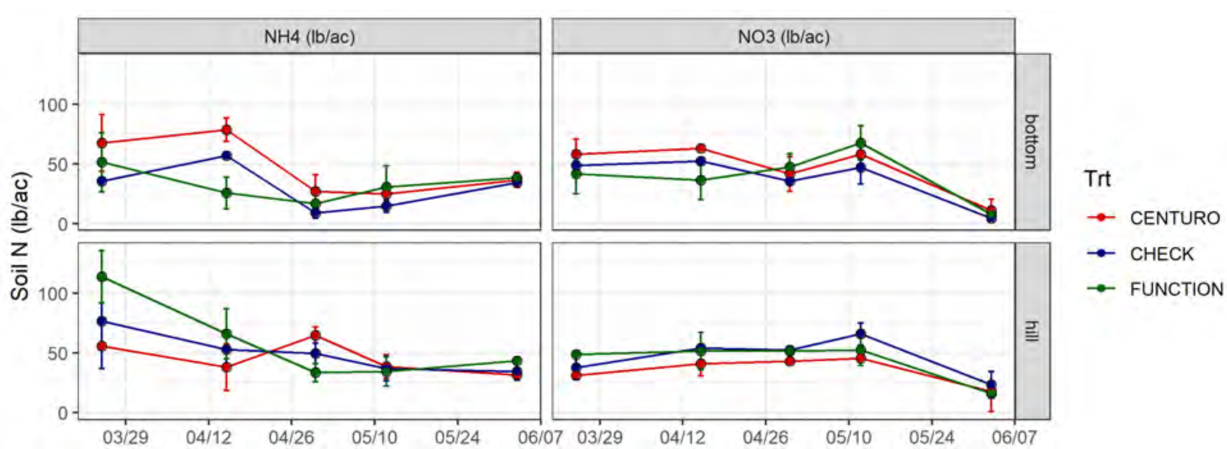


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across five dates, separated by landscape position.

Summary:

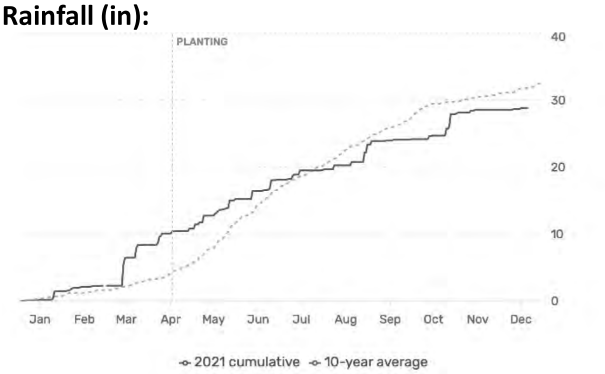
- There were no statistically significant differences in stand count or grain moisture.
- On the hill with silty clay loam soil, the CENTURO™ treatment had a 6 bu/ac significant yield increase compared to the check. FunctioN™ did not have a statistically significant yield increase compared to the check.
- There was no difference in yield or marginal net return between the inhibitors and the untreated check on the bottom landscape position with silt loam soils.

This research was supported in part by an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of MicroSource® DCD 25™ Inhibitor with Anhydrous Ammonia

Study ID: 1263159202101
County: Seward
Soil Type: Hastings silt loam 0-1% slope; Butler silt loam 0-1% slope
Planting Date: 4/16/21
Harvest Date: 10/22/21
Row Spacing (in): 30
Hybrid: DEKALB® DKC 64-34
Reps: 4
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** 1.5 qt/ac Acuron®, 12 oz/ac 2,4-D LV6, 32 oz/ac Roundup PowerMAX®, and 0.25 gal crop oil/100 gal water on 4/10/21 ***Post:*** 1.5 qt/ac Acuron®, 32 oz/ac Roundup PowerMAX®, and 0.5 gal crop oil/100 gal water
Seed Treatment: Poncho® 500

Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 175 lb/ac N as anhydrous ammonia on 3/13/21; 125 lb/ac 12-40-0-10-1 on 3/24/21
Irrigation: Pivot, Total: 8"
Rainfall (in):



Soil Samples: (April 2021)

Soil pH 1:1	Soluble Salts 1:1 mmho/cm	OM LOI-%	KCl Nitrate ppm N	Nitrate Lbs N/ac	M-3 P ppm	-Ammonium Acetate- K ppm	Ca ppm	Mg ppm	Na ppm	M-3 Sulfate ppm S	------------DTPA------------ Zn ppm	Fe ppm	Mn ppm	Cu ppm	Sum of Cations Me/100g	% Base ---Saturation--- H	K	Ca	Mg	Na
7.0	0.26	2.8	13.1	31	16	243	2654	312	37	8.2	1.63	25.3	7.5	0.83	16.6	0	4	79	16	1
7.2	0.15	3.1	7.5	18	33	347	3180	417	49	10.6	1.37	26.5	6.4	0.88	20.5	0	4	78	17	1
6.5	0.16	3.3	9.2	22	29	305	2571	324	39	9.7	1.44	38.3	8.3	0.70	18.2	9	4	71	15	1
7.3	0.14	3.4	17.1	41	24	322	2050	269	29	11.4	1.08	43.9	10.3	0.74	13.4	0	6	76	17	1

Introduction: MicroSource® DCD 25™ contains dicyandiamide (DCD), a product with known efficacy for inhibiting nitrification. The chemical compound DCD temporarily inhibits populations of the bacteria that convert ammonium to nitrite *(Nitrosomonas)* and nitrite to nitrate *(Nitrobacter)*. These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_4+) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as clays and organic matter); in comparison nitrate (NO_3-), which is negatively charged, can be converted to N_2O or N_2 gases in anerobic conditions, or can leach below the root zone with rain in well drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The purposes of this study were to evaluate the impact of MicroSource® DCD 25™ applied at a rate of 6 qt/ton with anhydrous ammonia on crop yield and soil ammonium and nitrate. Anhydrous was applied on March 13, 2021, at a rate of 175 lb/ac N. Soil samples were taken for ammonium-N and nitrate-N, starting on March 31, 2021 (Figure 1). Soil samples were collected at 1' depth, starting in the band and at 7" and 15" on either side of the band for a total of five soil cores for each treatment, replication, and sampling date.

Total N application on this field was 190 lb N/ac. For reference, with an expected yield of 258 bu/ac, the University of Nebraska-Lincoln N recommendation for pre-plant N on this field was 203 lb N/ac.

Results:

	Stand Count (plants/ac)	Stalk Rot (%)	Greensnap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	30,625 B*	5.63 A	1 A	15.5 A	257 A	1,336 A
DCD	31,750 A	2.50 A	1 A	15.6 A	259 A	1,339 A
P-Value	0.037	0.312	1	0.323	0.178	0.696

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $8/ac for MicroSource® DCD 25™.

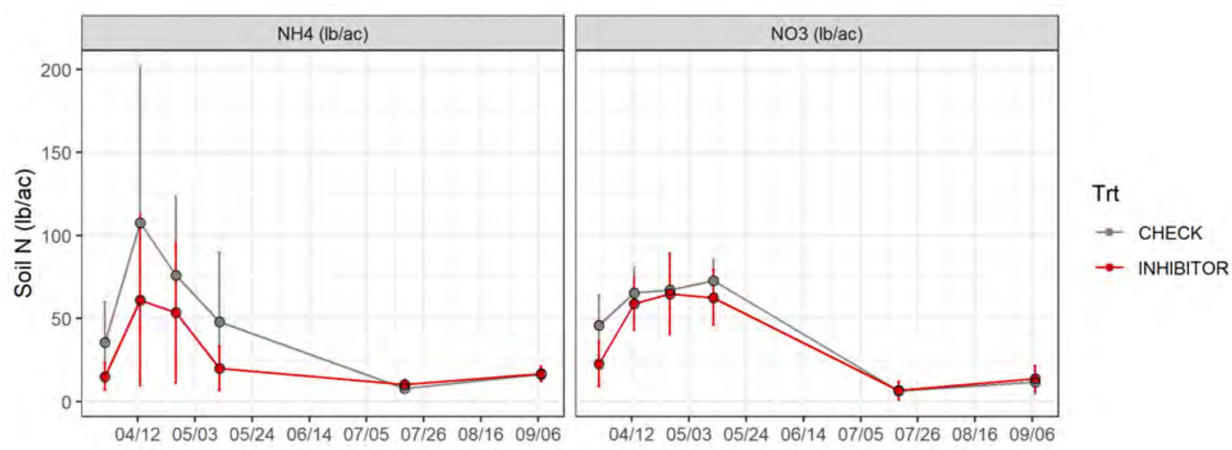


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across six dates.

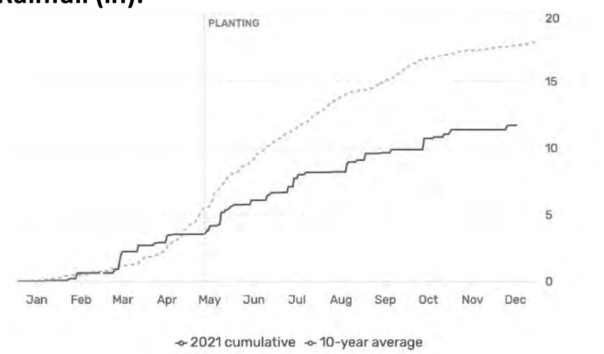
Summary:

- Stand counts were approximately 1,000 plants/ac higher for the MicroSource® DCD 25 treatment compared to the check.
- There were no differences in stalk quality, yield, or net return between the MicroSource® DCD 25 treatment and the untreated check.

This research was supported in part by MicroSource®, LLC and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of CENTURO™ and MicroSource® DCD Inhibitors with UAN Application

Study ID: 0015013202101
County: Box Butte
Soil Type: Alliance loam 1-3% slope; Alliance-Rosebud loam 3-6% slopes
Planting Date: 5/11/21
Harvest Date: 11/12/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Stine® 9437-10
Reps: 4
Previous Crop: Dry Edible Beans
Tillage: Strip-till
Herbicides: ***Pre:*** Roundup® and Banvel® ***Post:*** Status®
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 45 gal/ac UAN 32% (160 lb/ac N) on 4/28/21; 40 lb/ac N through pivot on 8/6/21
Irrigation: Pivot, Total: 11-12"
Rainfall (in):



Soil Tests: (December 2020)

Soil pH 1:1	Soluble Salts 1:1 mmho/cm	OM LOI-%	KCl Nitrate ppm N	Nitrate lb N/ac	P ppm	-Ammonium Acetate- K ppm	Ca ppm	Mg ppm	NA ppm	---DTPA--- Zn ppm	Fe ppm	Mn ppm	Cu ppm	Sum of Cations me/100g	% Base ---Saturation--- H	K	Ca	Mg	Na
7.9	0.4	1.7	16	38	17	368	3510	337	61	1.8	6	3	0.3	21.6	0	4.4	81.4	13	1.2

Introduction: CENTURO™ by Koch™ Agronomic Services LLC and MicroSource® DCD are products with known efficacy for inhibiting nitrification. The chemical compound in CENTURO™ is pronitridine, whereas the chemical compound in MicroSource® DCD is dicyandiamide (DCD). Both products inhibit populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_{4+}) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as in clays and organic matter); in comparison nitrate (NO_{3-}), which is negatively charged, can be converted to N_2O or N_2 gases in waterlogged conditions, or can leach below the root zone with rain in well drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The goal of this study was to evaluate these two nitrification inhibitor products. Nitrogen was applied as 32% UAN (160 lb N/ac) in a strip-till application, at an 8-10" depth on April 28. Centuro was applied at a rate of 2.5 gal/ton of 32% UAN and MicroSource® DCD was applied at a rate of 2 qt/ton of 32% UAN. Corn was planted on May 11 directly on the strip-till, N band. Crop yield was measured by harvesting the center 8 rows of the 12-row plots. Soil samples were taken for ammonium-N and nitrate-N on four dates, starting on May 14, 2021. Soil samples were collected at 1' depth starting in the band and at 7" and 15" on either side of the band for a total of five soil cores for each treatment, replication, and sampling date.

Total N application on this field was 200 lb N/ac. For reference, with an expected yield of 192, the University of Nebraska-Lincoln N recommendation for split N application on this field was 190 lb N/ac.

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	33,588 A*	14.8 A	189 A	984 A
DCD	33,643 A	14.8 A	195 A	1,008 A
Centuro™	34,241 A	14.8 A	193 A	987 A
P-Value	0.139	0.940	0.73	0.791

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $5.25/ac for DCD, and $18.75/ac for CENTURO™.

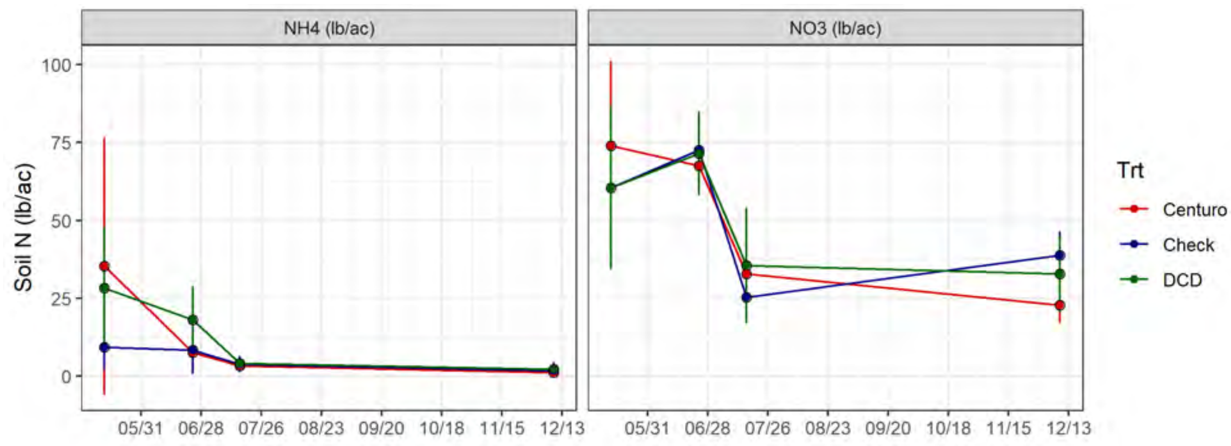


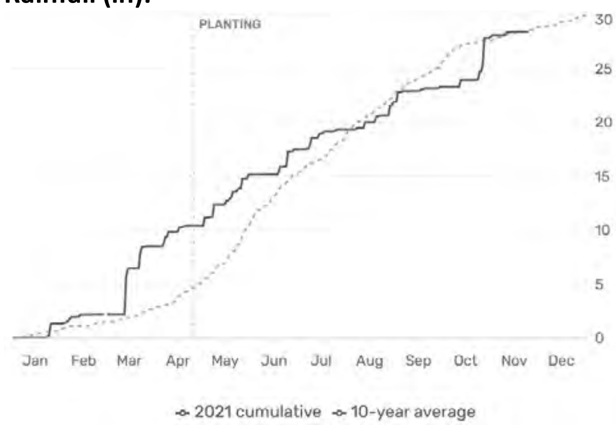
Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across four dates.

Summary: There were no differences in stand counts, moisture, yield, and net return between the inhibitors and the untreated check.

This research was supported in part by an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of MicroSource® DCD Inhibitor with UAN Application

Study ID: 0620059202102
County: Fillmore
Soil Type: Butler silt loam 0-1% slope; Crete silt loam 0-1% slope; Fillmore silt loam drained, 0-1% slopes; Crete silt loam 1-3% slope
Planting Date: 4/25/21
Harvest Date: 10/6/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: DEKALB® DKC66-74
Reps: 14
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 3 qt/ac Lexar® on 4/13/21 ***Post:*** 1 qt/ac Acuron® and 1 qt/ac Durango® on 6/3/21
Foliar Insecticides: None
Foliar Fungicides: None
Irrigation: Pivot, Total: 7"
Rainfall (in):



Soil Tests: (April 2021)

					Ammonium Acetate (ppm)				CEC	% Base Saturation				
pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
6.0	6.6	3.6	3.4	6	224	2405	415	41	20.0	19	3	60	17	1
6.8		3.9	3.1	5	270	2764	473	45	18.6	0	4	74	21	1
6.4	6.7	3.7	2.7	4	317	3174	566	40	24.4	11	3	65	19	1
6.8		3.9	3.8	7	313	3161	564	39	21.5	0	4	73	22	1
6.2	6.7	3.4	3.6	8	325	3440	635	32	26.1	10	3	66	20	1
6.7		3.0	3.5	6	316	3122	526	36	21.0	0	4	74	21	1

Introduction: MicroSource® DCD contains dicyandiamide (DCD), a product with known efficacy for inhibiting nitrification. The chemical compound DCD temporarily inhibits populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_{4+}) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as in clays and organic matter); in comparison nitrate (NO_{3-}), which is negatively charged, can be converted to N_2O or N gases in waterlogged conditions, or can leach below the root zone with rain in well drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The goal of this study was to evaluate the impact of MicroSource® DCD applied with UAN on crop yield and soil ammonium and nitrate. UAN (32%) was knifed in 5-6" from planted row on April 4 and 5 at a rate of 37 gal/ac (131 lb N/ac) with and without MicroSource® DCD. MicroSource® DCD was applied at the recommended rate of 1 gal/ton (26 oz/ac). Other fertilizer applications were 4.5 gal/ac of 6-24-6 starter applied on April 25 (3 lb N/ac, 12 lb P/ac, and 3 lb K/ac) and 20 gal/ac of UAN (32%) applied as side-dress dribbled next to corn at time of hilling on June 13 (71 lb N/ac). Total N application on the field was 205 lb N/ac. For reference, with an expected yield of 228 bu/ac, the UNL N recommendation for split N application on this field was 207 lb N/ac.

Crop yield and soil ammonium and nitrate were measured. Soil samples were taken for ammonium-N and nitrate-N on six dates, starting on April 22, 2021 (Figure 1). Soil samples were collected at 1' depth starting in the band and at 7” and 15” on either side of the band for a total of five soil cores for each treatment, replication, and sampling date. A crop insurance representative found an average of 7.5% green snap for the field from a July 9, 2021, windstorm.

Results:

	Stand Count (plants/ac)	Stalk Rot (%)	Greensnap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	32,083 A	4.33 A	3 A	17.1 A	227 A	1,182 A
MicroSource® DCD	32,500 A*	1.83 A	1 A	16.9 A	229 A	1,180 A
P-Value	0.584	0.171	0.336	0.117	0.160	0.810

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $10.50/ac for MicroSource® DCD.

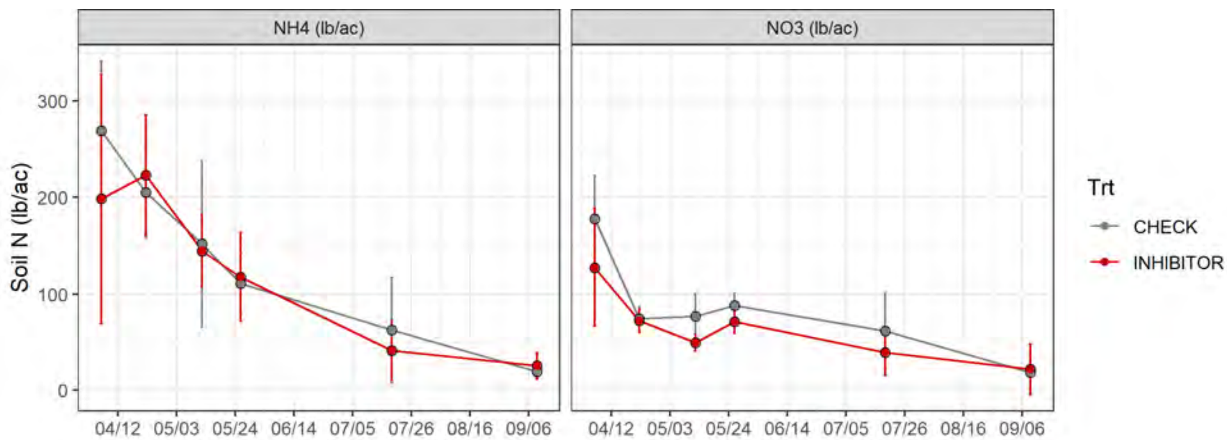


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across six dates.

Summary:

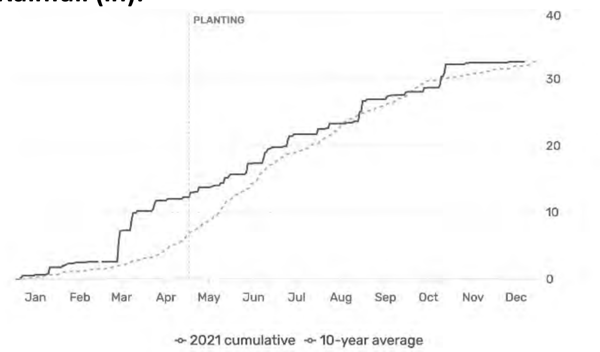
- There were no differences in green snap, stalk rot, stand count, grain moisture, yield, or net return between the MicroSource® DCD and the check.
- There were no differences between nitrate and ammonium between the check and MicroSource® DCD treatment in the May through September soil samples.

This research was supported in part by MicroSource®, LLC and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of CVA® Elite Protect UAN with Side-dress Application

Study ID: 0085141202103
County: Platte
Soil Type: Gibbon silt loam 0-2% slope; Wann loam occasionally flooded
Planting Date: 5/1/21
Harvest Date: 10/7/21
Seeding Rate: 33,200
Row Spacing (in): 30
Hybrid: DEKALB® DKC59-82
Reps: 6
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 2 qt/ac Degree Xtra®, 7 oz/ac Sterling Blue®, and 3 oz/ac Balance® Flexx on 5/10/21
Seed Treatment: Acceleron® Elite
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 50 lb/ac potash, 45 lb/ac 11-52-0, and 45 lb/ac 12-40-0-10S-1Zn (Micro-Essentials® SZ®) on 12/11/20; 8 gal/ac 32% UAN (28 lb N/ac) and 2 gal/ac thiosulfate dribbled behind planter on 5/1/21; 4.75 gal/ac Kugler LS 624, 1 pt/ac zinc, and 1 pt/ac Kugler KS MicroMax applied in-furrow on 5/7/21; 41 gal/ac 32% UAN (146 lb N/ac), and 5 gal/ac thiosulfate applied with 360 Y-Drop® on 6/4/21
Irrigation: Gravity
Rainfall (in):



Introduction: CVA® Elite Protect UAN contains N-(n-butyl) thiophosphoric triamide (NBPT) urease inhibitor, dicyandiamide (DCD) nitrification inhibitor, and vapor-liquid-solid (VLS) polymer to slow bacterial enzymes. The chemical compound NBPT blocks the activity of the urease enzyme that breaks down urea into ammonium. The chemical compound DCD temporarily inhibits populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against volatilization, denitrification, and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_4+) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as clays and organic matter); in comparison nitrate (NO_3-), which is negatively charged, can be converted to N_2O or N_2 gases in anerobic conditions, or can leach below the root zone with rain in well drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The purposes of this study were to evaluate the impact of CVA® Elite Protect UAN applied at a rate of 1.5-2.5 qt/ton of UAN on crop yield and soil ammonium and nitrate. UAN was applied with Y-drops on June 4, 2021, at a rate of 146 lb/ac N, with and without the inhibitor product. Soil samples were taken for ammonium-N and nitrate-N, starting on June 9, 2021 (Figure 1). Soil samples were collected at 1' depth, starting in the band and at 7” and 15” on either side of the band for a total of five soil cores for each treatment, replication, and sampling date.

Results:

	Early Season Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	33,958 A*	16.6 B	252 A	1,311 A
Inhibitor	34,000 A	16.9 A	255 A	1,318 A
P-Value	0.895	0.049	0.157	0.508

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $9/ac for the CVA® inhibitor.

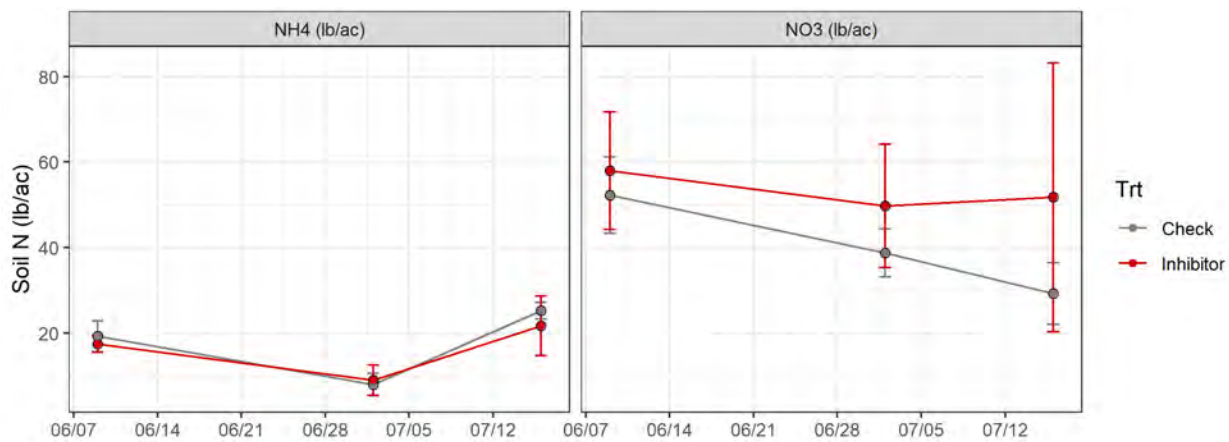


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across three sample dates.

Summary:

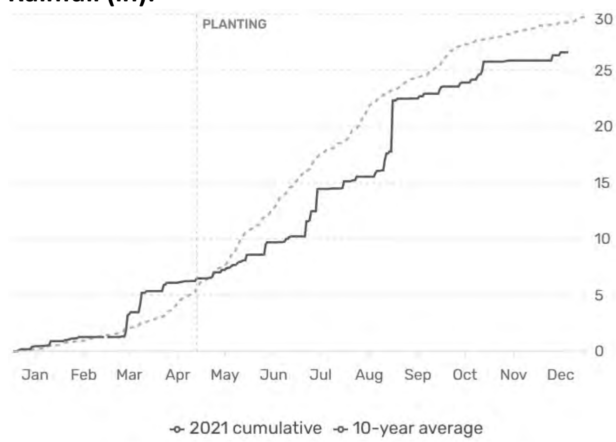
- There were no differences in stand counts, yield, or marginal net return between the untreated check and the CVA® Elite Protect UAN inhibitor.
- Soil samples showed a trend of greater nitrate (NO_3) for the inhibitor treatment, but this difference was not statistically significant.

This research was supported in part by an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Impact of CENTURO™ Inhibitor with In-season UAN Application

Study ID: 1256107202101
County: Knox
Soil Type: Nora silt loam 2-6% slopes; Crofton-Nora complex 6-11% slopes, eroded; Thurman fine sandy loam; Moody silty clay loam
Planting Date: 4/27/21
Harvest Date: 10/26/21
Seeding Rate: 27,500
Row Spacing (in): 30
Hybrid: Channel® 213-19VT2 RIB
Reps: 6
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** Sharpen® and Abundit® Edge on 4/26/21 to terminate cover crop ***Post:*** Abundit® Edge, atrazine 4L, and Realm® Q on 6/2/21
Seed Treatment: None
Foliar Insecticides: None
Foliar Fungicides: Aproach® Prima aerially applied by helicopter on 7/26/21

Fertilizer: Variable-rate 18-46-0 pre-plant (average of 122 lb/ac, contributing an average of 22 lb N/ac); variable-rate 0-0-45-9 pre-plant (average of 84 lb/ac); 4 gal/ac 3-18-18 applied in-furrow (1.4 lb N/ac) at planting, 8 gal/ac "triple nickel" (8-20-5-5-.5, 7.4 lb N/ac), 10 gal/ac 32% UAN (35.5 lb N/ac), and 3.5 gal/ac Thio-Sul® (4.7 lb N/ac) applied at planting in 2x2 placement; 100 lb N/ac as 32% UAN and Thio-Sul® side-dressed on 6/3/21
Irrigation: None
Rainfall (in):



	OM LOI %	Soil Texture	Sand (%)	Silt (%)	Clay (%)
North	3	Loam	35	38	27
South	2.3	Sandy Loam	67	20	13
Middle	3	Loam	45	34	21

Introduction: CENTURO™ by Koch Agronomic Services LLC has known efficacy for inhibiting nitrification. The chemical compound in CENTURO™ is pronitridine. This products inhibits populations of the bacteria that convert ammonium to nitrite (*Nitrosomonas*) and nitrite to nitrate (*Nitrobacter*). These compounds protect against both denitrification and leaching by retaining fertilizer N in the ammonium form. Ammonium (NH_4^+) is a positively charged ion (cation) that can be held on negatively charged exchange sites in soils (such as in clays and organic matter); in comparison nitrate (NO_3^-), which is negatively charged, can be converted to N_2O or N_2 gases in waterlogged conditions, or can leach below the root zone with rain in well-drained soils. You can learn more about nitrogen inhibitors at https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency.

The goal of this study was to evaluate the nitrification inhibitor product in a field with variable soil texture. A total of 100 lb N/ac was applied as 32% UAN and Thio-Sul® in a June 3, 2021, side-dress application. Side-dress applications were made with and without CENTURO™. A total of 172 lb N/ac was applied over the growing season. For reference, with an expected yield of 217 bu/ac, the University of Nebraska-Lincoln N recommendation for split-N application on this field was 161 lb N/ac.

Crop yield and soil ammonium and nitrate were measured. Soil samples were taken for ammonium-N and nitrate-N on five dates, starting on June 14, 2021. Soil samples were collected at 1' depth starting in the band and then at 7" and 15" on either side of the band for a total of 5 soil cores for each treatment, replication, and sampling date.

The field had a a cereal rye cover crop (56 lb/ac) planted on October 20, 2020. The cover crop was terminated at planting on April 26, 2021; cover crop height was 12" at termination.

Results:

	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	18.0 A*	216 A	1,125 A
Centuro™	18.0 A	220 A	1,132 A
P-Value	0.863	0.229	0.614

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $10.50/ac for CENTURO™.

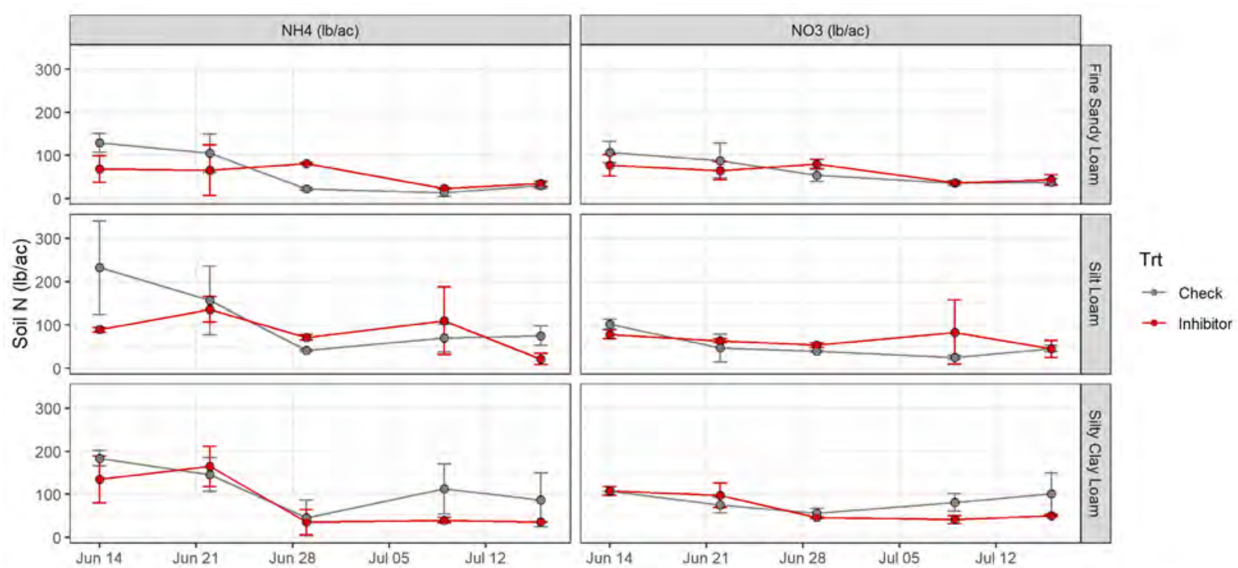


Figure 1. Soil ammonium (lb/ac) and nitrate (lb/ac) at one-foot depth across five dates, separated by soil texture.

Summary: On a whole-field basis, the use of CENTURO™ did not result in differences in corn yield or net return. Further analysis will look at the response to CENTURO™ in contrasting portions of the field.

This research was supported in part by Koch Industries Inc™ and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Project SENSE – 2021 Research and 7-Year Summary Report

Sensors for Efficient Nitrogen use and Stewardship of the Environment

The Nebraska On-Farm Research Network launched a project in 2015 focused on improving the efficiency of nitrogen fertilizer use. Project SENSE (Sensors for Efficient Nitrogen use and Stewardship of the Environment) compares crop canopy sensors to fixed-rate, in-season nitrogen application in corn. From 2015 to 2021, 62 site-studies were conducted with five partnering Natural Resources Districts (NRDs): Central Platte, Little Blue, Lower Loup, Lower Platte North, and Upper Big Blue. Since 2018, the project has progressed to fewer sites each year; however, sites were not constrained to a specific NRD or to irrigated fields. The 2021 study-site results are reported individually following this summary.

Nitrogen Management Challenges

Since 1988, the nitrate concentration in groundwater in Nebraska's Central Platte River Valley has been steadily declining, largely due to the conversion from furrow to center-pivot irrigation. However, over the last 25 years, fertilizer nitrogen use efficiency has remained static. This trend points to the need for adoption of available technologies such as crop canopy sensors for further improvement in nitrogen use efficiency. Strategies that direct crop nitrogen status at early growth stages are promising to improve nitrogen fertilizer efficiency.

Managing Variability with Sensors

It is difficult to determine the optimum amount of nitrogen to apply in a field; nitrogen needs in a field vary spatially and from year to year. Because crop canopy sensors are designed to be responsive to nitrogen needs, they can help account for this variability. Active sensors work by emitting light onto the crop canopy and then measuring reflectance from the canopy with photodetectors (*Figure 1*). When used to detect plant health, light in both the visible (VIS; 400-700 nanometers [nm]) and near-infrared (NIR; 700-1,000 nanometers [nm]) portions of the electromagnetic spectrum are generally measured. These wavelengths are combined to create various vegetation indices (VI). In this study, the normalized difference red edge (NDRE) index was used in the algorithm to prescribe an in-season nitrogen recommendation rate.

Study Design

A high-clearance applicator was equipped with an Ag Leader® Integra in-cab monitor and four OptRx® sensors *(Figure 1)*. A master module enables connection between the OptRx® sensors, which are capturing the normalized difference red edge (NDRE), and Ag Leader® in-cab monitor, which is computing the recommended N rate. An application rate module communicates the target rate from the Ag Leader® monitor to the rate controller. The applicator was equipped with straight stream drop nozzles in order to apply UAN fertilizer to the crop as it was sensed *(Figure 2)*. This configuration of active sensors with a high-clearance machine has several benefits. Nitrogen rates are prescribed in real-time by the system and account for spatial variability across the field, application can occur up until the V12 growth stage, and sensing does not rely on sunlight; the active sensors provide their own light source.

Figure 1: Active crop canopy sensor (left) positioned over the corn canopy and high-clearance applicator (right) equipped with OptRx® crop canopy sensors, GPS, and drop nozzles.

Project SENSE plots were arranged in a randomized complete block design with six replications *(Figure 2).* The grower's normal N management was compared with the Project SENSE N management. For the Project SENSE strips, a base rate (75 lb N/ac for most sites) was applied at planting or very early in the growing season.

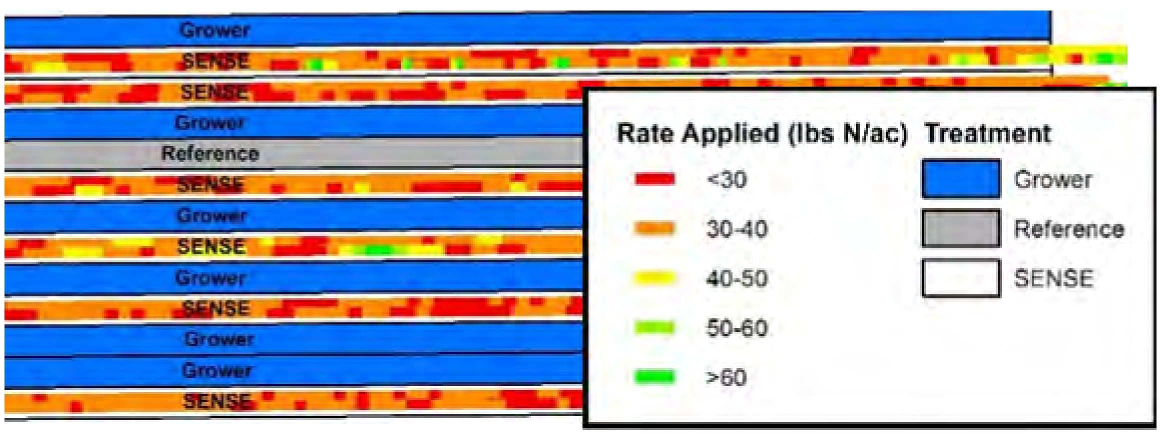


Figure 2: Layout of Project SENSE field trials with grower, SENSE, and reference strips.

Between V8 and V12, corn was sensed with the crop canopy sensors and variable-rate N was applied on-the-go *(NDRE values shown in Figure 3)*. The collected data consisted of grower N rates, Project SENSE in-season N rates, and yield data, which was averaged by treatment strip. For each site, the average difference in N applied (lb/acre) and the average difference in yield (bu/acre) were calculated. Nitrogen use efficiency (NUE) was also calculated as partial factor productivity of N (PFPn) (lb grain/lb N fertilizer) and as lb N applied per bushel of grain produced.

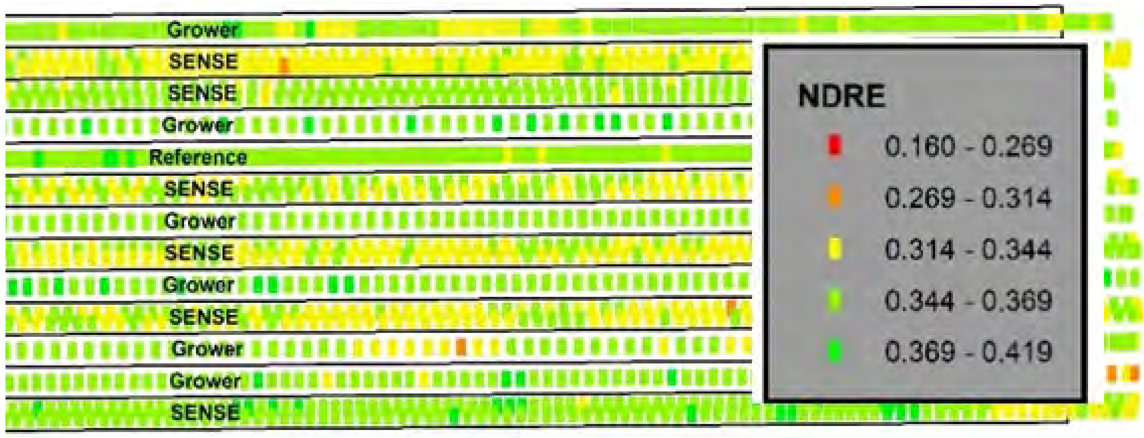


Figure 3: NDRE values recorded during sensing/application through Grower, SENSE, and Reference strips.

2015-2021 Irrigated Site Results

Data were analyzed using the GLIMMIX procedure in SAS 9.4 (SAS Institute Inc., Cary, NC). Mean separation was performed with Fisher's LSD. Across the 62 sites (Table 1), ***the sensor-based approach used 34 lb-N/ac less*** than the cooperating growers' approaches; the result was an ***average of 1 bu/ac less corn produced using the sensor-based method***. In terms of productivity and NUE, the sensor-based approach produced an additional 15.4 lb-grain/lb-N compared to the cooperator approaches. The sensor-based approach resulted in an average increase in profit compared to the grower approaches.

At higher N and corn prices ($0.60/lb-N and $4.00/bu) noted during the study, ***the sensor-based approach was $16.33/ac more profitable.*** At lower N and corn prices ($0.41/lb-N and $3.15/bu), ***the sensors were $10.76/ac more profitable compared to the grower approaches***. Input costs and crop revenues are important considerations regarding decisions about technology adoption; however, the sensors were a viable option for improving economic returns based on this study.

Table 1. Summary of 62 sites from 2015 to 2021 comparing sensor-based N management to the grower's traditional method in irrigated corn production.

Five Year Average	SENSE	Grower
Total N rate (lb-N/ac)	158.7 B*	192.3 A
Yield (bu/ac)	220.6 A	221.6 A
Partial Factor of Productivity (lb grain/lb-N)	82.4 A	66.4 B
Nitrogen Use Efficiency (lb-N/bu grain)	0.74 B	0.91 A
Partial Profitability ($/ac) [@4.00/bu and $0.60/lb-N]	$787.36 A	$771.02 A
Partial Profitability ($/ac) [@3.15/bu and $0.41/lb-N]	$629.96 A	$619.20 A

*Values with the same letter are not significantly different at a 95% confidence interval (SENSE vs. Grower).

Further analysis found the active crop canopy sensor treatments often performed better in sandy soil types due to high N application rates by growers compared to the optimal nitrogen rate. In addition, fields where the base nitrogen rate was lower had greater nitrogen use efficiencies in the sensor-based system. Summaries for each site from 2015 to 2021 can be found at https://cropwatch.unl.edu/on-farm-research.

Figure 4 shows the overall distribution of the 62 irrigated field sites in terms of profitability and partial factor of productivity (PFP). Since 2015, 68% of field sites benefitted in terms of both profit (+ $32/ac) and productivity (+ 21 lb-grain/lb-N) from using the sensor-based approach. Another 21% of field sites showed increased productivity (+ 13 lb-grain/lb-N); however, profit was negatively impacted (- $17/ac). About 10% of sites exhibited less profitability (- $30/ac) coupled with less productivity (- 13 lb-grain/lb-N). In irrigated production, these data indicate there is high potential for improving productivity and profitability if growers could utilize a sensor-based, in-season approach to N management.

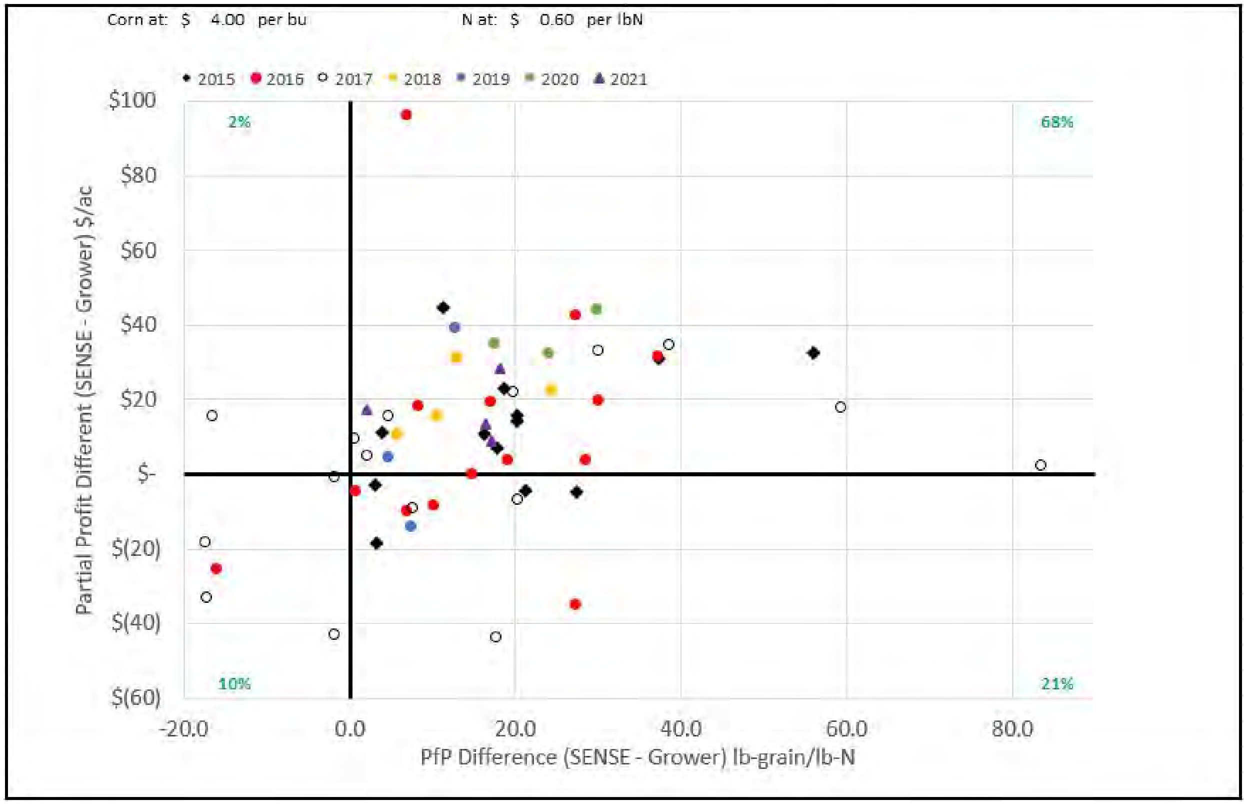


Figure 4: Profitability and nitrogen use efficiency of sensor-based N management compared to the grower's traditional management.

2019-2021 Non-Irrigated Site Results

Two sites in 2021 were placed on non-irrigated fields to evaluate the SENSE methodology with increased temporal and spatial variability. The five or six replications of grower and sensor-based N strips with a high N reference strip were used in the randomized complete block design just as in the irrigated sites *(Figure 2)*. The N was applied between V8 and V12 growth stage and an N inhibitor was used with the UAN on the 2021 sites. Throughout the season, aerial imagery, precipitation, and soil moisture data were logged, and at harvest, yield data were collected.

Table 2. Summary of 11 sites from 2019-2021 comparing sensor-based N management to the grower's traditional method in non-irrigated corn production.

Three-Year Average	SENSE	Grower
Total N rate (lb-N/ac)	123.4 B*	151.3 A
Yield (bu/ac)	214.0 B	219.6 A
Partial Factor of Productivity (lb grain/lb-N)	98.5 A	83.6 B
Nitrogen Use Efficiency (lb-N/bu grain)	0.58 B	0.70 A
Partial Profitability ($/ac) [@4.00/bu and $0.60/lb-N]	$781.92 B	$787.58 A
Partial Profitability ($/ac) [@3.15/bu and $0.41/lb-N]	$623.49 B	$629.68 A

*Values with the same letter are not significantly different at a 95% confidence interval (SENSE vs. Grower).

2021 Overview

Results of six studies, four irrigated and two non-irrigated, in 2021 are in the following pages of this report. Project SENSE will come to an end with this collection of data. However, sensor-based nitrogen application research will continue as side-dress applications as part of other grants as well as improvements in fertigation management using imagery.

Project SENSE was made possible through support from:

Nebraska's Natural Resources Districts

Central Platte
Little Blue
Lower Loup
Lower Platte North
Upper Big Blue

Nebraska CornBoard

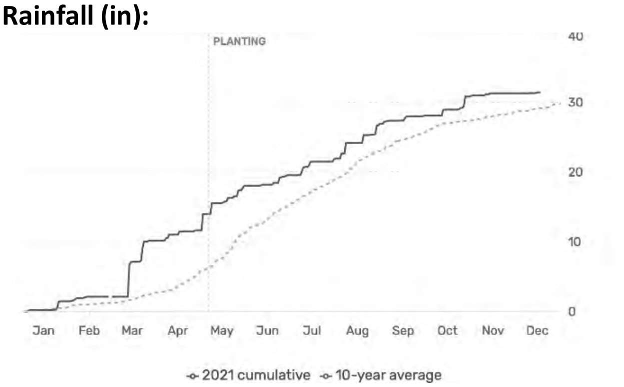
USDA

Learn more about Project SENSE at: https://on-farm-research.unl.edu/project-sense

Project SENSE (Sensor-based In-season N Management) on Irrigated Corn

Study ID: 0817081202103
County: Hamilton
Soil Type: Crete silt loam 0-1% slope; Hastings silt loam 0-1% slope; Hastings silty clay loam 3-7% slopes, eroded; Hobbs silt loam occasionally flooded
Planting Date: 5/6/21
Harvest Date: 11/3/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1185AM
Reps: 6
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 12 oz/ac Verdict® and 32 oz/ac MOUNTAINEER® 6 MAX on 5/3/21 ***Post:*** 36 oz/ac Liberty®, 1.5 qt/ac Atra-V™ 4L, and 16 oz/ac Armezon® PRO on 6/2/21

Seed Treatment: Maxim® Quattro, Lumiflex™, Lumiante™, L-2012R, Lumivia®, Lumisure™, and Lumialza™
Foliar Insecticides: 6 oz/ac Hero® applied aerially on 7/30/21
Foliar Fungicides: 10 oz/ac Headline AMP® applied aerially on 7/30/21
Irrigation: Pivot, Total: 8.6"
Rainfall (in):



Soil Samples (November 2020):

pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% Base Saturation H	K	Ca	Mg	Na
7.0	2.7	4.2	22	378	2540	310	65	17	0	6	77	16	2
7.0	2.6	6.2	17	385	2520	291	64	16	0	6	77	15	2

Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management.

Grower Nitrogen Treatment: The grower rate was 176 lb N/ac; 135 lb N/ac was applied as anhydrous ammonia pre-plant, 35 lb N/ac was applied as UAN at planting with NutriSphere-N® stabilizer, and 5.8 lb N/ac was applied at planting in 10-34-0 starter.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the 101 lb N/ac base rate (applied prior to in-season sensing) was established with 60 lb N/ac pre-plant anhydrous ammonia, 35 lb N/ac as UAN at planting with NutriSphere-N® stabilizer, and 5.8 lb N/ac at planting in 10-34-0 starter. Crop canopy sensing and application occurred on June 30, 2021. An irrigation of 0.80" was applied on July 1, 2021. The average N rate applied based on the in-season sensing was 46 lb N/ac and the average total N rate was 147 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	176 A*	268 A	85 B	0.66 A	1,322 B
SENSE	147 B	267 A	102 A	0.55 B	1,330 A
P-Value	<0.0001	0.398	<0.0001	<0.0001	0.094

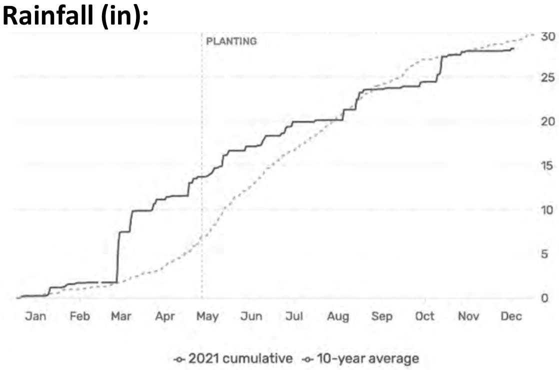
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- The Project SENSE N rate was 28 lb N/ac lower than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was equal to that of the grower's N management.
- ***Profitability*** was $8/ac greater for the Project SENSE management compared to the grower's N management due to the reduced N fertilizer cost and no yield difference.
- ***Efficiency*** of nitrogen fertilizer applied was 17% better for the Project SENSE management.

Project SENSE (Sensor-based In-season N Management) on Irrigated Corn

Study ID: 0811185202102
County: York
Soil Type: Hastings silt loam 3-7% slopes; Hord silt loam 1-3% slope
Planting Date: 5/11/21
Harvest Date: 11/3/21
Seeding Rate: 32,500
Row Spacing (in): 30
Hybrid: Pioneer® P1366AM
Reps: 6
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** 3 qt/ac Lexar® EZ, 24 oz/ac Durango®, and 6 oz/ac DiFlexx® on 5/11/21 ***Post:*** 1 qt/ac Acuron®, 12 oz/ac atrazine, and 32 oz/ac Roundup PowerMAX® on 6/3/21
Seed Treatment: Lumialza™
Foliar Insecticides: 6 oz/ac Brigade® on 8/11/21
Foliar Fungicides: 13.7 oz/ac Trivapro® on 8/11/21
Irrigation: Pivot, Total: 9.5"
Rainfall (in):



Soil Tests (April 6, 2021):

	pH	BpH	OM LOI %	Nitrate – N ppm N	Bray P1 ppm	Sulfate-S ppm S	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
Zone 1	6.6	6.8	2.7	0.6	16	5	414	2260	506	15	17.7	21	51	26
Zone 2	6.2	6.7	3.3	1.6	5	6	307	2548	578	29	21	25	45	28
Zone 3	6.1	6.7	3.3	1.1	8	6	192	1570	246	15	12.2	31	47	20
Zone 4	6.4	6.8	3.1	1.6	24	7	252	1512	243	14	11.3	29	51	18

Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management.

Grower Nitrogen Treatment: The grower rate was 185 lb N/ac; 150 lb N/ac was applied as anhydrous ammonia on April 4, 2021, and 35 lb N/ac was applied through fertigation.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the 75 lb N/ac base rate (applied prior to in-season sensing) was established with anhydrous ammonia on April 4, 2021. Crop canopy sensing and application occurred on June 29, 2021, and the field was irrigated following application. The average N rate applied based on the in-season sensing treatments was 73 lb N/ac, applied as UAN. The field also received 35 lb N/ac through fertigation. The average total N rate was 183 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	185 A*	263 B	80 B	0.70 A	1,294 B
SENSE	183 A	267 A	82 A	0.69 B	1,313 A
P-Value	0.219	0.057	0.079	0.078	0.055

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

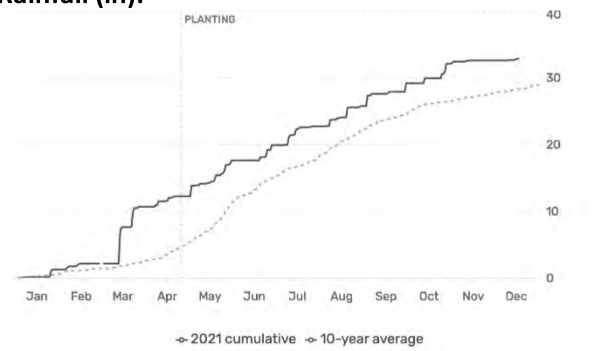
Summary:

- The Project SENSE N rate was not significantly different than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was 4 bu/ac greater than the grower's N management.
- ***Profitability*** was $19/ac greater for the Project SENSE management due to increased yield.
- ***Efficiency*** of nitrogen fertilizer applied was 1% better for the Project SENSE management.

Project SENSE (Sensor-based In-season N Management) on Irrigated Corn

Study ID: 0715035202101
County: Clay
Soil Type: Crete silt loam 0-1% slope; Hastings silt loam 1-3% slope
Planting Date: 4/24/21
Harvest Date: 11/4/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P2042
Reps: 6
Previous Crop: Alfalfa
Tillage: Strip-till
Herbicides: ***Pre:*** Degree Xtra® and Sharpen® Powered by Kixor® ***Post:*** Status® and glyphosate
Seed Treatment: LumiGEN™

Foliar Insecticides: None
Foliar Fungicides: None
Irrigation: Pivot, Total: unknown due to mechanical failure w/flow meter
Rainfall (in):



Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management.

Grower Nitrogen Treatment: The grower rate was 165 lb N/ac; 71 lb N/ac was applied as UAN at planting, 5.8 lb N/ac was applied with 10-34-0 starter at planting, and 88 lb N/ac was applied as UAN side-dress on June 12, 2021.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the 77 lb N/ac base rate (applied prior to in-season sensing) was established with 71 lb N/ac applied as UAN and 5.8 lb N/ac applied as 10-34-0 at planting. Crop canopy sensing and application occurred on June 30, 2021. The field was irrigated following sensor-based application. The average N rate applied based on the in-season sensing treatments was 61 lb N/ac, applied as UAN. The average total N rate was 138 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	165 A*	255 A	87 B	0.65 A	1,262 B
SENSE	138 B	258 A	105 A	0.54 B	1,285 A
P-Value	<0.0001	0.165	<0.0001	<0.0001	0.025

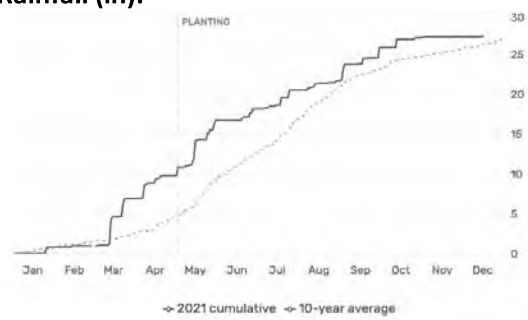
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:
- The Project SENSE N rate was 27 lb N/ac lower than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was equal to that of the grower's N management.
- ***Profitability*** was $23/ac greater for the Project SENSE management compared to the grower's N management due to the reduced N fertilizer cost and no yield difference.
- ***Efficiency*** of nitrogen fertilizer applied was 17% better for the Project SENSE management.

Project SENSE (Sensor-based In-season N Management) on Irrigated Corn

Study ID: 0621023202101
County: Butler
Soil Type: Thurman loamy fine sand; Simeon loamy sand
Planting Date: 5/2/21
Harvest Date: 10/12/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Channel® 213-19VT2P
Reps: 6
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** 1.5 qt/ac Harness® Xtra, 3 oz/ac Balance® Flexx, and 6 oz/ac Sterling Blue® ***Post:*** 3 oz/ac Laudis®, 1 qt/ac atrazine, and 32 oz/ac Roundup®, 1 qt/ac Warrant®

Seed Treatment: None
Foliar Insecticides: 16 oz/ac Tundra® Supreme, 6 oz/ac Yuma® 4E
Foliar Fungicides: 8 oz/ac Delaro Compete®
Irrigation: Pivot, Total: 10.76"
Rainfall (in):



Soil Tests (0-6"): May 2021

Soil pH 1:1	Sand (%)	Silt (%)	Clay (%)	OM LOI-%	KCl Nitrate ppm N	Mehlich III P ppm	Mehlich III K ppm	Mehlich III Ca ppm	Mehlich III Mg ppm	Mehlich III Na ppm	Mehlich III Zn ppm	Mehlich III Fe ppm	Mehlich III Mn ppm	Mehlich III Cu ppm	Sum of Cations Me/100g	% Base Saturation H	% Base Saturation K	% Base Saturation Ca	% Base Saturation Mg	% Base Saturation Na
6.5	77	22	1	2.2	1	12	58	1225	119	6	3.4	68	42	0.6	7.9	7.6	1.9	77.5	12.6	0.3
6.7	83	12	5	1.5	1.6	15	62	1039	94	8	3.8	56	33	0.5	6.5	4.6	2.4	79.9	12.1	0.5
6.0	87	8	5	2.2	2.7	23	68	972	72	7	5.0	76	38	0.5	6.7	14.9	2.6	72.5	9.0	0.5
6.2	71	18	11	1.5	2.8	6	43	840	109	2	1.6	57	26	0.3	5.9	11.9	1.9	71.2	15.4	0.1

Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management.

Grower Nitrogen Treatment: The grower rate was 228 lb N/ac; 53 lb N/ac was applied as UAN pre-emerge, 5.8 lb N/ac was applied with 10-34-0 starter at planting, 6.4 lb N/ac was applied with 8-20-5 starter at planting, 21 lb N/ac was applied as 12-0-0-24 AMS side-dress, and 142 lb N/ac was applied as UAN side-dress.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the 86 lb N/ac base rate (applied prior to in-season sensing) was established with 53 lb N/ac applied as UAN pre-emerge, 5.8 lb N/ac applied with 10-34-0 starter at planting, 6.4 lb N/ac applied with 8-20-5 starter at planting, and 21 lb N/ac applied as 12-0-0-24 AMS side-dress. Crop canopy sensing and application occurred on June 30, 2021. The field was irrigated following sensor-based application. The average N rate applied based on the in-season sensing treatments was 87 lb N/ac, applied as UAN. The average total N rate was 173 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	228 A*	245 A	60 B	0.93 A	1,182 A
SENSE	173 B	239 B	77 A	0.73 B	1,175 A
P-Value	<0.0001	0.006	<0.0001	<0.0001	0.354

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

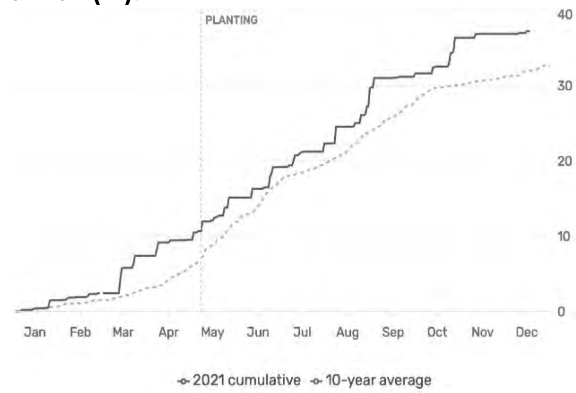
Summary:

- The Project SENSE N rate was 55 lb N/ac lower than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was 6 bu/ac lower than the grower's N management.
- ***Profitability*** was not different between the Project SENSE management and the grower's N management.
- ***Efficiency*** of nitrogen fertilizer applied was 22% better for the Project SENSE management.

Project SENSE (Sensor-based In-season N Management) on Non-Irrigated Corn

Study ID: 0108155202101
County: Saunders
Soil Type: Yutan silty clay loam 2-6% slopes, eroded; Tomek silt loam 0-2% slope; Filbert silt loam
Planting Date: 5/7/21
Harvest Date: 10/21/21
Seeding Rate: 28,000
Row Spacing (in): 30
Hybrid: DEKALB® DKC60-88
Reps: 8
Previous Crop: Wheat
Tillage: No-till
Herbicides: ***Burndown:*** 32 oz/ac Durango®, and 12 oz/ac 2,4-D LV6 with 2.2 lb/ac AMS on 4/6/21; ***Pre:*** 2.2 lb/ac AMS, 1 pt/ac atrazine 4L, 32 oz/ac Durango®, 8 oz/ac DiFlexx®, 18 oz/ac Verdict®, and 19.4 oz/ac MSO on 5/11/21 ***Post:*** 1 pt/ac atrazine 4L, 35 oz/ac Durango®, 3 oz/ac Laudis®, and 9.7 oz/ac Superb® HC with 2.2 lb/ac AMS on 6/9/21

Seed Treatment: Acceleron®
Foliar Insecticides: None
Foliar Fungicides: None
Irrigation: None
Rainfall (in):



Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management.

Grower Nitrogen Treatment: The grower rate was 188 lb N/ac, applied as anhydrous ammonia pre-plant.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the base rate (applied prior to in-season sensing) was established with 78 lb N/ac pre-plant anhydrous ammonia. Crop canopy sensing and application occurred on June 23, 2021, at the V8 growth stage. The average N rate applied based on the in-season sensing was 74 lb N/ac, applied as UAN. The field received 1.7" rain the following day, June 24, 2021. The average total N rate was 152 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	188 A*	276 A	82 B	0.68 A	1,361 A
Project SENSE	152 B	274 B	101 A	0.56 B	1,363 A
P-Value	0.0001	0.028	0.0003	0.0001	0.490

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

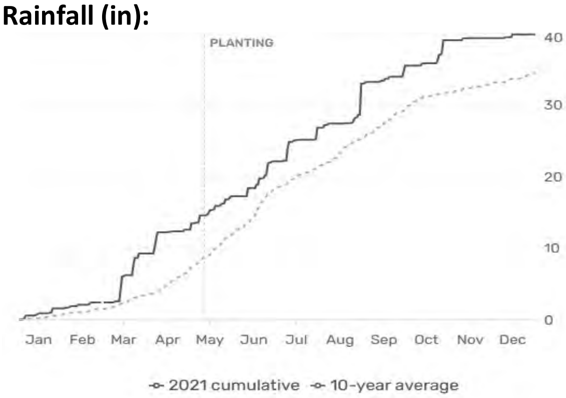
Summary:

- The Project SENSE N rate was 36 lb N/ac lower than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was 2 bu/ac less than the grower's N management.
- ***Profitability*** was the same between the Project SENSE management and the grower's N management due to the reduced N fertilizer cost.
- ***Efficiency*** of nitrogen fertilizer applied was 18% better for the Project SENSE management.

Project SENSE (Sensor-based In-season N Management) on Non-irrigated Corn

Study ID: 0103053202101
County: Dodge
Soil Type: Moody silty clay loam 2-6% slopes; Moody silty clay loam 6-11% slopes, eroded
Planting Date: 5/11/21
Harvest Date: 10/16/21
Seeding Rate: 30,900
Row Spacing (in): 30
Hybrid: Fontanelle Hybrids® 13G519
Reps: 6
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Pre:*** 5.6 oz/ac Corvus®, 1 qt/ac atrazine, and 32 oz/ac Roundup PowerMAX®
Seed Treatment: Acceleron® Elite

Foliar Insecticides: None
Foliar Fungicides: None
Irrigation: None
Rainfall (in):



Soil Tests (April 13, 2021):

	pH	BpH	OM LOI %	Nitrate – N ppm N	Bray P1 ppm	Sulfate-S ppm S	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
Zone 1	6.5	6.8	4.8	1.3	77	1	410	1984	186	2	13.5	33	48	18
Zone 2	6.2	6.8	3.9	1.0	27	9	211	1918	262	4	14.0	25	50	24
Zone 3	5.8	6.7	3.5	1.1	29	9	218	1813	251	4	14.5	27	52	20

Introduction: A high-clearance applicator was equipped with Ag Leader® OptRx® sensors. UAN fertilizer was applied with drop nozzles as the crop canopy was sensed. This study compares crop canopy sensor-based in-season N application with the grower's standard N management. The field had a cereal rye cover crop planted on November 10, 2020, at 50/ac. The cover crop was terminated with herbicide on April 20, 2021, when rye was 6" tall.

Grower Nitrogen Treatment: The grower rate was 138 lb N/ac; 100 lb/ac of 12-4-0 (12 lb N/ac) was applied pre-plant, 6 gal/ac of 6-24-6 (3 lb N/ac) was applied in-furrow at planting, 10 gal/ac 32% UAN (35 lb N/ac) was applied June 10, 2021, and 25 gal/ac 32% UAN (88 lb N/ac) was applied as side-dress.

Project SENSE Nitrogen Treatment: For the SENSE treatment strips, the 50 lb N/ac base rate (applied prior to in-season sensing) was established with 100 lb/ac of 12-4-0 (12 lb N/ac) pre-plant, 6 gal/ac of 6-24-6 (3 lb N/ac) in-furrow at planting, and 10 gal/ac 32% UAN (35 lb N/ac). Crop canopy sensing and application occurred on July 1, 2021, but didn't receive significant rainfall until July 10, 2021. The UAN was mixed with Nitrain® nitrogen stabilizer. The average N rate applied based on the in-season sensing treatments was 92 lb N/ac, applied as UAN. The average total N rate was 142 lb N/ac.

Results:

	Total N rate (lb/ac)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/bu grain	Marginal Net Return‡ ($/ac)
Grower	138 A	227 A	92 A	0.61 A	1,126 A
SENSE	142 A	231 A	91 A	0.61 A	1,145 A
P-Value	0.143	0.468	0.594	0.594	0.493

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- The Project SENSE N rate was 4 lb N/ac greater than the grower's N management.
- ***Productivity*** for the Project SENSE treatment was equal to that of the grower's N management.
- ***Profitability*** was not significantly different between the Project SENSE management and the grower's N management.
- ***Efficiency*** of nitrogen fertilizer applied was the same for both treatments.

Sensor-based Nitrogen Fertigation

From 2019-2021, growers participating in the Nebraska On-Farm Research Network experimented with using imagery to direct responsive nitrogen (N) application to corn through *fertigation* - application of fertilizer through an irrigation system. The adoption of technology such as sensors mounted on an aerial platform may be used to improve nitrogen use efficiency (NUE) by responding to actual plant N need. There were five sites in 2019, five sites in 2020, and 4 sites in 2021; two of these sites were repeated in multiple years (Figure 1).

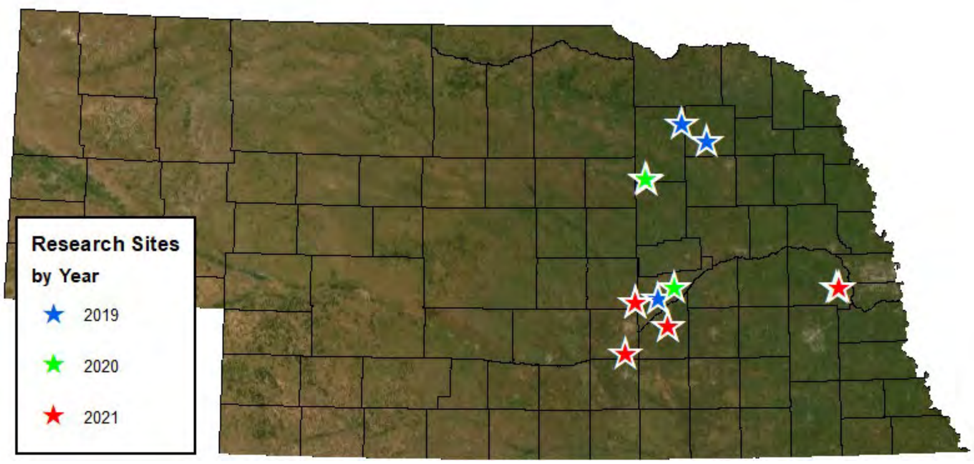


Figure 1. Sensor-based nitrogen fertigation research site locations. Duplicate and close-proximity site locations are non-distinguishable.

Managing Variability with Drone-based Sensors

Nitrogen need varies spatially within a field and from year to year. This study utilized a Parrot® Sequoia+ multispectral sensor, which captures imagery in four bands: green, red, red edge, and near-infrared. These bands allow the normalized difference vegetation index (NDVI) and the normalized difference red edge (NDRE) index to be calculated. These vegetation indices are correlated with crop biomass and nitrogen status, and therefore can inform growers about the crop's N need. The Parrot® Sequoia+ was mounted on a senseFly eBee fixed-wing drone (Figure 2). Pre-programmed flight paths were developed and autonomously flown on a weekly basis.

Figure 2. senseFly eBee fixed-wing drone (left) and Parrot® Sequoia+ sensor (top right).

Study Design

The experiments were arranged in a randomized complete block design with four replications of three treatments. Treatments were applied in 15° sectors on half of a quarter section under pivot irrigation. By the V7 growth stage, *indicator blocks* were established in the field using traditional ground-based

Figure 3. Center-pivot system equipped with a variable rate fertilizer injection pump.

application equipment (e.g., high-clearance applicator) or via center-pivot fertigation. Indicator blocks included at least two plots – an indicator plot and a reference plot – of two different N rates. Indicator plots received 30 lb-N/ac less than the bulk sector rate and reference plots received at least 30 lb-N/ac more than the bulk sector rate. Four indicator blocks were established in each sector in 2019, whereas indicator blocks were established in each management zone represented in a sector in 2020. Following indicator block establishment, each field site was flown weekly with the drone to collect multispectral imagery. Collected imagery was then analyzed, fertigation decisions were made for each treatment sector, and a fertigation prescription was generated. If indicator blocks of a given sector suggested that an N application was needed, fertigation was initiated at a rate of 30 lb-N/ac. Only the sectors that indicated N application was needed received fertilizer; therefore, on a given fertigation date, it was possible for only one of the sectors of a given treatment to receive N, or for all four sectors of a given treatment to receive N. Each field site was equipped with a variable-rate fertilizer injection pump that injected liquid fertilizer into the irrigation water to fertigate the corn through the center-pivot irrigation system (Figure 3). This allowed each sector to be managed independently using variable-rate fertigation applications.

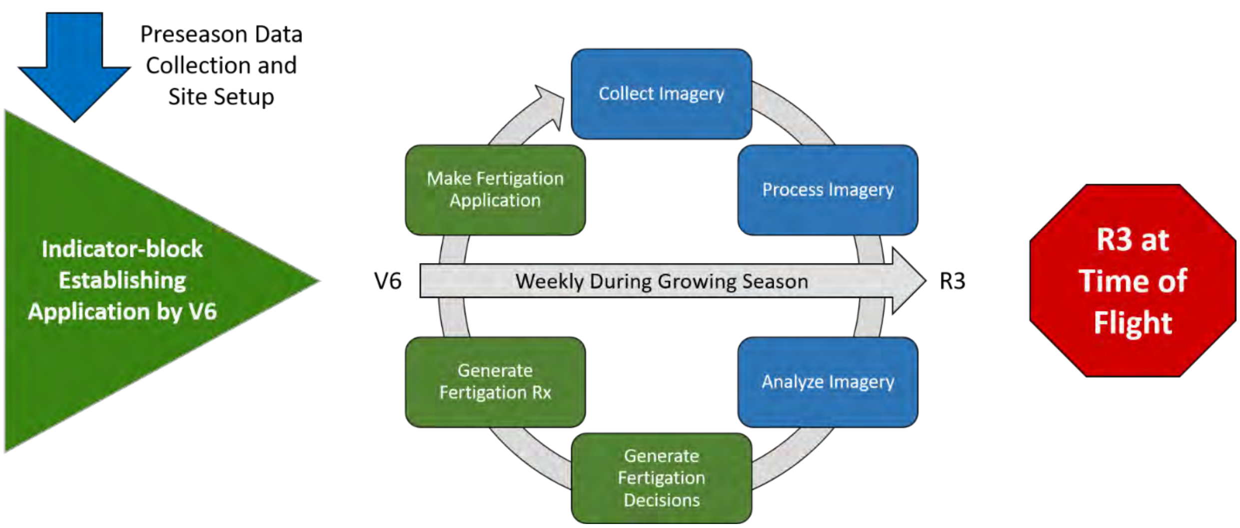


Figure 4. Visual summary of SBFM implementation.

Consecutive fertigation applications were not allowed to occur based on imagery captured within 8 days of a previous fertigation application to allow the crop enough time to take up and incorporate applied nitrogen, thereby reducing the risk of excess fertilizer applications. Fertigation applications were allowed to occur up to the R3 growth stage as observed at the time of image capture. The grower management was determined by the grower. Ultimately, this method sought to improve fertigation application timing and make only necessary fertigation applications. Successfully accomplishing this goal would match applied N to the N uptake dynamics of corn and reduce the total N applied when possible, optimizing N management. Comprehensively, this method is referred to as sensor-based fertigation management (SBFM). A visual summary of SBFM implementation is presented in Figure 4.

In 2019, treatments investigated were the grower's traditional N management, a constrained risk-averse SBFM approach (RAC), and a constrained risk-tolerant SBFM approach (RTC) as shown in Figure 5. RAC and RTC treatments differed only in the amount of measured N deficiency required to trigger a fertigation application, with the risk-tolerant approach requiring more deficiency than the risk-averse approach to trigger an application. Risk-averse and risk-tolerant language was used to describe the two treatments, because the risk-averse approach was designed to emphasize protecting yield potential over reducing applied N, whereas the risk-tolerant approach was designed to emphasize saving N over protecting yield potential. Both RAC and RTC treatments were implemented to make fertigation decisions only once the applied N for the season was within 60 lb-N/ac of the grower's intended total applied N. In 2020 and 2021, treatments included the grower's traditional N management, a constrained SBFM approach (risk-averse constrained, RAC), and a post-establishment SBFM (risk-averse post-establishment, RAP) approach as shown in Figure 6. The RAC treatment in 2020 was the same as the RAC treatment in 2019. RAP followed the risk-averse approach for the entire growing season beginning at the V6 growth stage or 10 days after indicator establishment, whichever was later.

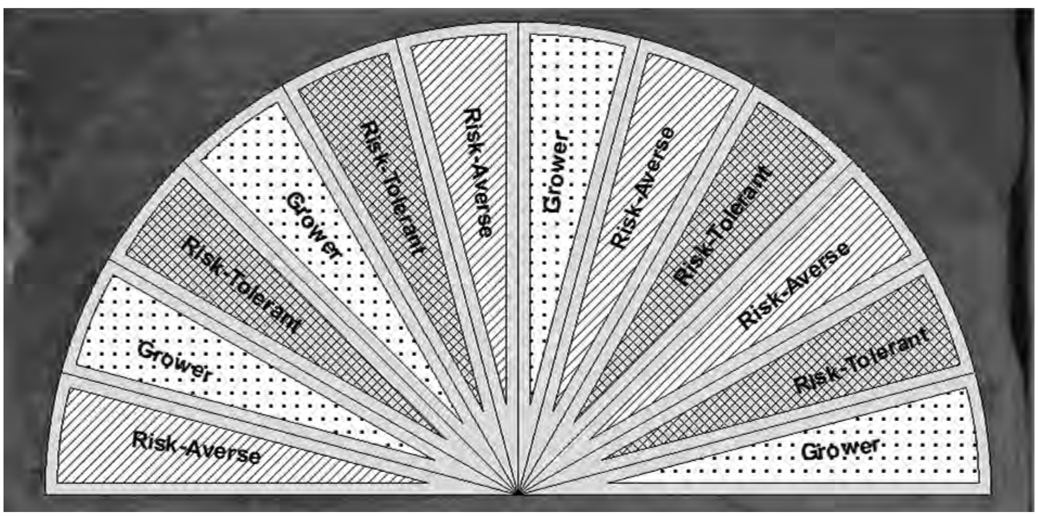


Figure 5. Experiment design with four replications of three treatments (grower's traditional management and the risk-tolerant and risk-averse sensor-based fertigation approaches) arranged in sectors.

Three additional treatments were included in some of the 2021 on-farm research trials: risk-averse constrained R4 (RAC R4), risk-averse post-establishment R4 (RAP R4), and risk-averse post-establishment increased rate (RAP IR). RAC R4 followed the same implementation as the RAC treatment except that the fertigation application window was extended to observation of the R4 growth stage instead of the R3 growth stage at the time of image capture. Similarly, RAP R4 followed the same implementation as the RAP treatment except with an extended fertigation application window to the R4 growth stage at the time of image capture. Finally, RAP IR followed the same implementation as the RAP treatment except that any fertigation application triggered between the V9 and V14 growth stages was made at a rate of 60 lb-N/ac rather than the typical rate of 30 lb-N/ac. Treatment specifications are outlined in Table 1 and treatment implementation constraints are depicted in Figure 7.

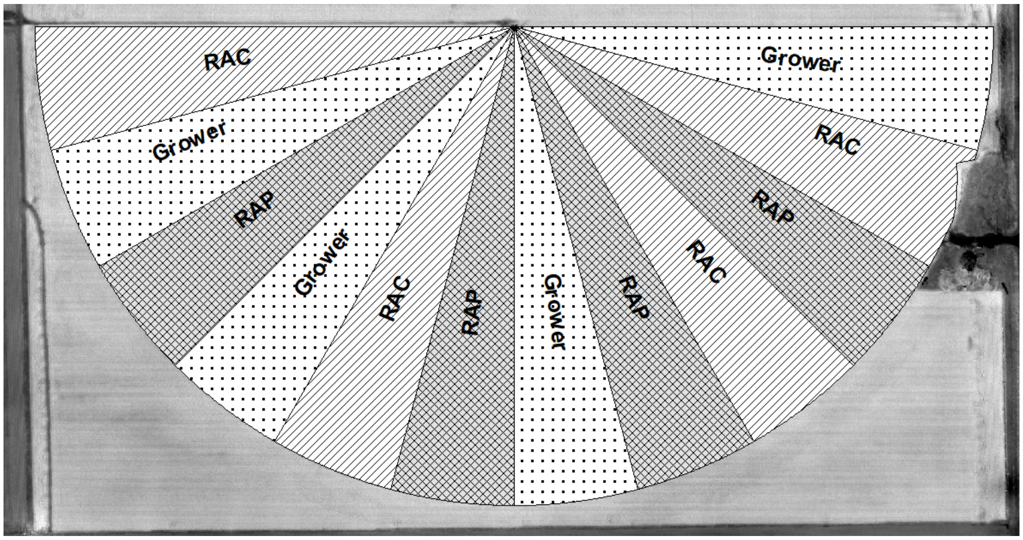


Figure 6. Representative experimental design for 2020 and 2021 with four replications of three treatments (grower's traditional management and the constrained and full-season sensor-based management approaches) arranged in sectors.

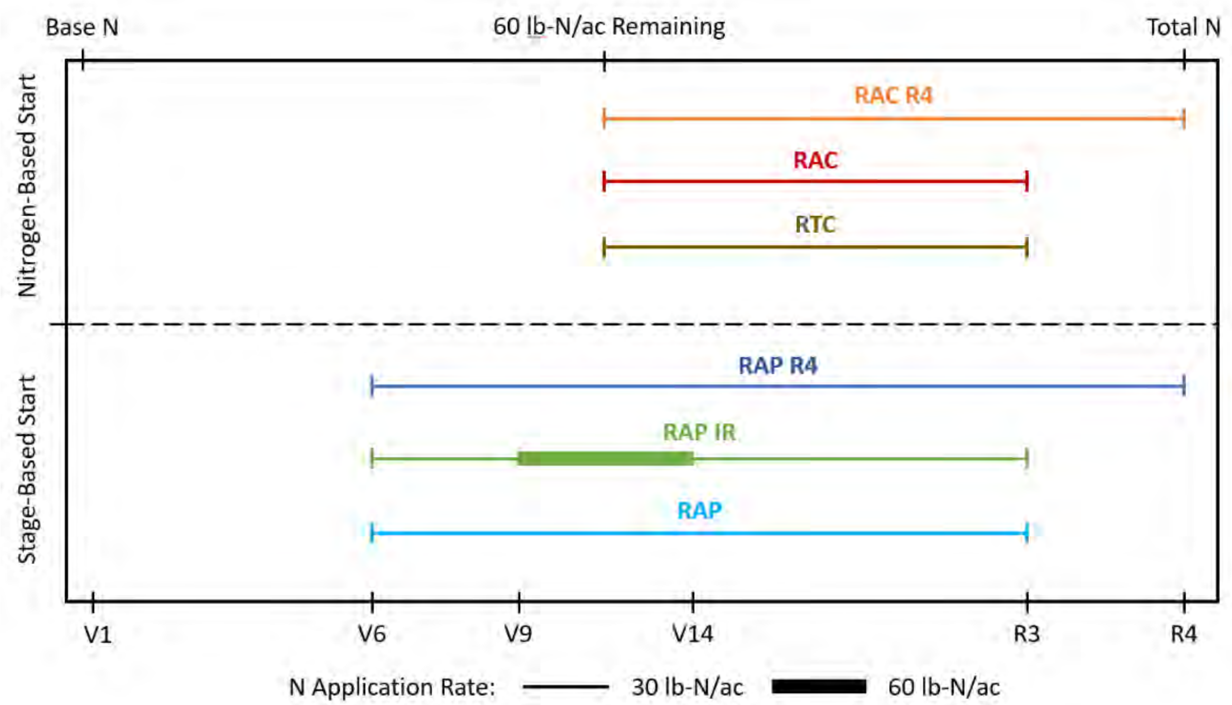


Figure 7. Timeline summary of treatment types indicating at what point in the growing season SBFM began controlling fertigation applications, the application rate of fertigation applications by growth stage, and the growth stage at which no further fertigation applications were made. RTC, RAC, and RAC R4 treatments all assumed control of fertigation applications when there were 60 lb-N/ac remaining relative to the grower's planned total N rate. RAP, RAP IR, and RAP R4 all began as early as the V6 growth stage and controlled all fertigation applications after indicator block establishment. For all treatments, no fertigation applications were allowed once a certain growth stage was observed.

Table 1. Summary table of SBFM treatments investigated between 2019 and 2021. Key attributes of initiation condition, fertigation application rate, and termination condition are provided for each treatment type. Treatments included in 2021 are highlighted in gray.

Treatment	Acronym	Years	Initiation Condition	Fertigation Application Rate	Termination Condition
Risk-Averse Constrained	RAC	2019-2021	Last 60 lb N ac^{-1}	30 lb-N/ac	R3
Risk-Tolerant Constrained	RTC	2019	Last 60 lb N ac^{-1}	30 lb-N/ac	R3
Risk-Averse Post-Establishment	RAP	2020-2021	V6 (10 days post-est.)	30 lb-N/ac	R3
Risk-Averse Constrained R4	RAC R4	2021	Last 60 lb N ac^{-1}	30 lb-N/ac	R4
Risk-Averse Post-Establishment R4	RAP R4	2021	V6 (10 days post-est.)	30 lb-N/ac	R4
Risk-Averse Post-Establishment Increased Rate	RAP IR	2021	V6 (10 days post-est.)	60 lb-N/ac for V9-V14, 30 lb-N/ac otherwise	R3

Data Analysis

Yield for the plots were recorded with calibrated yield monitors. Following harvest, yield data was post-processed using the USDA Yield Editor software to remove erroneous data points, then the average yield from each sector was computed. Yield from indicator plots was included in the analysis as they are a necessary element of this N fertilization method. Because the indicator plots occurred in all three treatments, they impacted yield equally. Statistical analysis and Tukey's HSD mean separation were completed with R (R Core Team, 2019).

Comprehensive Data

Data from all sites from 2019 through 2021 have been compiled and analyzed. Summary information is presented in this section. SBFM treatments are compared versus typical grower management in terms of marginal net return (MNR, $/ac) and partial factor productivity (PFP, lb grain/lb N). Figure 8 shows the distribution of all sites' PFP differences versus MNR differences compared with typical grower management at that site. Values to the right of the y-axis indicate that the SBFM treatment was more efficient than typical grower management, whereas values left of the y-axis indicate that SBFM was less efficient than typical grower management. Similarly, points above the x-axis indicate that SBFM was more profitable than typical grower management, whereas points below the x-axis indicate that SBFM was less profitable than typical grower management. If SBFM was both more profitable and more efficient than typical grower management at a particular site, the point for that treatment at that site lies in the upper right-hand quadrant.

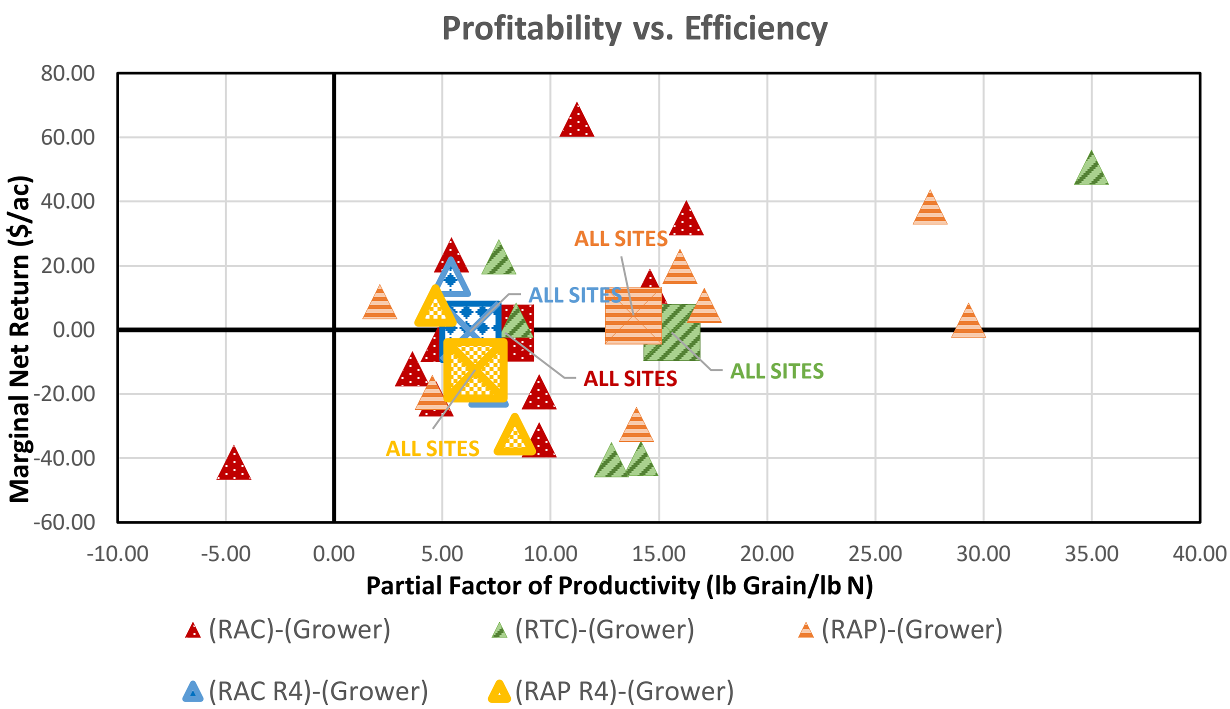


Figure 8. Profitability (y-axis) versus efficiency (x-axis) differences by site for sensor-based fertigation-management treatments compared with traditional grower management. Large squares indicate treatment averages across three years; only sites with a grower management treatment are included.

This distribution shows that approximately 96% of sensor-based fertigation treatment instances across all sites were more efficient than typical grower management. Only 56% of sensor-based fertigation treatment instances across sites were more profitable than typical grower management. Average treatment outcome differences versus traditional grower management are directly quantified in Figure 9. On average, the RAP treatment demonstrated the best overall performance. It increased profitability by $4.52/ac versus typical grower management, while also increasing efficiency by 13.83 lb-grain per lb-N applied. All SBFM treatments improved efficiency on average and the RTC approach realized the most substantial improvement at 15.6 lb-grain/lb-N. With three years of data collected, the RAC approach appears to offer appreciable improvements in efficiency. Average differences in profitability between the RTC, RAC, and RAC R4 approaches and typical grower management on a site-by-site basis were negligible. The RAP R4 approach implemented for the first time in 2021 appears to present significant profitability risk with an average loss of $12.44/ac accompanied by an efficiency increase of only 6.51 lb-grain/lb-N. This apparent profit risk is strongly influenced by one site where profit loss was substantial, though the other site showed a profit increase of $7.14/ac versus typical grower management. The RAC R4 approach performed similarly, with slightly higher profitability and slightly lower efficiency observed.

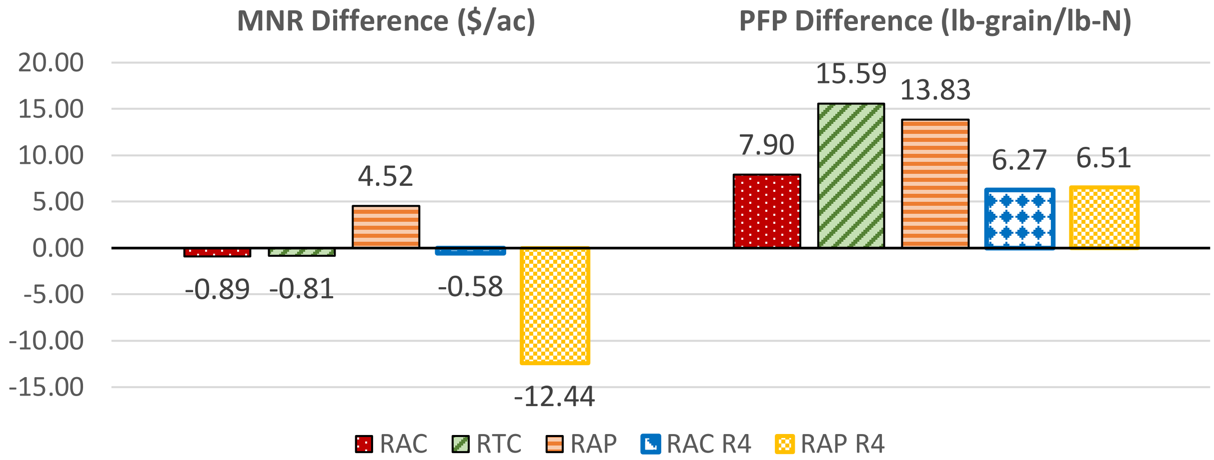


Figure 9. Average profitability and efficiency differences between SBFM approaches and typical grower management across all sites in which there was a grower management treatment.

Conclusions

A couple conclusions can be drawn from the comprehensive dataset compiled over the past three years. First, SBFM is likely to substantially improve NUE versus typical grower management. It is important to note that the efficiency improvements observed in these trials are relative to grower management strategies following recommended best management practices, such as multiple fertigation applications of small amounts throughout the growing season. Improvements in efficiency may be even more substantial compared with growers not currently following best practices. Second, implementing the RAP approach appears to offer the best combination of profitability and efficiency outcomes. Initial results do not indicate any appreciable benefit to extending the application window to the R4 growth stage. Though not included in this summary, the RAP IR approach implemented on one site in 2021 shows significant potential for further enhancing SBFM's performance. Based on these results, further exploration of the RAP IR approach is warranted in future studies alongside continued tuning of the RAC, RTC, and RAP approaches to improve consistency in profitability and further increase efficiency.

Continued Development

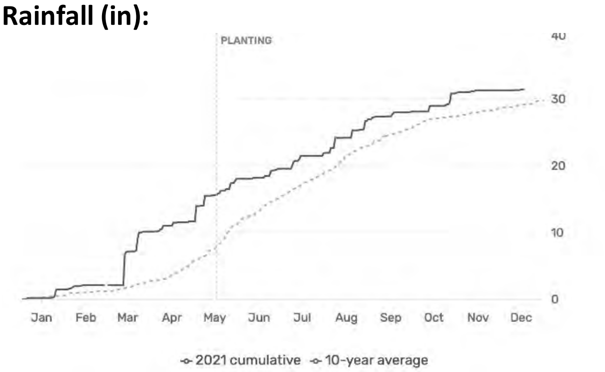
This study will continue in 2022 on as many as 6 sites. A software decision support tool called N-Time™ Fertigation Management System (N-Time™ FMS) was completed in spring 2021 and used to implement the 2021 SBFM research trials. N-Time FMS facilitates the SBFM process and automates image analysis, fertigation recommendation, and fertigation prescription processes. Additional agronomic analysis is being undertaken to determine the potential for adjusting fertigation application rates during critical application windows and extending the application window for sensor-based fertigation past the R2 growth stage. Improvement of current SBFM approaches, integration of scalable imagery sources, and quantification of nitrate losses continue to be major objectives of future iterations of the study. Updates regarding this research will be provided through UNL Extension media and at field days in 2022.

The sensor-based fertigation project is made possible through support from:

Nebraska CornBoard
USDA
Water for Food DAUGHERTY GLOBAL INSTITUTE at the University of Nebraska

Sensor-Based Nitrogen Fertigation Management

Study ID: 0817081202101
County: Hamilton
Soil Type: Crete silt loam 0-1% slope; Hastings silt loam 0-1% slope; Hastings silt loam 1-3% slope; Hastings silty clay loam 3-7% slopes, eroded; Fillmore silt loam 0-1% slope
Planting Date: 5/6/21
Harvest Date: 11/15/21
Seeding Rate: 31,697
Row Spacing (in): 30
Hybrid: Pioneer® P1563AM
Reps: 4
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 12 oz/ac Verdict® and 32 oz/ac MOUNTAINEER® 6 MAX on 5/6/21 ***Post:*** 36 oz/ac Liberty®, 1.5 qt/ac Atra-V™ 4L, and 16 oz/ac Armezon® PRO on 6/2/21
Seed Treatment: L-2013P, Raxil® or Lumiflex™, and Poncho® 1250 + VOTiVO®
Foliar Insecticides: 6 oz/ac Hero® applied aerially on 7/30/21
Foliar Fungicides: 10 oz/ac Headline AMP® applied aerially on 7/30/21
Irrigation: Pivot, Total: 9.49"
Rainfall (in):



Introduction: Corn nitrogen management may be improved by using sensors or imagery to detect and respond to corn nitrogen needs during the growing season. This study used weekly aerial imagery obtained with a multispectral sensor on a fixed-wing drone to monitor indicator plots that had lower N rates. If indicator plots demonstrated nitrogen deficiency, a fertigation application of 30 lb/ac was triggered. This study compared the grower's standard N management with two reactive, sensor-based fertigation approaches as follows:

***Grower Management*:** Cooperating grower made the fertigation management decisions for this treatment throughout the growing season.

Risk-Averse Constrained Sensor-Based Management R4 (RAC-R4): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery once applied N was within 60 pounds of the total N goal until the R4 growth stage was observed. Prior to this point, fertigation applications were managed identically to grower management treatments.

Risk-Averse Post-Establishment Sensor-Based Management R4 (RAP-R4): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R4 growth stage.

Soil Test (March 2021, soil tests are averages of four replications of each of the three treatments):

	NO_3-N ppm N 0-8"	NO_3-N ppm N 8-24"	OM LOI%
Grower	5.6 A*	3.075 A	3.55 A
RAC-R4	4.0 A	2.9 A	3.45 A
RAP-R4	3.8 A	2.65 A	3.45 A
P-Value	0.258	0.809	0.718

*Values with the same letter are not significantly different at a 90% confidence level.

Application Table: Unless otherwise noted, N was applied using 32% UAN. The gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all four reps; therefore, if only one out of four replications triggered an application of 30 lb N/ac, a value of 7.5 lb N/ac is reported as the average treatment N application.

	4/2	4/13	5/6	5/10	6/23	7/7	7/13	7/27	8/3	8/11	8/23	
Treatment	*lb N/ac applied*											
Grower	30 [a]	90 [b]	6 [c]	36	35	18	-	18	-	-	-	**233**
RAC-R4	30 [a]	90 [b]	6 [c]	36	35	-	-	-	-	-	7.5	**205**
RAP-R4	30 [a]	90 [b]	6 [c]	36	15	-	7.5	-	7.5	7.5	-	**199**

[a] Product used is 11-52-0 broadcast
[b] Product used is anhydrous ammonia
[c] Product used is 10-34-0 in-furrow with planting

Results:

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
Grower	233 A*	15.9 A	264 A	64 B	0.88 A	1,280 A
RAC-R4	205 B	15.9 A	259 AB	71 A	0.79 B	1,262 AB
RAP-R4	199 B	15.8 A	255 B	72 A	0.78 B	1,248 B
P-Value	0.028	0.580	0.039	0.041	0.038	0.072

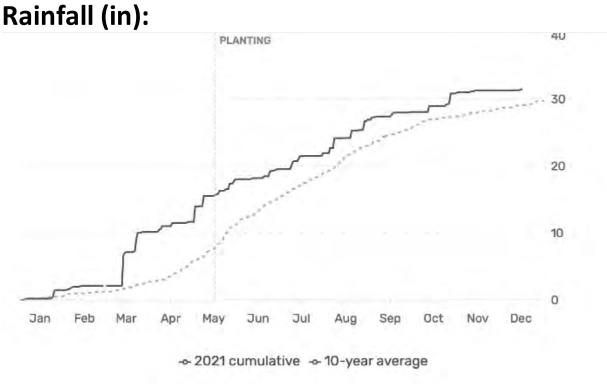
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- The RAP-R4 treatment approach applied 34 lb/ac less N than the grower's N management, whereas the RAC-R4 treatment approach applied 28 lb/ac less N than the grower's N management.
- The RAP-R4 approach had a 9 bu/ac decrease in yield and $32/ac decrease in profitability compared to the grower's N management.
- The RAC-R4 approach did not have significantly different yield or profitability compared to the grower's N management.
- The RAC-R4 and RAP-R4 approaches had higher N efficiency compared to the grower's N management.
- While the RAP-R4 approach had greater N efficiency, it resulted in yield and profitability losses. The RAC-R4 approach was able to achieve greater N efficiency without yield or profit loss.

Sensor-Based Nitrogen Fertigation Management

Study ID: 0817081202102
County: Hamilton
Soil Type: Crete silt loam 0-1% slope; Hastings silt loam 0-1% slope; Hastings silt loam 1-3% slope; Hastings silty clay loam 3-7% slopes, eroded; Fillmore silt loam 0-1% slope
Planting Date: 5/6/21
Harvest Date: 11/15/21
Seeding Rate: 31,397
Row Spacing (in): 30
Hybrid: Pioneer® P1563AM
Reps: 4
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 12 oz/ac Verdict®, 32 oz/ac MOUNTAINEER® 6 MAX ***Post:*** 36 oz/ac Liberty®, 1.5 qt/ac Atra-V™ 4L, and 16 oz/ac Armezon® PRO on 6/2/21
Seed Treatment: L-2013P, Raxil® or Lumiflex™, and Poncho® 1250 + VOTiVO®
Foliar Insecticides: 6 oz/ac Hero® applied aerially on 7/30/21
Foliar Fungicides: 10 oz/ac Headline AMP® applied aerially on 7/30/21
Irrigation: Pivot, Total: 9.49”
Rainfall (in):



Introduction: Corn nitrogen management may be improved by using sensors or imagery to detect and respond to corn nitrogen needs during the growing season. This study used weekly aerial imagery obtained with a multispectral sensor on a fixed-wing drone to monitor indicator plots that had lower N rates. If indicator plots demonstrated nitrogen deficiency, a fertigation application of 30 lb/ac was triggered. This study compared the grower’s standard N management with two reactive, sensor-based fertigation approaches as follows:

Grower Management: Cooperating grower made the fertigation management decisions for this treatment throughout the growing season.

Risk-Averse Constrained Sensor-Based Management (RAC): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery once applied N was within 60 pounds of the total N goal until the R3 growth stage was observed. Prior to the last 60 lb N, fertigation applications were managed identically to grower management treatments.

Risk-Averse Post-Establishment Sensor-Based Management (RAP): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R3 growth stage.

Soil Tests (March 2021, soil tests are averages of four replications of each of three treatments):

	NO_3-N ppm N 0-8”	NO_3-N ppm N 8-24”	OM LOI%
Grower	4.2 A*	2.3 A	3.5 A
RAC	3.8 A	2.4 A	3.6 A
RAP	3.7 A	2.0 A	3.5 A
P-Value	0.724	0.782	0.415

*Values with the same letter are not significantly different at a 90% confidence level.

Application Table: Unless otherwise noted, N was applied using 32% UAN. Gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all four reps; therefore, if only one out of four replications triggered an application of 30 lb N/ac, a value of 7.5 lb N/ac is reported as the average treatment N application.

	4/2	4/13	5/6	5/10	6/23	7/7	7/13	7/27	8/3	8/11	8/23	Total N Applied
Treatment	---------------------------------------*lb N/ac applied*---											
Grower	30 [a]	90 [b]	6 [c]	36	35	18	-	4.5	13.5	-	-	**233**
RAC	30 [a]	90 [b]	6 [c]	36	35	-	15	-	-	-	-	**212**
RAP	30 [a]	90 [b]	6 [c]	36	7.5	15	-	-	30	-	-	**215**

[a] Product used is 11-52-0 broadcast
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Results:

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
Grower	233 A*	15.9 A	255 A	61 A	0.91 A	1,230 A
RAC	212 A	15.9 A	249 B	66 A	0.85 A	1,209 B
RAP	215 A	15.9 A	249 B	66 A	0.86 A	1,211 AB
P-Value	0.293	0.845	0.024	0.416	0.449	0.072

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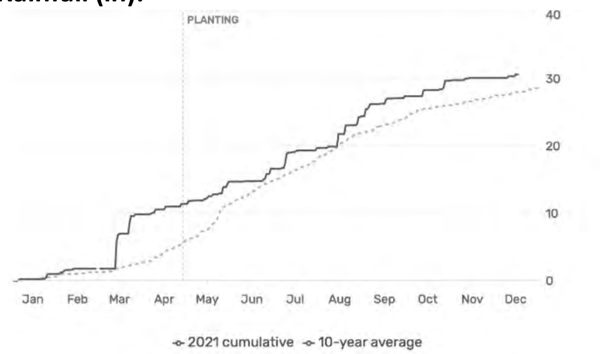
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- At this site, there was no significant difference in total N applied, productivity, and nitrogen use efficiency across all treatment types.
- The grower's N management approach had a 6 bu/ac increase in yield comparatively to both sensor-based fertigation approaches.
- Comparing the grower's N approach and the RAC approach, the grower had an increase of $21/ac in profitability, whereas there was no significant difference between the grower's approach and the RAP approach.

Sensor-Based Nitrogen Fertigation Management

Study ID: 0815093202102
County: Howard
Soil Type: Thurman loamy fine sand 2-6% slopes; Valentine-Thurman soils 0-17% slopes; Libory-Boelus loamy fine sand; Kenesaw silt loam 0-1% slope; Ortello loamy fine sand 1-6% slopes
Planting Date: 4/28/21
Harvest Date: 10/28/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1415Q
Reps: 4
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 16 oz/ac Buccaneer Plus®, 10 oz/ac Verdict®, 32 oz/ac atrazine, 16 oz/ac methylated seed oil (MSO), 6 oz/ac liquid AMS, and 5 oz/ac Reign® on 5/7/21 ***Post:*** 64 oz/ac Halex® GT, 12 oz/ac Buccaneer Plus®, 16 oz/ac atrazine, 6.4 oz oz/ac non-ionic surfactant (NIS), 6 oz/ac liquid AMS, 4 oz/ac Status®, and 5 oz/ac Reign® on 6/9/21
Foliar Insecticides: 6.6 oz/ac bifenthrin on 4/27/21; 6 oz/ac bifenthrin and 2 oz/ac Warrior ll with Zeon Technology® on 7/17/21
Foliar Fungicides: 10 oz/ac Trivapro® on 7/17/21
Irrigation: Pivot, Total: 12.35"
Rainfall (in):



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Grower Management: Cooperating grower made the fertigation management decisions for this treatment throughout the growing season.

Risk-Averse Constrained Sensor-Based Management R4 (RAC-R4): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery once applied N was within 60 pounds of the total N goal until the R4 growth stage was observed. Prior to this point, fertigation applications were managed identically to grower management treatments.

Risk-Averse Post-Establishment Sensor-Based Management R4 (RAP-R4): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R4 growth stage.

Soil Test (April 2021, soil tests are averages of four replications of each of the three treatments):

	NO_3-N ppm N 0-8"	NO_3-N ppm N 8-24"	OM LOI%
Grower	3.4 A*	1.8 AB	1.1 A
RAC-R4	3.7 A	1.2 B	1.0 A
RAP-R4	4.8 A	2.75 A	1.5 A
P-Value	0.6559	0.0599	0.7074

*Values with the same letter are not significantly different at a 90% confidence level.

Application Table: Unless otherwise noted, N was applied using 32% UAN. Gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all four reps; therefore, if only one out of four replications triggered an application of 30 lb N/ac, a value of 7.5 lb N/ac is reported as the average treatment N application.

	4/5	4/28	4/28	6/9	6/23	7/1	7/8	7/15	7/21	7/29	8/6	8/10	Total N Applied
Treatment						*lb N/ac applied*							
Grower	14 [a]	6 [b]	60	37	23	25	20	-	25	20	-	20	**250**
RAC-R4	12.5[a]	6 [b]	60	38	23	25	20	-	25	-	23	-	**232**
RAP-R4	14.5[a]	6 [b]	60	36	17.5	9.5	22.5	7.5	15	15	7.5	22.5	**233**

[a] Product used is 11-52-0 broadcast

[b] Product used is 10-34-0 in-furrow with planting

Results:

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
Grower	250 A	16.9 A	268 A	60 A	0.94 A	1,291 A
RAC-R4	232 A	16.8 A	269 A	65 A	0.86 A	1,307 A
RAP-R4	233 A	16.9 A	268 A	65 A	0.87 A	1,298 A
P-Value	0.236	0.548	0.925	0.263	0.199	0.820

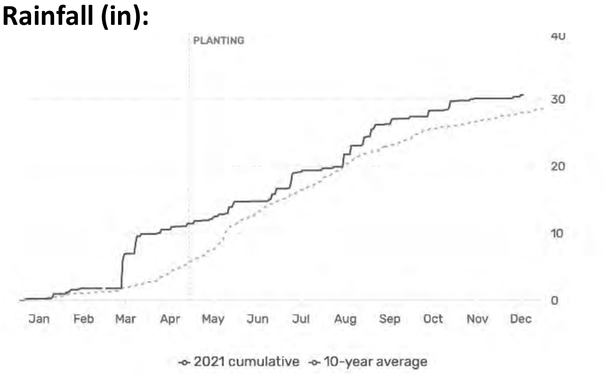
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- There was no significant difference in total N applied, yield, profitability, or N efficiency between all three treatment approaches.
- Extreme soil variability and topography differences across this site could contribute to the lack of significant differences across various treatment types.

Sensor-Based Nitrogen Fertigation Management

Study ID: 0815093202103
County: Howard
Soil Type: Thurman loamy fine sand 2-6% slopes; Valentine-Thurman soils 0-17% slopes
Planting Date: 4/28/21
Harvest Date: 10/28/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1415Q
Reps: 3
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 16 oz/ac Buccaneer Plus®, 10 oz/ac Verdict®, 32 oz/ac atrazine, 16 oz/ac methylated seed oil (MSO), 6 oz/ac liquid AMS, and 5 oz/ac Reign® on 5/7/21 ***Post:*** 64 oz/ac Halex® GT, 12 oz/ac Buccaneer Plus®, 16 oz/ac atrazine, 6.4 oz oz/ac non-ionic surfactant (NIS), 6 oz/ac liquid AMS, 4 oz/ac Status®, and 5 oz/ac Reign® on 6/9/21
Foliar Insecticides: 6.6 oz/ac bifenthrin on 4/27/21; 6 oz/ac bifenthrin and 2 oz/ac Warrior ll with Zeon Technology® on 7/17/21
Foliar Fungicides: 10 oz/ac Trivapro® on 7/17/21
Irrigation: Pivot, Total: 12.35”
Rainfall (in):



Introduction: Corn nitrogen management may be improved by using sensors or imagery to detect and respond to corn nitrogen needs during the growing season. This study used weekly aerial imagery obtained with a multispectral sensor on a fixed-wing drone to monitor indicator plots that had lower N rates. If indicator plots demonstrated nitrogen deficiency, a fertigation application of 30 lb/ac was triggered. Due to an equipment malfunction at this site, the fertigation application rate was not prescribed correctly and changed to 25 lb/ac for the sensor-based applications. This study compared the grower’s standard N management with two reactive, sensor-based fertigation approaches as follows:

Grower Management: Cooperating grower made the fertigation management decisions for this treatment throughout the growing season.

Risk-Averse Constrained Sensor-Based Management (RAC): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery once applied N was within 60 pounds of the total N goal until the R3 growth stage was observed. Prior to the last 60 lb N, fertigation applications were managed identically to grower management treatments.

Risk-Averse Post-Establishment Sensor-Based Management (RAP): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R3 growth stage.

Soil Tests (April 2021, soil tests are averages of four replications of each of the three treatments):

	NO_3-N ppm N 0-8”	NO_3-N ppm N 8-24”	OM LOI%
Grower	1.1 A	1.5 A	4.5 A
RAC	1.1 A	1.4 A	4.2 A
RAP	1.1 A	1.3 A	3.4 A
P-Value	0.7038	0.5165	0.4112

*Values with the same letter are not significantly different at a 90% confidence level.

Application Table: Unless otherwise noted, N was applied using 32% UAN. Gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all 4 reps; therefore, if only one out of four replications triggered an application of 25 lb N/ac, a value of 6 lb N/ac is reported as the average treatment N application. All four replications of treatments are accounted for in this application table.

	4/5	4/28	4/28	6/9	6/23	7/1	7/8	7/15	7/21	7/29	8/6	8/10	Total N Applied
Treatment		--*lb N/ac applied*--											
Grower	10.5 [a]	6 [b]	60	37.5	23	25	20	-	25	20	-	20	**246**
RAC	11[a]	6 [b]	60	35	23	25	20	-	-	25	-	-	**205**
RAP	12 [a]	6 [b]	60	35	26	-	18	-	18	-	-	-	**175**

[a] Product used is 11-52-0 broadcast

[b] Product used is 10-34-0 in-furrow with planting

Results: Replication one has a history of extremely variable yield within the replication; therefore, it was removed from the analysis and not included in the results below.

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
Grower	246 A*	17.0 A	264 A	60 A	0.94 A	1,272 A
RAC	205 A	16.5 A	254 A	69 A	0.81 AB	1,238 A
RAP	175 A	16.5 A	259 A	89 A	0.68 B	1,275 A
P-Value	0.112	0.083	0.472	0.229	0.089	0.486

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

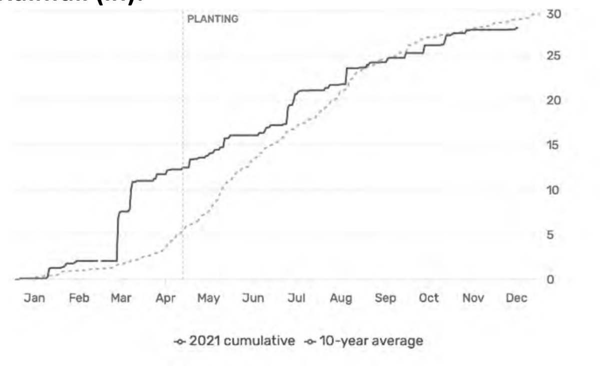
Summary:

- There was no significant difference in total N applied, moisture, yield, or profitability between the three treatments evaluated.
- There was a 0.26 increase in N efficiency for the RAP approach compared to the grower's N management.
- There was no significant difference for N efficiency for the RAC approach when compared to the grower's N management or the RAP treatments.
- A high variability of soils within treatments may result in lack of significant differences.

Sensor-Based Nitrogen Fertigation Management

Study ID: 1260079202101
County: Hall
Soil Type: Cozad sandy substratum 0-3% slope; Alda loam rarely flooded; Valentine loamy fine sand 0-3% slope
Planting Date: 4/27/21
Harvest Date: 10/20/21
Seeding Rate: 32,000
Row Spacing (in): 36
Hybrid: Pioneer® P1366
Reps: 4
Previous Crop: Corn
Tillage: Conventional + strip-till
Foliar Insecticides: None
Foliar Fungicides: 10 oz/ac Quilt Xcel® on 7/25/21

Irrigation: Pivot, Total: 8.72”, 2.5 ppm N in irrigation water
Rainfall (in):



Introduction: Corn nitrogen management may be improved by using sensors or imagery to detect and respond to corn nitrogen needs during the growing season. This study used weekly aerial imagery obtained with a multispectral sensor on a fixed-wing drone to monitor indicator plots that had lower N rates. If indicator plots demonstrated nitrogen deficiency, a fertigation application of 30 lb/ac was triggered. This study compared the grower’s standard N management with two reactive, sensor-based fertigation approaches as follows:

Grower Management: Cooperating grower made the fertigation management decisions for this treatment throughout the growing season.

***Risk-Averse Constrained Sensor-Based Management (RAC)*:** Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery once applied N was within 60 pounds of the total N goal until the R3 growth stage was observed. Prior to the last 60 lb N, fertigation applications were managed identically to grower management treatments.

Risk-Averse Post-Establishment Sensor-Based Management (RAP): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R3 growth stage.

Application Table: Unless otherwise noted, N was applied using 32% UAN. Gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all four reps; therefore, if only one out of four replications triggered an application of 30 lb N/ac, a value of 7.5 lb N/ac is reported as the average treatment N application.

Treatment	4/12	4/27	6/7	6/23	7/6	7/7	7/13	7/27	8/3	8/11	8/23	Total N Applied
Grower	70 [a]	3 [b]	113	36	36	-	-	-	-	-	-	**258**
RAC	70 [a]	3 [b]	90	36	-	-	-	-	-	-	-	**199**
RAP	70 [a]	3 [b]	90	7.5	-	-	-	-	-	-	-	**170**

[a] Product used is 10-34-0 in-furrow with coulter
[b] Product used is 10-34-0 in-furrow with planting

Results:

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
Grower	258 A	15.5 A	241 A	52 C	1.07 A	1,149 A
RAC	199 B	15.4 A	243 A	69 B	0.82 B	1,184 A
RAP	170 C	15.1 A	241 A	80 A	0.71 C	1,187 A
P-Value	<0.0001	0.866	0.856	<0.0001	<0.0001	0.177

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

- At this site, sensor-based fertigation management used less N than the grower's typical management. The RAP approach applied 88 lb/ac less N than the grower's N management and the RAC approach applied 59 lb/ac less N than the grower's N management.
- There were no significant differences in yield or profitability.
- The RAP approach had the greatest N efficiency with a 21 lb grain/lb N increase in partial productivity of N compared to the grower's N management, and an 11 lb grain/lb N increase in partial productivity of N compared to the RAC approach. The RAC approach increased partial productivity of N by 17 lb grain/lb N in comparison to the grower's N management. Similarly, the RAP approach had 36% greater N efficiency (measured as lbs N/bu grain) compared to the grower. The RAC approach had 25% greater N efficiency (measured as lbs N/bu grain) compared to the grower.
- Results at this site demonstrate that RAP fertigation had the highest efficiency for reducing N application, maintaining yield, and increasing N efficiency of the crop.

Sensor-Based Nitrogen Fertigation Management

Study ID: 1171155202101
County: Saunders
Soil Type: Yutan silty clay loam terrace, 2-6% slopes, eroded; Tomek silt loam 0-2% slope; Filbert silt loam 0-1% slope
Planting Date: 4/26/21
Harvest Date: 11/8/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1563AM
Reps: 4
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Burndown:*** 12 oz/ac 2,4-D, and 32 oz/ac Durango® DMA® on 4/14/21; ***Pre:*** 2.19 lb/ac AMS, 2 pt/ac Anthem® ATZ, and 8 oz/ac DiFlexx®, with 2.19 lb/ac AMS and 19.4 oz/ac crop oil on 4/26/21 ***Post:*** 1 pt/ac atrazine 4L, 1.5 oz/ac Steadfast®, and 3 oz/ac Callisto® with 2.19 lb/ac AMS and 19.4 oz/ac crop oil on 6/1/21

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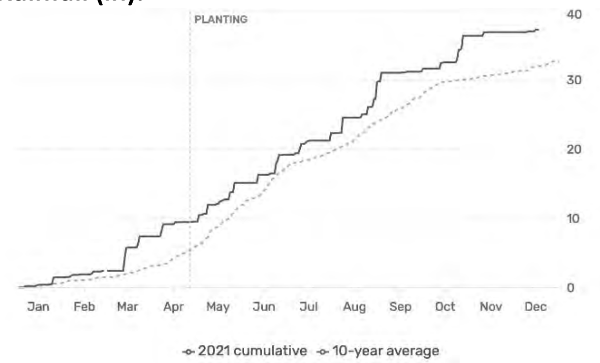
Seed Treatment: LumiGEN®
Foliar Insecticides: None
Foliar Fungicides: None
Irrigation: Pivot, Total: 7.14", 1.1 ppm N in irrigation water
Rainfall (in):



Soil Tests (March 2021, soil tests have 6 samples averaged across entire site):

		OM	Nitrate- N	Mehlich P-III	Sulfate-S	Ammonium Acetate(ppm)				CEC	% Base Saturation				
pH	BpH	LOI%	ppm N	ppm P	ppm S	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
6.5	7.0	3.8	8.4	19.5	11	284	2370	376	39	17	8	5	69	18	1

Introduction: Corn nitrogen management may be improved by using sensors or imagery to detect and respond to corn nitrogen needs during the growing season. This study used weekly aerial imagery obtained with a multispectral sensor on a fixed-wing drone to monitor indicator plots that had lower N rates. If indicator plots demonstrated nitrogen deficiency, a fertigation application of 30 lb/ac was triggered. This study compared the three reactive, sensor-based fertigation approaches as follows:

***Risk-Averse Post-Establishment Sensor-Based Management (RAP)*:** Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R3 growth stage.

Risk-Averse Post-Establishment Sensor-Based Management R4 (RAP-R4): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R4 growth stage.

Risk-Averse Post-Establishment Sensor-Based Management IR (RAP-IR): Fertigation application decisions were made based on decision logic and analytics applied to aerial imagery from the V6 growth stage to the R3 growth stage with application rate increased from 30 lb N/ac to 60 lb N/ac for any fertigation applications recommended between V9 and V14.

Application Table: Unless otherwise noted, N was applied using 28% UAN. Gray shaded area to the right of the striped line indicates where sensor-based management dictated N rates. The applied values are averages across all four reps; therefore, if only one out of four replications triggered an application of 30 lb N/ac, a value of 7.5 lb N/ac is reported as the average treatment N application.

	4/5	6/15	6/30	7/7	7/13	7/19	7/27	8/11	Total N Applied
Treatment	----------------	----------------	----------------	----------------	*lb N/ac applied*	----------------	----------------	----------------	----------------
RAP	66 [a]	22.5	-	-	-	22.5	22.5	-	**133**
RAP-R4	66 [a]	22.5	7.5	7.5	7.5	-	22.5	15	**148**
RAP-IR	34 [a]	30	60	-	15	-	-	-	**139**

[a] Product used is anhydrous ammonia

Results:

	Total N rate (lb/ac)	Moisture (%)	Yield (bu/ac)†	Partial Factor Productivity of N (lb grain/lb N)	lbs N/ bu grain	Marginal Net Return‡ ($/ac)
RAP	133 A*	15.5 A	264 A	111 A	0.50 A	1,320 A
RAP-R4	133 A	15.5 A	264 A	115 A	0.50 A	1,321 A
RAP-IR	139 A	15.5 A	269 A	110 A	0.52 A	1,342 A
P-Value	0.872	0.587	0.277	0.848	0.946	0.158

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

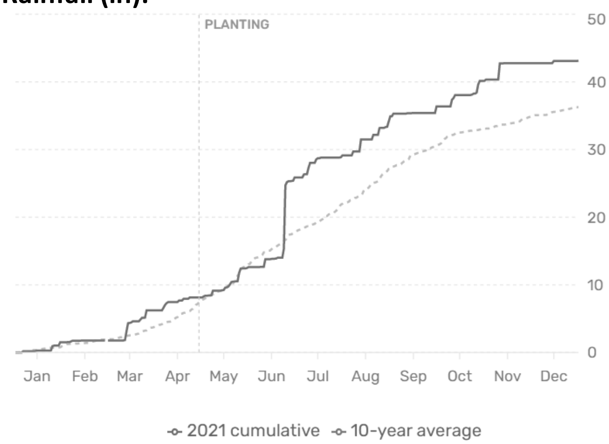
Summary:

- Only sensor-based fertigation management approaches were compared; there was no grower N management. There were no significant differences in total N, grain yield, N efficiency, or profitability between the three sensor-based approaches.
- Nitrogen efficiency for the three treatments evaluated was very good, with averages from 0.52 to 0.56 lb N to produce a bushel of grain.
- Each sensor-based fertigation management approach resulted in high N efficiency and yield. This suggests that several approaches may be acceptable, and the simplest approach to implement could be selected.

Evaluating Corteva Granular for Pre-Plant Variable-Rate Nitrogen Management in Non-Irrigated Corn

Study ID: 0510KS013202101
County: Brown, KS
Soil Type: Marshall silty clay loam 5-9% slopes; Marshall silt loam 2-5% slopes
Planting Date: 4/29/21
Harvest Date: 10/9/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1572AM
Reps: 9
Previous Crop: Soybean
Tillage: Strip-till

Irrigation: None
Rainfall (in):



Baseline Soil Samples, 0-6" (December 2020):

	pH	BpH	OM LOI %	Melich-III P ppm	Nitrate – N ppm N	Bray P1 ppm	Sulfate-S ppm S	-------Melich III------- K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
Zone 1	6.7	6.9	3.4	24	2.1	18	9	242	2571	301	13	16.8	-	-	-
Zone 2	6.6	6.8	3.9	20	3.8	15	7	215	2477	258	9	16.1	-	-	-
Zone 3	6.4	6.8	4.2	20	3.4	15	8	214	3134	269	9	20.3	22	59	18

Introduction: This study evaluated a crop model based N tool, Granular a subsidiary of Corteva Agriscience™ company, and compared it to the grower's traditional N management. Nitrogen applications on the field included:

1) 100 lb/ac 11-52-0, contributing 11 lb N/ac.

2) Anhydrous ammonia application applied on December 21, 2020, following either the grower's typical management of 180 lb N/ac or the variable-rate Granular prescription (Figure 1).

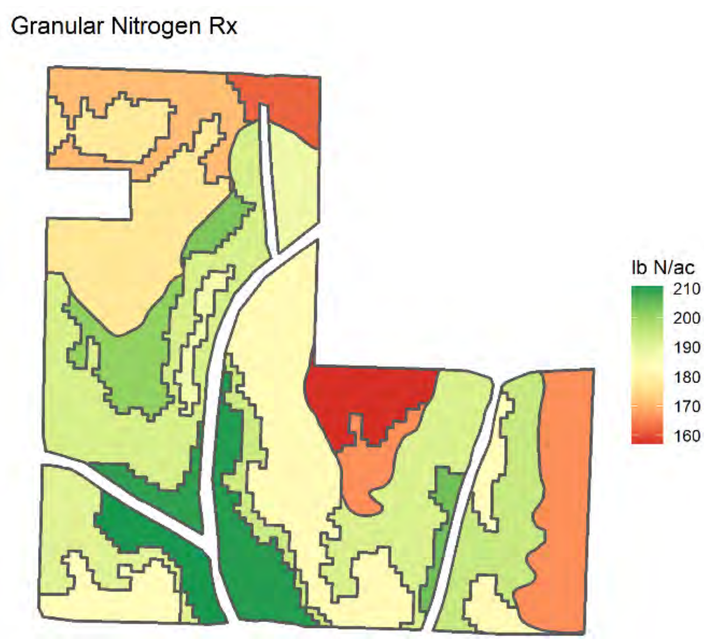


Figure 1. Granular N recommendation prescription (Rx) for corn pre-plant fertilizer application.

Three sets of N rate blocks were established using a variable-rate anhydrous prescription and in-season UAN application. Within each block, seven N rates were applied with total N ranging from 71 to 271 lb N/ac. These N rate blocks were placed in three distinct zones and used to determine the observed economic optimum nitrogen rate (EONR) for each zone using the best fit model. The EONR maximizes profit and minimizes N losses to the environment. Three zones were delineated based on historical yield data.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application, and yield monitor data were used to analyze differences between treatments.

Results and Summary:

Whole-field results

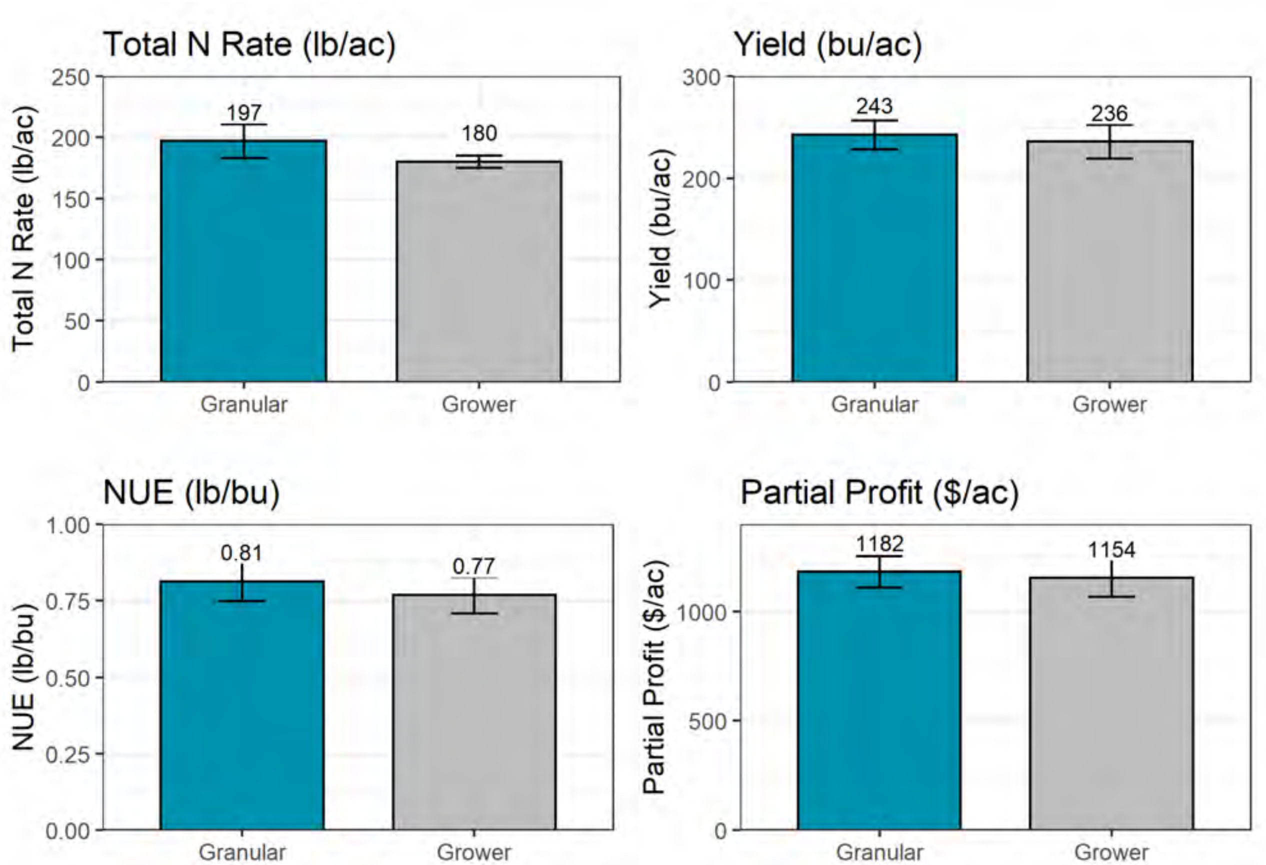


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management and Corteva Agriscience™ Granular model.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lb N/bu grain)	Partial Profit‡ ($/ac)
Grower N Management	180 B*	240 A	0.75 B	1,176 A
Granular	200 A	244 A	0.82 A	1,191 A
P-Value	0.005	0.233	0.007	0.406

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

- The total N rate for the grower's traditional management was 20 lb/ac lower than the Granular model on average (Figure 2); however, the Granular model distributed N applications site-specifically based on historic yield, soil texture, and elevation (Figure 1).
- Yield, N and profit were very similar between the grower's traditional management and the Granular model on a whole-field basis (Figure 2).
- Nitrogen use efficiency was good for both approaches, below the traditional 1.2 lb of N per bushel of grain assumed for yield-base N recommendations. The grower's typical N management had better nitrogen use efficiency than Granular on a whole-field basis.

Zone-specific results:

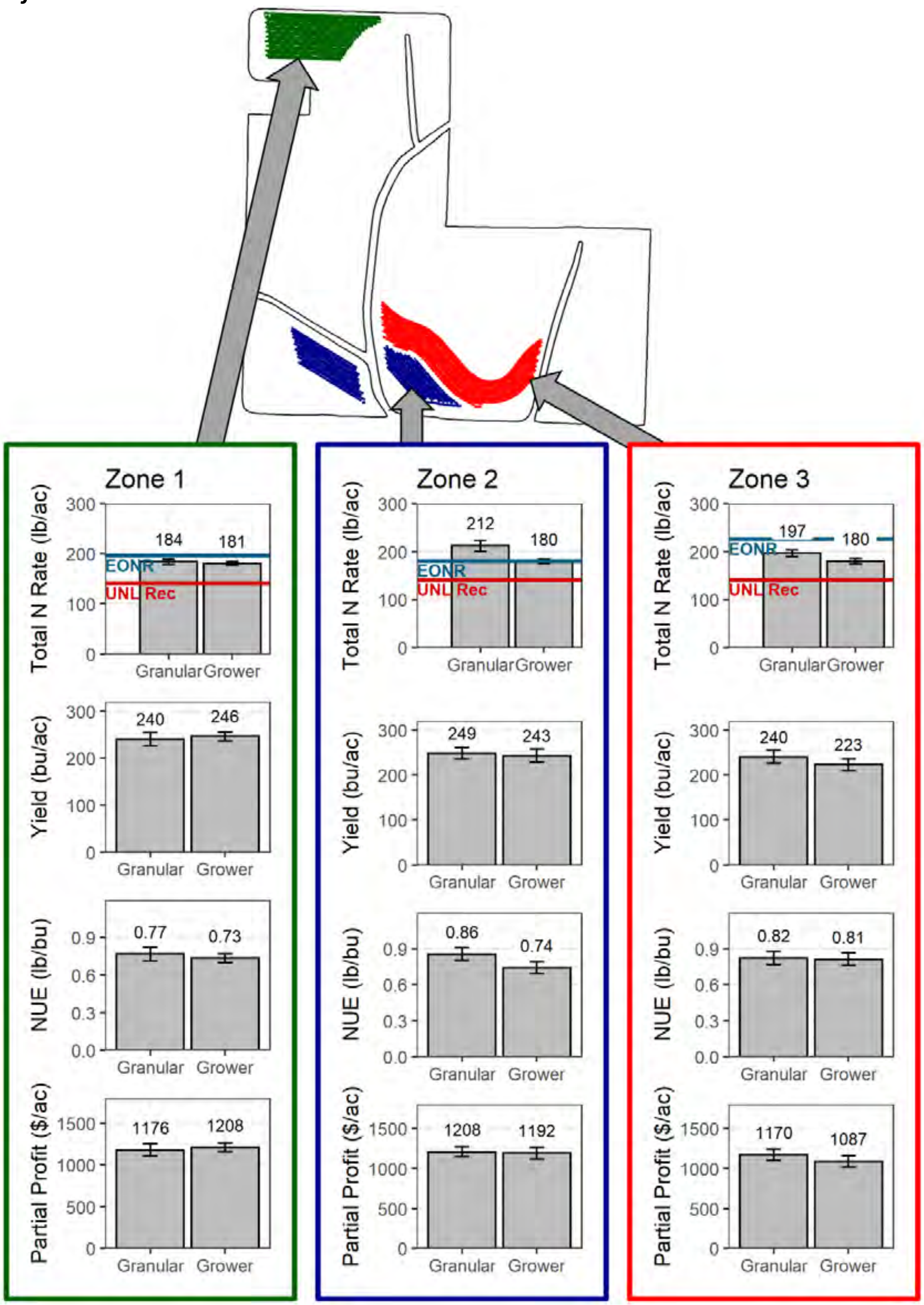


Figure 3. Total N rate applied by the grower and Corteva Agriscience™ Granular model in three contrasting zones in the field (displayed in green, blue, and red). For each zone, the observed economic optimum nitrogen rate (EONR) and the University of Nebraska–Lincoln recommendation (UNL Rec) are shown. Averages reported are means of all observations grouped by zone and will not be identical to results in table below, which are summarized by replication and zone.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lbs N/bu grain)	Partial Profit‡ ($/ac)
			Zone 1	
Grower N Management	181 A	246 A	0.73 B	1,208 A
Granular	184 A	240 A	0.77 A	1,176 A
P-Value	0.218	0.393	0.065	0.359
			Zone 2	
Grower N Management	180 B	243 A	0.74 B	1,192 A
Granular	212 A	249 A	0.86 A	1,208 A
P-Value	0.006	0.168	0.004	0.413
			Zone 3	
Grower N Management	180 B	223 A	0.81 A	1,087 A
Granular	197 A	240 A	0.82 A	1,170 A
P-Value	0.008	0.110	0.467	0.119

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

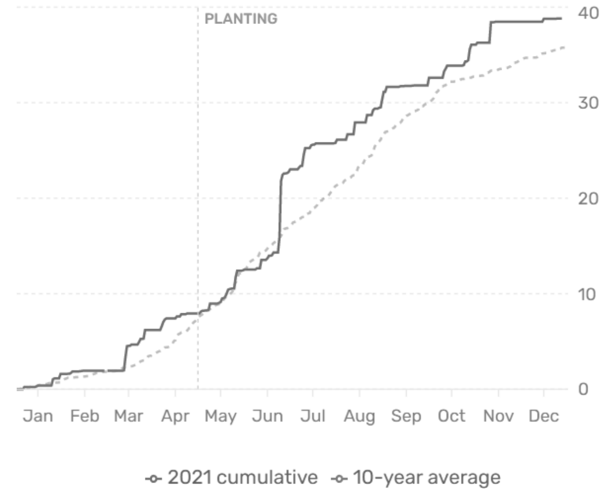
- EONR ranged from 180 to 198 lb N/ac for zones one and two; in zone three, the EONR was considerably higher, at 228 lb N/ac (Figure 3, blue horizontal line). The field received a 9+" rainfall in less than 24 hours in June; zone three consists of some terrace channels that were likely subject to more leaching and denitrification, resulting in a higher EONR.
- The UNL nitrogen recommendation was calculated for the field on a site-specific basis (Figure 3, red horizontal line). The residual nitrate input was held constant at 3.6 ppm. Organic matter was greater than 3% (the maximum input for the UNL algorithm) so a value of 3% was used for all three zones. Expected yield was kept constant across all zones at 230 bu/ac. The UNL nitrogen recommendation under-recommended N by 57 lb N/ac for zone one, 39 lb N/ac in zone two, and 87 lb N/ac in zone three.
- In zone one, both the grower and Granular model were very close to EONR (under-applied by approximately 15 lb N/ac). In zone two, the grower rate was identical to the EONR; the Granular model rate over-applied N by 32 lb N/ac. In zone three, both the grower and Granular model under-applied N by 31 lb N/ac (Granular) and 48 lb N/ac (grower) compared to the observed EONR (Figure 3). In zone three, the additional N applied by Granular resulted in an increase in yield. The range of EONR observed in this field indicates that a variable-rate N application may be required to optimize N fertilizer use.

This research was supported in part by Granular, Inc., a Corteva Agriscience™ Company and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Evaluating Corteva Agriscience™ Granular Nitrogen Model for Pre-Plant Variable-Rate Nitrogen Management in Non-Irrigated Corn

Study ID: 0416147202101
County: Richardson
Soil Type: Kennebec silt loam rarely flooded; Zook silty clay loam occasionally flooded
Planting Date: 4/30/21
Harvest Date: 9/25/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Pioneer® P1108Q
Reps: 4
Previous Crop: Soybean
Tillage: Strip-till

Irrigation: None
Rainfall (in):



Baseline Soil Samples, 0-6" (December 2020):

	pH	BpH	OM LOI %	Melich lll- P ppm	Nitrate – N ppm N	Bray P1 ppm	Sulfate-S ppm S	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
Zone 1	5.5	6.6	5.1	37	3.8	28	5	124	1528	152	3.3	146	35	50	15
Zone 2	6.8	6.7	-	42	-	23	16	119	1761	241	2.5	102	35	50	15
Zone 3	6.8	6.9	4.3	-	1.2	32	7	129	2137	238	2.0	130	22	57	20

Introduction: This study evaluated a crop model based N tool, Granular a subsidiary of Corteva Agriscience™, and compared it to the grower's traditional N management. Nitrogen applications on the field included:

1) 100 lb/ac 11-52-0, contributing 11 lb N/ac.

2) Anhydrous ammonia application applied on December 11, 2020, following either the grower's typical management of 180 lb N/ac or the variable-rate Granular prescription (Figure 1).

Figure 1. Granular N recommendation prescription (Rx) for corn pre-plant fertilizer application.

Four sets of N rate blocks were established using a variable-rate anhydrous prescription and in-season UAN application. Within each block, eight N rates were applied ranging from 71 to 249 lb N/ac. These N rate blocks were placed in three distinct zones and used to determine the observed economic optimum nitrogen rate (EONR) for each zone using the best fit model. The EONR maximizes profit and minimizes N losses to the environment. Three zones were delineated based on four years of yield data and elevation map.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application, and yield monitor data were used to analyze differences between treatments.

Results and Summary:

Whole-field results

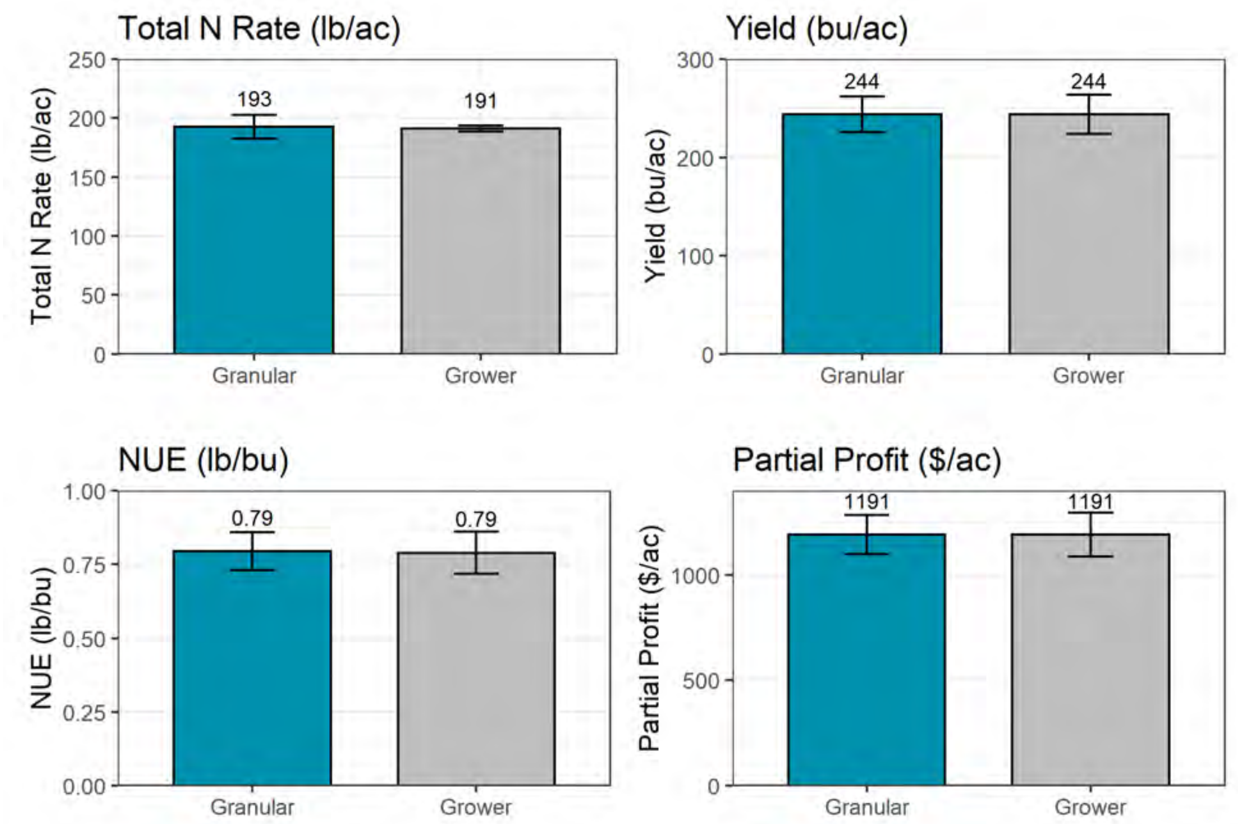


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management and Corteva Agriscience™ Granular model.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lbs N/bu grain)	Partial Profit‡ ($/ac)
Grower N Management	191 A*	244 A	0.79 A	1,191 A
Granular	193 A	244 A	0.79 A	1,191 A
P-Value	0.532	0.809	0.815	0.852

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

- The total N rate for the grower's traditional management and Granular model were very similar on average (Figure 2); however, the Granular model distributed N applications site-specifically based on historic yield, soil texture, and elevation (Figure 1).
- Yield, N use efficiency, and profit were also very similar between the grower's traditional management and the Granular model (Figure 2).
- Nitrogen use efficiency was good for both approaches, averaging 0.8 lb of N per bushel of grain produced, which is below the traditional 1.2 lb of N per bushel of grain assumed for yield-base N recommendations.

Zone-specific results

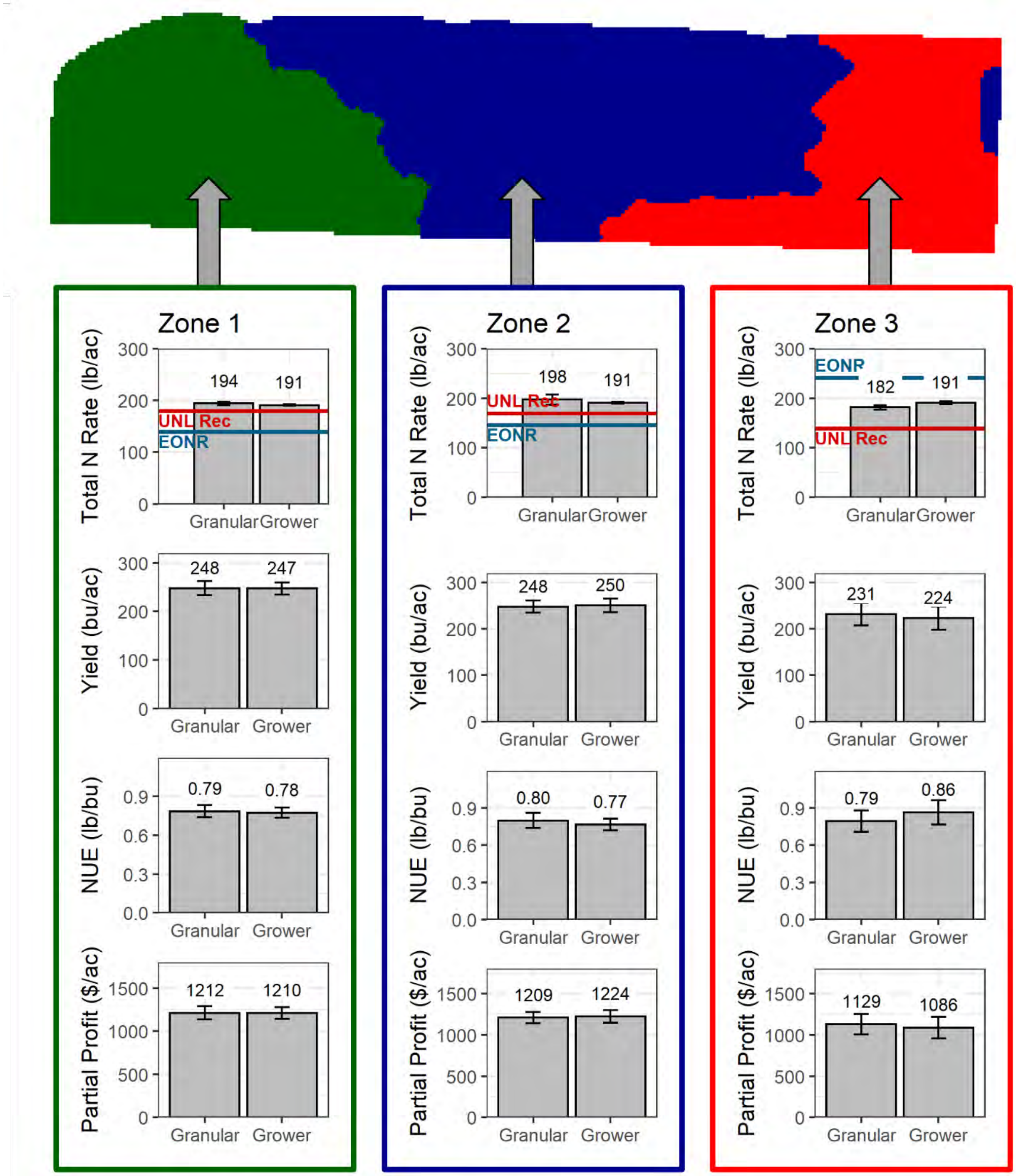


Figure 3. Total N rate applied by the grower and Corteva Agriscience™ Granular model in three contrasting zones in the field (displayed in green, blue, and red). For each zone, the observed economic optimum nitrogen rate (EONR) and the University of Nebraska–Lincoln recommendation (UNL Rec) are shown. Averages reported are means of all observations grouped by zone and will not be identical to results in table below, which are summarized by replication and zone.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lbs N/bu grain)	Partial Profit‡ ($/ac)
			Zone 1	
Grower N Management	191 B	246 A	0.78 A	1,205 A
Granular	195 A	248 A	0.79 A	1,214 A
P-Value	0.065	0.642	0.531	0.678
			Zone 2	
Grower N Management	191 A	250 A	0.77 A	1,223 A
Granular	194 A	248 A	0.79 A	1,210 A
P-Value	0.559	0.571	0.450	0.524
			Zone 3	
Grower N Management	191 A	229 A	0.844 A	1,116 A
Granular	183 B	241 A	0.768 B	1,182 A
P-Value	0.021	0.126	0.031	0.110

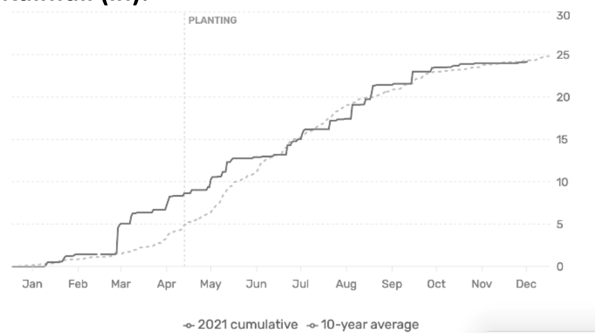
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

- EONR ranged from 139 to 146 lb N/ac for zones one and two; in zone three, the EONR was considerably higher, at 241 lb N/ac (Figure 3, blue horizontal line). The field was flooded following a 9+" rainfall in less than 24 hours in June; zone three is in the lower elevation portion of the field that remained underwater the longest and was likely subject to the most leaching and denitrification, resulting in a higher EONR.
- The UNL nitrogen recommendation was also calculated for the field on a site-specific basis (Figure 3, red horizontal line). The residual nitrate input was held constant at 3.6 ppm. Organic matter was greater than 3% (the maximum input for the UNL algorithm) so a value of 3% was used for all three zones. Expected yield was adjusted for each zone, with an expected yield of 280 bu/ac for zone 1, 267 bu/ac for zone 2, and 228 bu/ac for zone 3. The UNL nitrogen recommendation over-recommended N by 41 lb N/ac for zone one, it was within 30 lb N/ac of the EONR in zone two (over-recommended by 23 lb N/ac), and under-recommended N by 102 lb N/ac for zone three.
- Both the grower and Granular model over-applied by approximately 50 lb N/ac in zone one and two and under-applied N by 50 lb N/ac (Granular) and 58 lb N/ac (grower) in zone three compared to the observed EONR (Figure 3).

This research was supported in part by Granular, Inc., a Corteva Agriscience™ Company and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Evaluating Corteva Granular N Management on Irrigated Corn

Study ID: 0709047202107
County: Dawson
Soil Type: Cozad silty clay loam 0-1% slope; Hord silt loam 0-1% slope
Planting Date: 4/27/21
Harvest Date: 10/29/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1185Q
Reps: 7
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** Burndown: 3 qt/ac Vilify™ and 24 oz/ac Buccaneer® 5 Extra on 4/30/21
Foliar Insecticides: 6.4 oz/ac bifenthrin and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Irrigation: Gravity, Total: 12"
Rainfall (in):



Soil Tests (April 2, 2021):

	pH	Bp H	OM LOI %	Melich III -P ppm	Nitrate – N ppm N	Bray P1 ppm	Sulfate-S ppm S	------Melich III------ K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
Zone 1	8.7	6.9	3.2	204	5.5	155	53	818	2324	764	413	22.4	26	53	20
Zone 2	7.7	6.9	3.5	159	3.4	121	19	664	2215	459	102	17	28	51	20
Zone 3	8.5	6.9	2.0	49	4.0	37	57	351	1411	459	26	12.4	34	49	16
Zone 4	7.3	6.9	3.4	81	3.5	62	16	405	1805	304	61	12.9	30	55	14

Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. There are a number of digital agriculture tools available to provide site-specific, variable-rate, in-season N recommendations. This study evaluated a crop model based N tool, Granular a subsidiary of Corteva Agriscience™, and compared it to the grower's typical N management.

All treatments received 20 gal/ac of 32% UAN (71 lb N/ac) applied during strip-till on April 10, 2021, 1 gal/ac Altura™, 1 gal/ac ReaX™ K, and 0.25 gal/ac ReaX™ Zn (4.5 lb N/ac) applied in-furrow on 4/27/21, and 10 gal/ac 32% UAN (35.5 lb N/ac) applied with herbicide on April 30, 2021.

Grower Nitrogen Management: The grower's variable-rate side-dress N averaged approximately 90 lb N/ac and was applied on June 19, 2021. The average total N rate was 199 lb N/ac.

Granular Nitrogen Management: The Granular prescription for the entire field can be seen in Figure 1. The average N rate applied in the Granular strips was approximately 123 lb N/ac and the application was made on June 19, 2021. The average total N rate for the Granular N management (pre-plant and side-dress combined) was 234 lb N/ac.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application and yield monitor data were used to analyze differences between treatments.

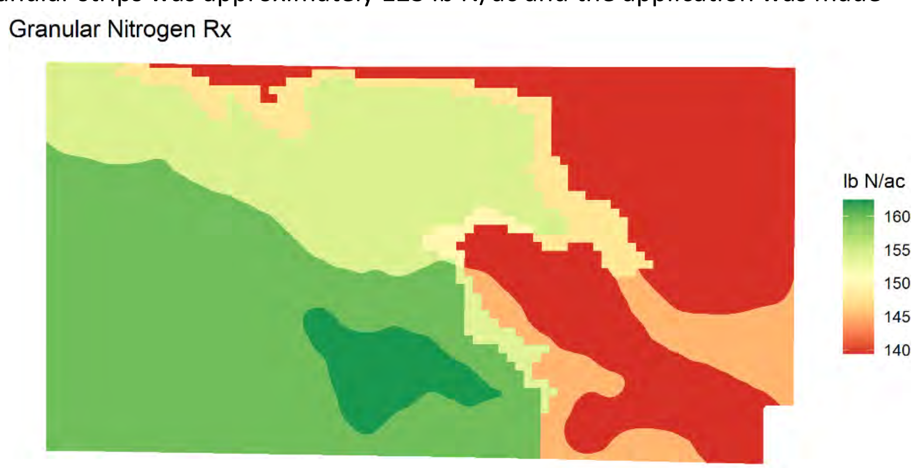


Figure 1. Granular recommendation prescription (Rx) for sidedress N application.

Results:

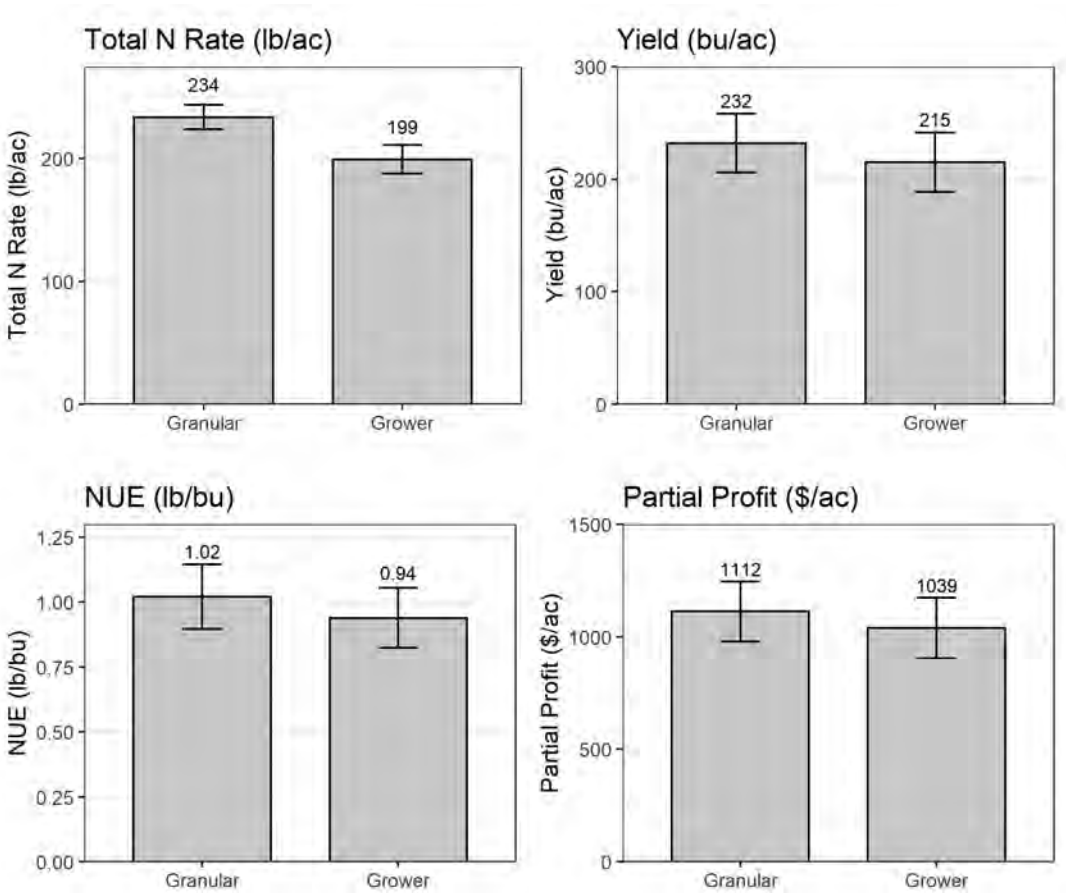


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management and the Granular model N management.

	Total N rate (lb/ac)	**Yield (bu/ac)†**	**Nitrogen Efficiency (lb N/bu grain)**	**Partial Profit‡ ($/ac)**
Grower N Management	199 B*	215 B	0.94 B	1,036 B
Granular N Management	234 A	232 A	1.02 A	1,114 A
P-Value	<0.0001	0.004	0.005	0.009

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

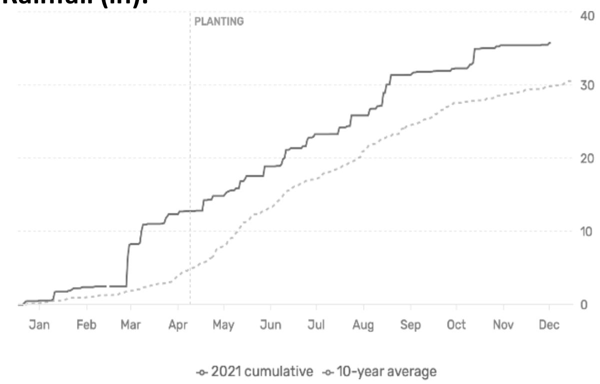
- The total N rate for the Granular N management was significantly more (35 lb N/ac) than the grower's traditional management.
- The Granular treatment resulted in an 17 bu/ac increase in yield and $78/ac increase in profit compared to the grower's traditional management.
- Nitrogen use efficiency was greater for the grower's N management. For both treatments, nitrogen use efficiency averaged below the traditional 1.2 lb of N per bushel of grain assumed for yield-based N recommendations.

This research was supported in part by Granular, Inc., a Corteva Agriscience™ Company and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Evaluating Corteva Granular N Management on Irrigated Corn

Study ID: 0389159202101
County: Seward
Soil Type: Hastings silt loam 1-3% slope
Planting Date: 4/23/21
Harvest Date: 10/1-2/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1185Q
Reps: 10
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 5.4 oz/ac Callisto®, 1.7 pt/ac StreliuS™ II, 0.66 lb/ac atrazine DF, 7.5 oz/ac Hot MES™, 2.9 oz/ac X-Celerate on 4/29/21 ***Post:*** 3 oz/ac Callisto®, 0.77 lb/ac atrazine DF, 3 pt/ac Warrant®, 2.5 oz/ac DiFlexx®, 1.6 lb/ac AMS, 10 oz/ac Hot MES™, and 3.3 oz/ac X-Celerate on 5/26/21

Note: Mild rootworm pressure
Irrigation: Pivot
Rainfall (in):



Soil Tests (November 4, 2020):

pH	BpH	OM LOI %	Melich III -P ppm	Nitrate – N ppm N	Sulfate-S ppm S	------Melich III (ppm)------ K	Ca	Mg	Na	CEC me/100g	Sand (%)	Silt (%)	Clay (%)
5.9	6.7	4.4	27	3.8	9	275	1905	107	15	13.5	23	57	20
2.2	6.6	3.5	17	6.5	11	230	1349	99	15	11.1	25	59	16
6.1	6.8	3.2	46	1.0	8	202	1689	124	22	11.7	23	55	22
5.8	6.7	3.3	9	5.7	8	182	1466	132	13	11.1	24	57	18

Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environment concerns and reduce profit. There are a number of digital agriculture tools available to provide site-specific, variable-rate, in-season N recommendations. This study utilized Granular by Corteva, a crop model based N tool for in-season N application, and compared it to the grower's typical pre-plant N management.

All treatments received a strip-till application on November 6, 2020 consisting of 10-34-0, Thio-Sul®, and ammoniated zinc that contributed 14 lb N/ac. At planting, all treatments received 35 lb N/ac as 9 gal/ac 32% UAN and 2.25 gal/ac ATS on April 23, 2021.

Grower Nitrogen Management: The grower's N application consisted of 163 lb N/ac applied as anhydrous ammonia on November 20, 2020. The total N application for the grower's treatment was 212 lb N/ac.

Granular Nitrogen Management: For the Granular N management, the anhydrous ammonia rate applied on November 20, 2020 was reduced to 76 lb N/ac. The Granular prescription for the entire field can be seen in Figure 1. The average N rate applied in the Granular strips was 113 lb N/ac and application was made on June 17, 2021. The average total N rate for the Granular N management (pre-plant and sidedress combined) was 238 lb N/ac.

Figure 1. Granular recommendation prescription (Rx) for sidedress N application.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application and yield monitor data was used to analyze differences between treatments.

Results:

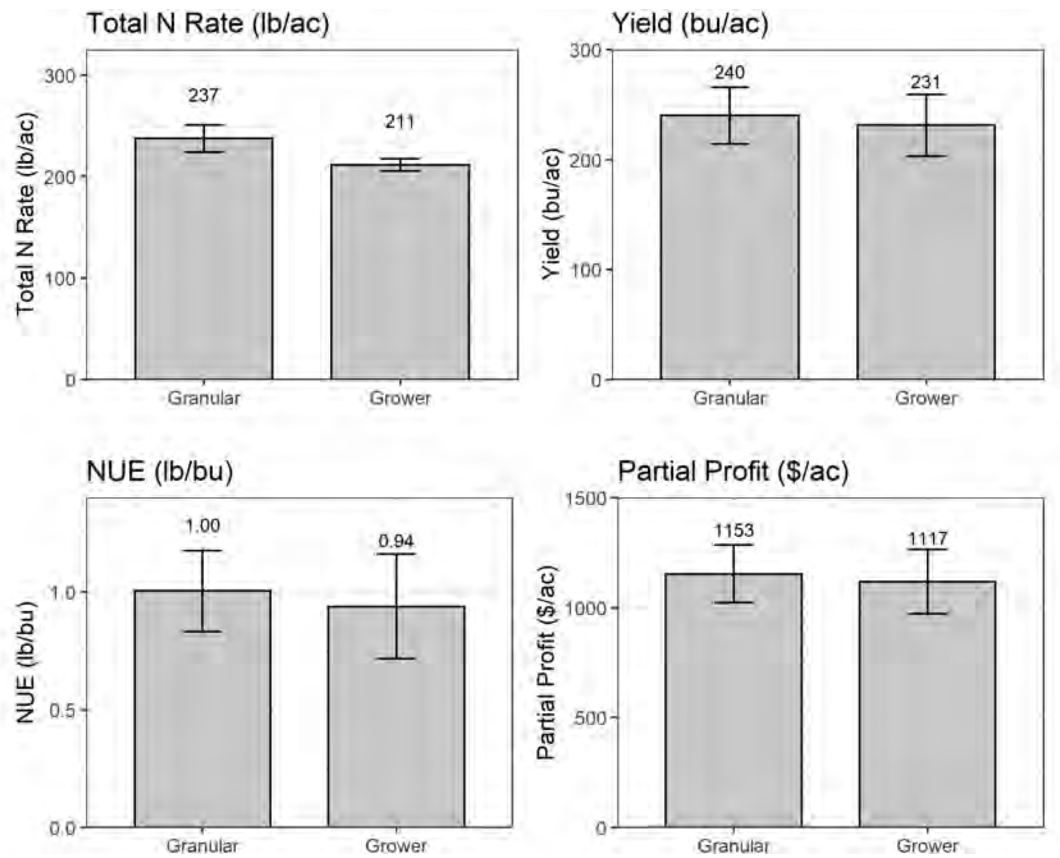


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management and the Granular model N management.

	Total N rate (lb/ac)	**Yield (bu/ac)†**	**Nitrogen Efficiency (lb N/bu grain)**	**Partial Profit ($/ac)‡**
Grower N Management	212 B*	230 B	0.94 B	1,111 B
Granular N Management	238 A	240 A	1.00 A	1,154 A
P-Value	<0.0001	0.0001	<0.0001	0.0003

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

Summary:

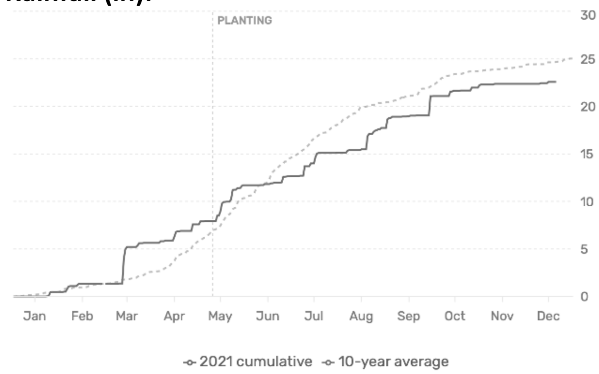
- The total N rate for the Granular N management was significantly more (26 lb N/ac) than the grower's traditional management.
- The Granular treatment resulted in an 10 bu/ac increase in yield and $43/ac increase in profit compared to the grower's traditional management.
- Nitrogen use efficiency was greater for the grower's N management. For both treatments, nitrogen use efficiency averaged below the traditional 1.2 lb of N per bushel of grain assumed for yield-based N recommendations.

This research was supported in part by Granular, Inc., a Corteva Agriscience™ Company and an award from the USDA-NRCS Conservation and Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Evaluating Corteva Agriscience™ Granular and Sensor-based In-season N Management on Irrigated Corn

Study ID: 1231111202101
County: Lincoln
Soil Type: Valentine fine sand 9-24% slopes; Anselmo fine sandy loam 1-3% slope
Planting Date: 5/10/21
Harvest Date: 10/16/21
Seeding Rate: 31,000
Row Spacing (in): 30
Hybrid: Brevant® B04292
Reps: 5
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 2.1 qt/ac FulTime® NXT, 4 qt/ac AAtrex®, and 12 oz/ac Agri Star® on 5/22/21 ***Post:*** 32 oz/ac Roundup PowerMAX®, 1.25 qt/ac Resicore®, and 8 oz/ac DiFlexx®

Seed Treatment: Poncho® 250
Foliar Insecticides: None
Foliar Fungicides: None
Note: Hail event just before VT
Irrigation: Pivot, Total: 8.582"
Rainfall (in):



Soil Tests (April 2021):

Soil pH 1:1	OM LOI-%	Mehlich III-P ppm	Nitrate ppm N	% Sand	% Silt	%Clay	Mehlich III K ppm	Mehlich III Ca ppm	Mehlich III Mg ppm	Mehlich III Na ppm	Mehlich III Zn ppm	Mehlich III Fe ppm	Mehlich III Mn ppm	Mehlich III Cu ppm	Sum of Cations meq/100g	% Base Saturation H	% Base Saturation K	% Base Saturation Ca	% Base Saturation Mg	% Base Saturation Na
6.3	1.8	46	1	80	10	10	117	810	102	9	3.8	100	29	0.5	6	10	7.6	67.5	14.2	0.7
6.6	2.0	31	3.5	70	20	10	291	1045	122	9	4.2	81	32	0.5	7.4	5.4	10.1	70.6	13.7	0.5
6.1	0.9	33	2.7	78	12	10	67	721	71	9	3.3	66	18	0.3	5.1	13.7	3.4	70.7	11.6	0.8

Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. There are a number of digital agriculture tools available to provide site-specific, variable-rate, in-season N recommendations. This study evaluated two tools: 1) a crop canopy sensor-based N recommendation using the Trimble® GreenSeeker® and 2) a crop model based N tool, Granular by Corteva Agriscience™. The tools were compared to the growers traditional N management.

All treatments received a variable rate of chicken litter (average N contribution of 17 lb N/ac), 50 lb N/ac applied as 32% UAN at planting, and 25 lb N/ac applied at R1 through the pivot.

Grower Nitrogen Management: The grower's varaible-rate side-dress N averages 94 lb N/ac and was applied as side-dress UAN on June 25, 2021. The total N rate for the grower's N management was 186 lb N/ac.

Sensor-based Nitrogen Management: Crop canopy sensing and application occurred on June 25, 2021. The average N rate applied based on the in-season sensing was 96 lb N/ac. The average total N rate for the sensor-based N management was 188 lb N/ac.

Granular Nitrogen Management: The Granular prescription for the entire field can be seen in Figure 1. The average N rate applied in the Granular strips was approximiately 129 lb N/ac. The average total N rate for the Granular N management (all N applications combined) was 220 lb N/ac.

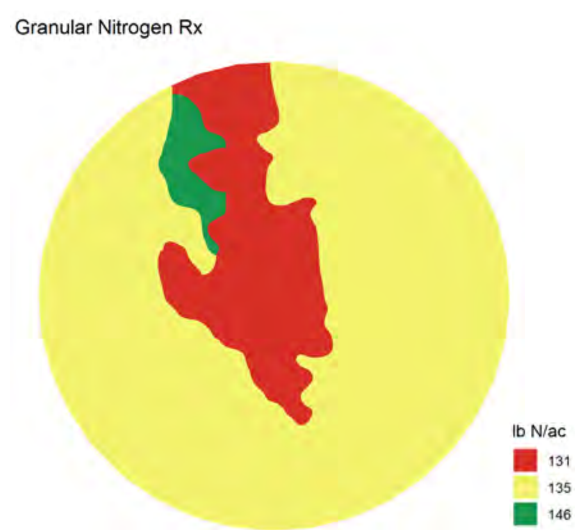


Figure 1. Granular recommendation prescription (Rx) for side-dress N application.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application and yield monitor data were used to analyze differences between treatments.

Results:

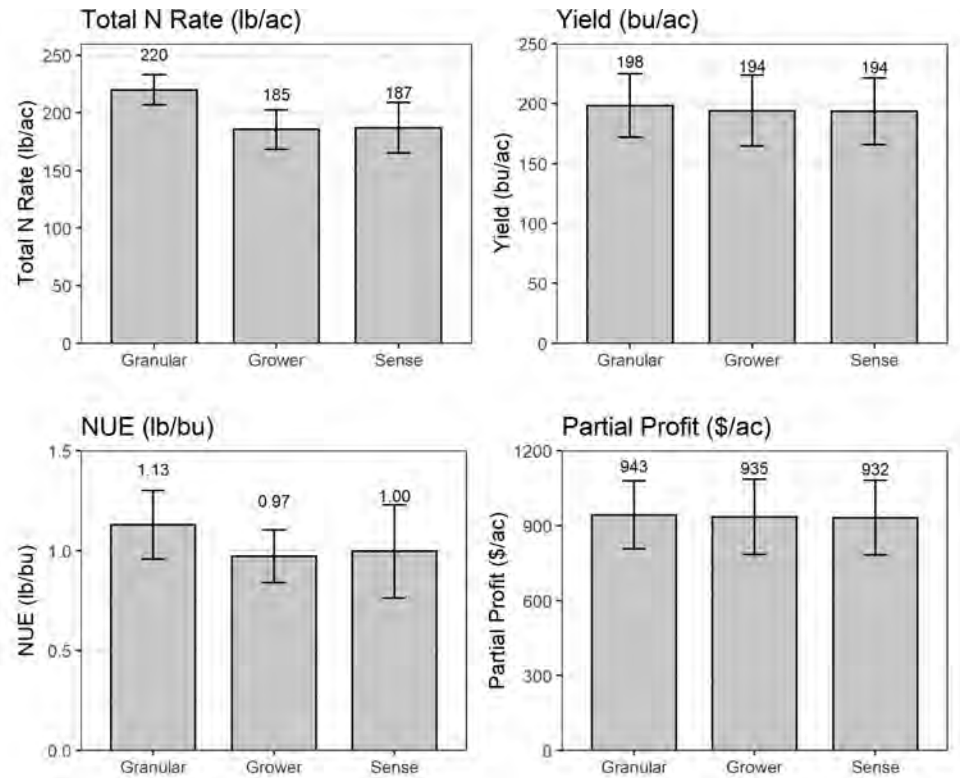


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management, Granular model N management, and sensor-based N management.

	Total N rate (lb/ac)	**Yield (bu/ac)†**	**Nitrogen Efficiency (lb N/bu grain)**	**Partial Profit‡ ($/ac)**
Grower N Management	186 B*	193 A	0.98 B	931 A
Sense N Management	188 B	193 A	1.00 B	930 A
Granular N Management	220 A	197 A	1.14 A	937 A
P-Value	<0.0001	0.302	0.0001	0.866

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

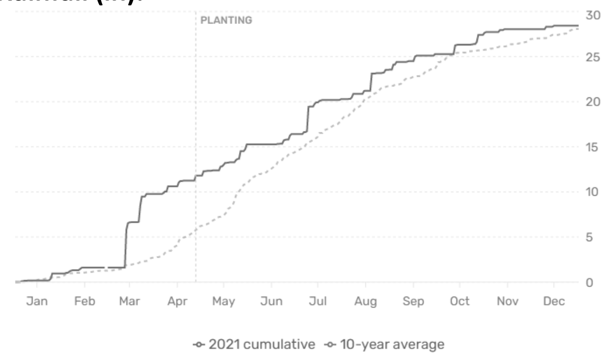
Summary:

- The total N rate for the Granular N management was significantly more (34 lb N/ac) than the grower's traditional management. On average, the sensor-based N management was very similar to the grower's traditional management.
- There were no yield or partial profit differences between the three N management strategies evaluated.
- Nitrogen use efficiency was greater for the grower's traditional N management and sensor-based N management compared to the Granular N management. The nitrogen use efficiency for all treatments was below the traditional 1.2 lb of N per bushel of grain assumed for yield-based N recommendations.

This research was supported in part by Granular, Inc., a Corteva Agriscience™ Company and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Evaluating Adapt-N and Sensor-based In-season N Management on Irrigated Corn

Study ID: 0908079202202
County: Hall
Soil Type: Detroit silt loam 0-1% slope; Hord silt loam 0-1% slope; Hall silt loam 3-6% slopes
Planting Date: 4/27/21
Harvest Date: 10/18/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: AgriGold® 6652VT2
Reps: 7
Previous Crop: Soybean
Tillage: Strip-till
Herbicides: ***Pre:*** Burndown: 64 oz/ac glyphosate and 8 oz/ac DiFlexx® on 4/30/21 ***Post:*** 4 oz/ac Status®, 32 oz/ac glyphosate, and 2 pt/ac Warrant® on 6/5/21
Seed Treatment: Acceleron® and Poncho® 1250 + VOTiVO®
Foliar Insecticides: None
Foliar Fungicides: 15.4 oz/ac Xyway™ LFR® applied in-furrow
Note: 5% wind damage with goose-necking
Irrigation: Pivot, Total: 11"
Rainfall (in):



Soil Tests (April 2021):

								--------Mehlich III---------				-------Mehlich III---------					--------% Base Saturation-------				
Zone	Soil pH 1:1	OM LOI-%	Melich III- P ppm	KCl Nitrate ppm N	% Sand	% Silt	% Clay	K ppm	Ca ppm	Mg ppm	Na ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Sum of Cations me/100g	H	K	Ca	Mg	Na
1	7.5	3.3	22	1.3	29	55	14	379	1737	190	27	5.1	60	68	0.8	11.4	0	8.5	76.2	13.9	13.9
1	7.5	2.8	14	1	39	43	16	394	2010	244	28	2.7	52	54	0.7	13.2	0	7.7	76.1	15.4	0.9
2	6.4	3.6	50	1	31	47	20	505	2143	261	26	4.8	92	89	1.2	15.7	8.9	8.2	68.2	13.9	0.7

Introduction: Nitrogen fertilizer is a significant input in corn systems. Additionally, N losses through leaching, volatilization, and denitrification pose environmental concerns and reduce profit. There are a number of digital agriculture tools available to provide site-specific, variable-rate, in-season N recommendations. This study evaluated two tools: 1) a crop canopy sensor-based N recommendation using the Ag Leader® OptRx® sensor system and 2) a crop model based N tool, Adapt-N by Yara North America, Inc. The tools were compared to the grower's traditional N management.

All treatments received 150 lb/ac of 11-52-0 (16.5 lb N/ac) and 10 lb/ac 35.5% zinc broadcast in fall 2020 with cover crop application and 20 gal/ac of 32% UAN (70 lb N/ac) applied pre-emerge in early April.

Grower Nitrogen Management: 22 gal/ac of 32% UAN (79 lb N/ac) was applied as side-dress on June 28, 2021. The total N rate was 166 lb N/ac.

OptRx® Sensor-based Nitrogen Management: Crop canopy sensing and application occurred on June 28, 2021. The average N rate applied based on the in-season sensing was 69 lb N/ac. The average total N rate for the sensor-based N management was 155 lb N/ac.

Adapt-N Nitrogen Management: The grower's management, soil types, soil organic matter (OM) and expected yields by management zones were input into the Adapt-N tool. The Adapt-N prescription for the entire field can be seen in Figure 1. The average N rate applied in the Adapt-N strips was 49 lb N/ac. The average total N rate for the Adapt-N management (pre-plant and side-dress combined) was 135 lb N/ac.

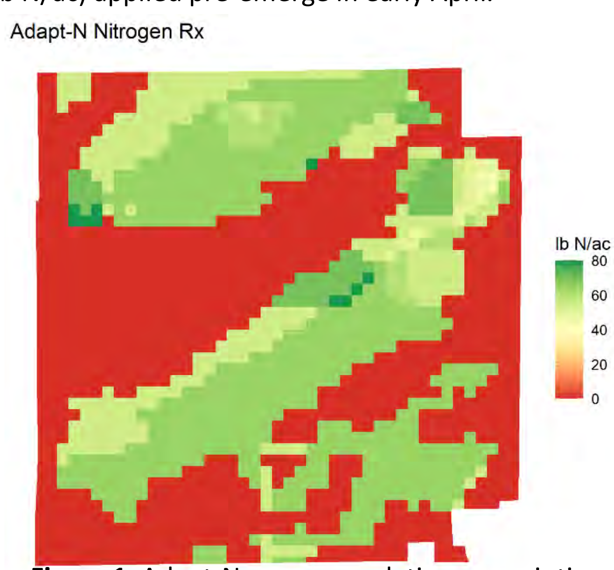


Figure 1. Adapt-N recommendation prescription (Rx) for side-dress N application.

Additionally, four sets of N rate blocks were established using the in-season UAN application. Within each block, six N rates were applied with total N ranging from 86 to 259 lb N/ac. These N rate blocks were placed in two distinct zones and used to determine the observed economic optimum nitrogen rate (EONR) for each zone using the best fit model. The EONR maximizes profit and minimizes N losses to the environment. The zones were delineated based on historical yield data.

As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application and yield monitor data was used to analyze differences between treatments.

Results and Summary:

Whole-field results

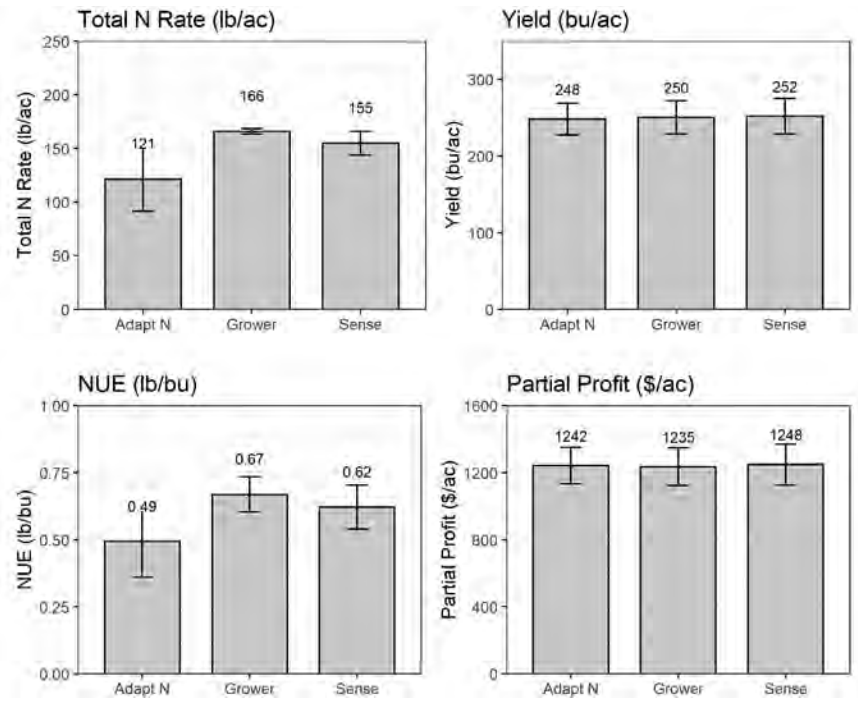


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management, sensor-based N management, and the Adapt-N model N management.

	Total N rate (lb/ac)	**Yield (bu/ac)†**	**Nitrogen Efficiency (lb N/bu grain)**	**Partial Profit‡ ($/ac)**
Grower N Management	166 A*	250 A	0.67 A	1,231 A
Sense N Management	155 A	251 A	0.63 AB	1,241 A
Adapt-N Management	135 B	245 A	0.55 B	1,239 A
P-Value	0.0002	0.876	0.019	0.983

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

- The total N rate for the grower's traditional management and OptRx® sensor-based N management were very similar on average (Figure 2). The Adapt-N model used significantly less N (31 lb N/ac less than the grower's traditional management). Many areas of the Adapt-N prescription recommended no additional in-season N application (Figure 1).
- Yield and profit were not statistically different between the three treatments evaluated (Figure 2).
- The Adapt-N management resulted in improved nitrogen use efficiency compared to the grower's traditional management. However, nitrogen use efficiency was excellent for all three treatments, with all approaches averaging below the traditional 1.2 lb of N per bushel of grain assumed for yield-based N recommendations.

Zone-specific results

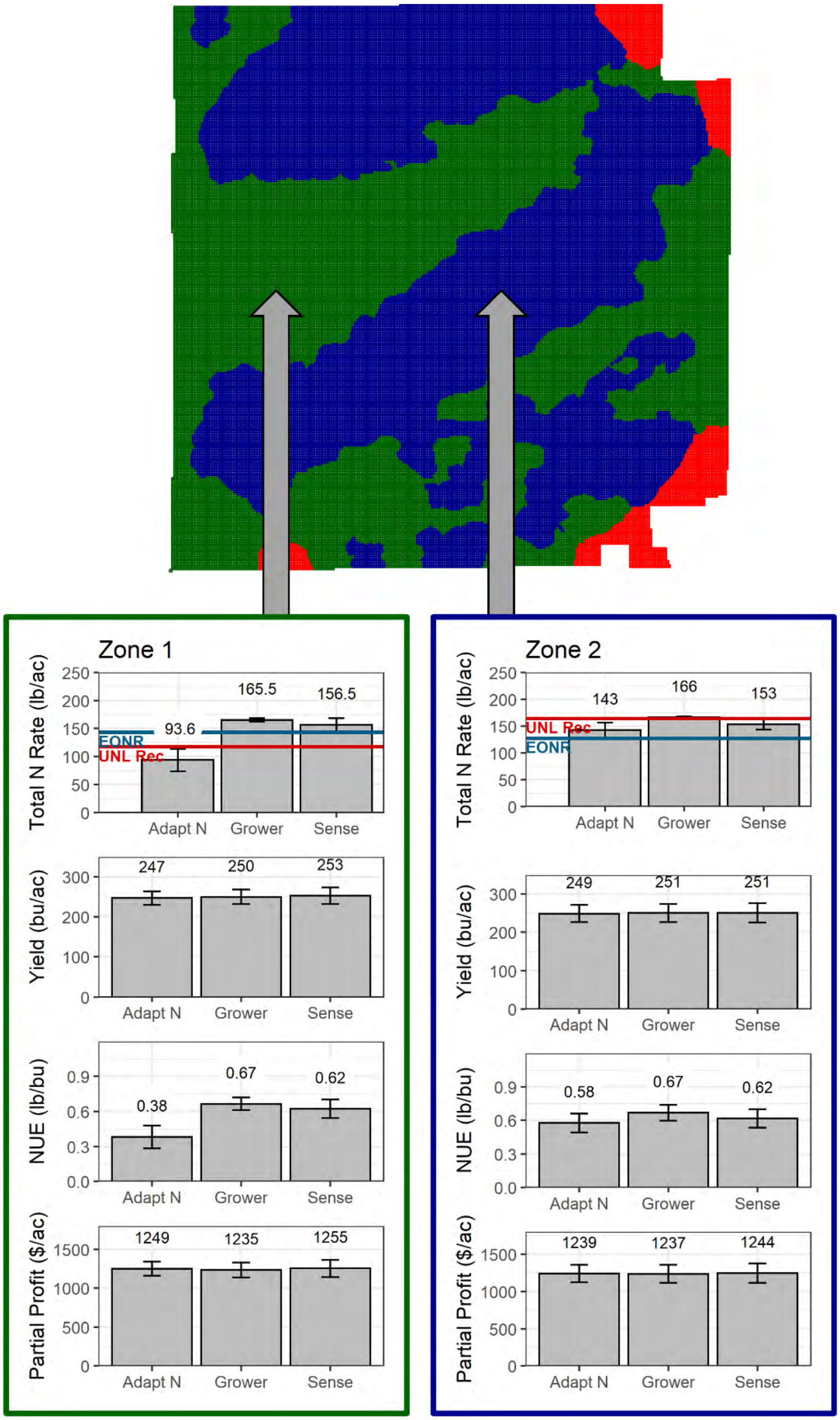


Figure 3. Total N rate applied by the grower and Corteva Agriscience™ Granular model in three contrasting zones in the field (displayed in green, blue, and red). For each zone, the observed economic optimum nitrogen rate (EONR) and the University of Nebraska–Lincoln recommendation (UNL Rec) are shown. Averages reported are means of all observations grouped by zone and will not be identical to results in table below, which are summarized by replication and zone.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lbs N/bu grain)	Partial Profit‡ ($/ac)
			Zone 1	
Adapt-N Management	117 B*	240 A	0.493 B	1,208 A
Grower N Management	165 A	246 A	0.677 A	1,215 A
Sense N Management	158 A	248 A	0.644 A	1,225 A
P-Value	0.0004	0.754	0.010	0.951
			Zone 2	
Adapt-N Management	144 C	251 A	0.580 B	1,247 A
Grower N Management	166 A	252 A	0.664 A	1,246 A
Sense N Management	152 B	253 A	0.608 AB	1,257 A
P-Value	<0.0001	0.969	0.065	0.978

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $0.40/lb N.

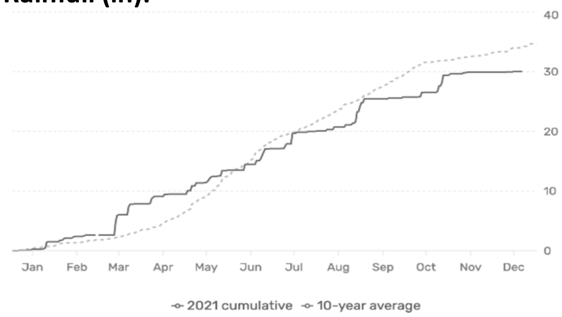
- EONR ranged from 127 in zone two to 143 lb N/ac in zone one (Figure 3, blue horizontal line).
- The UNL nitrogen recommendation was also calculated for the field on a site-specific basis (Figure 3, red horizontal line). The residual nitrate input was held constant at 3.6 ppm. Organic matter was greater than 3% (the maximum input for the UNL algorithm) so a value of 3% was used for all three zones. Expected yield was adjusted for each zone using elevation and two-years of historical yield, with an expected yield of 200 bu/ac for zone 1 and 260 bu/ac for zone 2. The UNL nitrogen recommendation was within 30 lb n/ac of the EONR in zone one (under-recommended N by 26 lb N/ac) and over-recommended N by 37 lb N/ac in zone two.
- In zone one, compared to EONR, the grower and sense management over-applied N, while the Adapt-N recommendation under-applied N. In zone two, compared to EONR, the grower and sense management over-applied N, while the Adapt-N management was within 10 lb N/ac of the EONR.
- While EONR was higher for zone one, the Adapt-N model recommended less N in this zone, likely due to the lower expected yield in zone one. An expected yield of 200 bu/ac for zone one and 260 bu/ac for zone two was input into Adapt-N. Expected yield was determined using historical yield and the grower's experience. Zone one yielded higher than expected (approximately 240-250 bu/ac); this demonstrates the importance of an accurate and informed yield prediction and model inputs.

This research was supported in part by Adapt-N, Yara North America, Inc., and an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Sensor-based In-season N Management for Winter Wheat

Study ID: 1268067202201
County: Gage
Soil Type: Nodaway silt loam 0-2% slope; Judson silt loam 2-6% slopes; Otoe silty clay loam 6-11% slopes; Wymore silty clay loam 2-6% slopes
Planting Date: 10/7/20
Harvest Date: 7/6-11/21
Seeding Rate: 1.2 million
Row Spacing (in): 7.5
Hybrid: AgriPro® SY Wolverine and Zenda
Reps: 3
Previous Crop: Soybean
Tillage: No-till
Herbicides: 0.8 oz/ac Affinity® BroadSpec on 4/1/21

Seed Treatment: Vibrance® Extreme
Foliar Insecticides: None
Foliar Fungicides: 13.7 oz/ac Miravis® Ace aerially applied on 5/27/21
Irrigation: None
Rainfall (in):



Soil Tests (October 1, 2020):

	pH	BpH	OM LOI %	Nitrate – N ppm N	Melich 3 P ppm	Sulfate-S ppm S	-------Melich III------- K	Ca	Mg	Na	CEC me/100g	% Base Saturation H	K	Ca	Mg	Na
Bottom	6.6	-	3.7	3.7	45	4	210	2997	350	15	18.5	0	3	81	16	0
Hill	6.4	6.7	3.7	4.8	26	6.3	248	2852	529	12	22.4	13	3	64	20	0

Introduction: This study evaluated a sensor-based N management strategy for winter wheat comparedd to the grower's traditional N management. The entire field received 50 lb/ac potash, 50 lb/ac AMS, and 100 lb/ac MAP on October 13, 2020, for a total of 22 lb N/ac.

- The grower's N management applied 66 lb N/ac as 32% UAN (3-orifice StreamJet nozzles) at greenup on April 7, 2021.
- The sensor-based N management utilized a high-clearancce applicator equipped with Ag Leader® OptRx® sensors. The field was sensed and variable-rate N as 32% UAN (3-orifice StreamJet nozzles) was applied on April 21, 2021, at jointing (Figure 1). An average of 93 lb N/ac was applied.

The study took place in two contrasting landscape positions:

- a terraced hillside with Otoe silty clay loam soil, 6 to 11 percent slopes, eroded and Judson silt loam 2 to 6 percent slopes
- a flat bottom area near a creek with Nodaway silt loam, occasionally flooded.

Three sets of N rate blocks were established on April 7, 2021, using a variable-rate prescription. Within each block, four N rates were applied with total N ranging from 22 to 122 lb N/ac. These N rate blocks were placed in the distinct landscape positions and used to determine the observed economic optimum nitrogen rate (EONR). As-applied fertilizer maps were used to evaluate the accuracy of fertilizer application and yield monitor data were used to analyze differences between treatments.

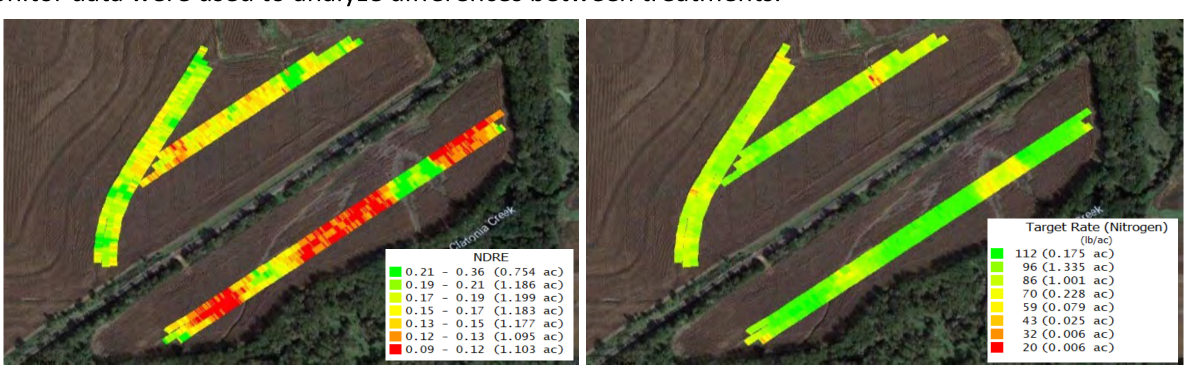


Figure 1. NDRE values from Ag Leader® OptRx® sensors (left) and variable-rate nitrogen directed by sensors (right) applied on April 21, 2021.

Results:

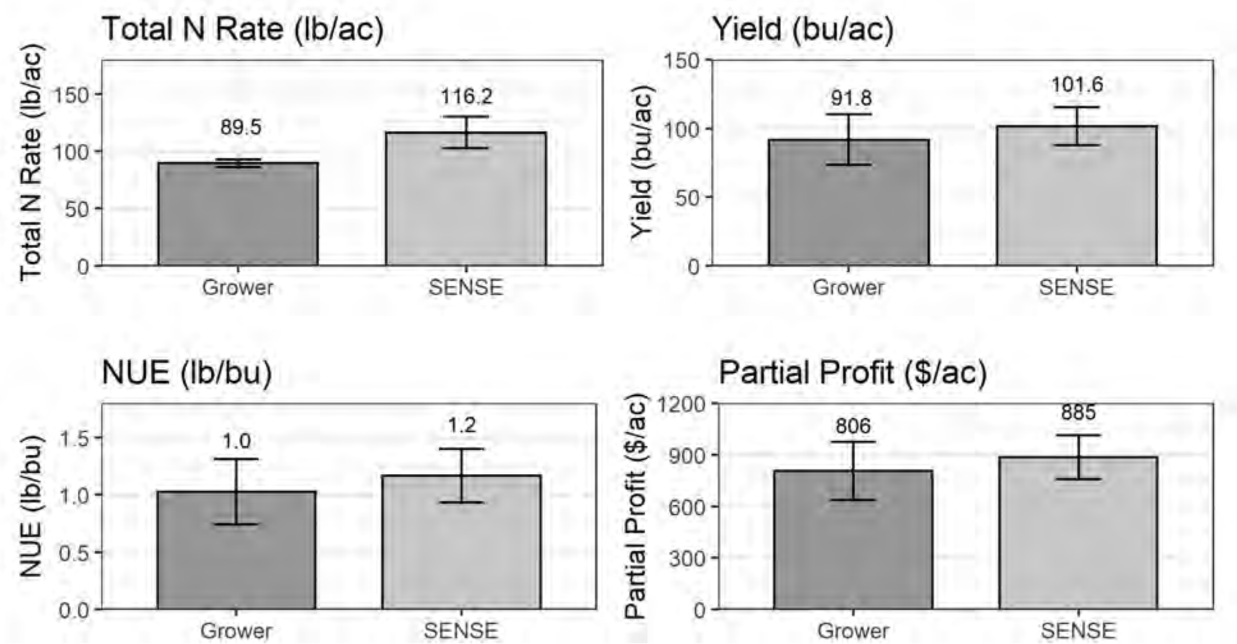


Figure 2. Total N rate, yield, nitrogen use efficiency (NUE), and partial profit for the grower's traditional management and sensor-based N management. Averages reported are means of all observations and will not be identical to results in table below, which are summarized first by replication.

	Total N rate (lb/ac)	Yield (bu/ac)†	Nitrogen Efficiency (lb N/bu grain)	Partial Profit‡ ($/ac)
Grower	89 B*	91 A	1.16 A	799 A
SENSE	115 A	101 A	1.04 A	878 A
P-Value	0.019	0.232	0.312	0.272

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13.5% moisture.
‡Marginal net return based on $7.05/bu wheat and $0.40/lb N.

Summary:

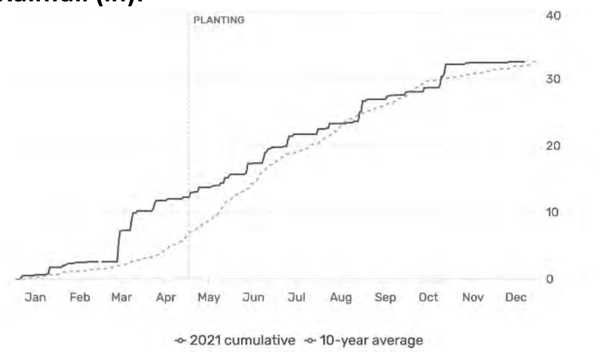
- The average stand count in the field was 730,000 plants/ac on November 5, 2020. A mid-October wind event and the proceeding late fall drought caused variable stand on the hills.
- The sensor-based approach applied 25 lb N/ac more than the grower's traditional management.
- After the grower N application on April 7, rainfall events occurred from April 8-10, but after the sensor-based application on April 21, a rainfall event did not occur until May 3, which potentially put the sensor-based application at a disadvantage for volatilization losses and delayed N uptake.
- Yield, nitrogen use efficiency, and partial profit were not significantly different between the grower's traditional management and the sensor-based approach.
- The EONR for the field varied based on landscape position; the EONR for the hill was 95 lb N/ac, whereas the EONR for the bottom was 151 lb N/ac. This showed that the grower's N rate may be close to sufficient in the hill position, but more N may be needed in the bottom landscape position, demonstrating that a variable-rate management approach may be advantageous.
- This field and area were abnormally dry according to the U.S. Drought Monitor (droughmonitor.unl.edu) during grain fill in June and confirmed by WATERMARK™ Soil Moisture Sensor readings, which may have limited yield potential and N uptake.

This research was supported in part by an award from the USDA-NRCS Conservation Innovation Grants, On-Farm Conservation Innovation Trials, award number NR203A750013G014.

Non-Traditional Products

Evaluating Verdesian SEED+™ Graphite Treatment

Study ID: 0085141202104
County: Platte
Soil Type: Gibbon silt loam 0-2% slope; Gibbon silt loam occasionally flooded; Wann loam occasionally flooded
Planting Date: 5/1/21
Harvest Date: 10/7/21
Seeding Rate: 33,200
Row Spacing (in): 30
Hybrid: DEKALB® DKC59-82
Reps: 5
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 2 qt/ac Degree Xtra®, 7 oz/ac Sterling® Blue®, and 3 oz/ac Balance® Flexx on 5/10/21
Seed Treatment: Acceleron® Elite
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 50 lb/ac potash, 45 lb/ac 11-52-0, and 45 lb/ac 12-40-0-10S-1Zn (MicroEssentials® SZ®) on 12/11/20; 8 gal/ac 32% UAN (28 lb N/ac) and 2 gal/ac thiosulfate dribbled behind planter on 5/1/21; 4.75 gal/ac Kugler LS 624 (6-24-6), 1 pt/ac zinc, and 1 pt/ac Kugler KS MicroMax applied in-furrow on 5/7/21; 41 gal/ac 32% UAN (146 lb N/ac), and 5 gal/ac thiosulfate applied with 360 Y-Drop® on 6/10/21
Irrigation: Gravity
Rainfall (in):



Introduction: This study evaluated standard graphite applied in the planter box compared to Verdesian SEED+™ Graphite planter box treatment. Verdesian SEED+™ Graphite contains fermentation metabolites to improve germination, crop emergence, seedling vigor, shoot and root hair development, and plant tolerance under abiotic stress. The product is a blend of talc and graphite and is applied at 8 oz/cwt of seed. The planter used was a John Deere® 1720 equiped with Precision Planting® vSet® meters and Precision Planting® SpeedTube® seed delivery system.

Results:

	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Verdesian Seed+™ Graphite	17.0 A*	261 A	1,354 A
Check	16.8 B	259 A	1,345 A
P-Value	0.007	0.235	0.302

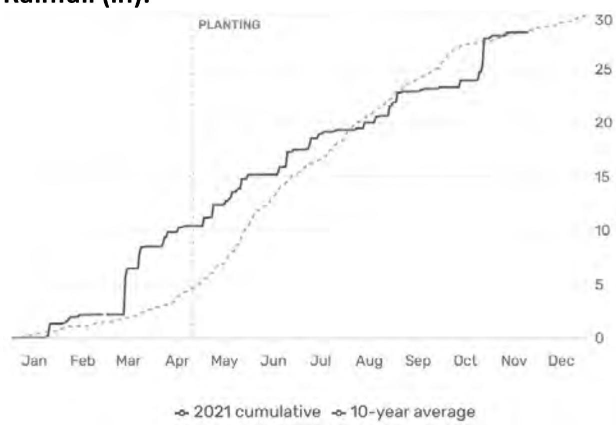
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $0.50/ac for regular graphite (check), and $2.00/ac for Verdisian SEED+™ Graphite.

Summary:
- There was no difference in yield or net return between the planter box treatments evaluated.
- Grain moisture was slightly higher for the Verdesian SEED+™ Graphite treatment compared to the standard graphite check.

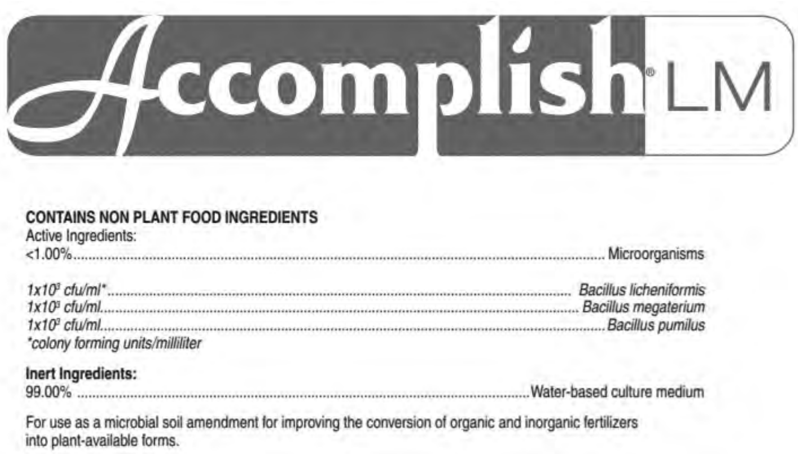
Accomplish® LM on Corn

Study ID: 0620059202101
County: Fillmore
Soil Type: Crete silt loam 0-1% slope; Butler silt loam 0-1% slope; Fillmore silt loam drained, 0-1% slopes
Planting Date: 4/24/21
Harvest Date: 10/8/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Brevant® B08L92AML
Reps: 9
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 3 qt/ac Lexar® EZ on 4/12/21
Post: 1 qt/ac Acuron® and 1 qt/ac Durango® DMA® on 6/3/21
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 31 gal/ac UAN 32% (110 lb N/ac) on 4/3/21; 4.5 gal/ac 6-24-6 with Accomplish® LM in-furrow (5-6" from corn row) on 4/24/21; 20 gal/ac UAN 32% (71 lb N/ac) on 6/12/21 via side-dress dribbled next to corn row at time of hilling
Irrigation: Pivot, Total: 6.9"
Rainfall (in):



Introduction: In this study the grower looked at the effect of Accomplish® LM on corn yield and economics compared to an untreated check. Accomplish® LM is described as a biochemical fertilizer catalyst designed to be used with liquid fertilizer to increase fertilizer availability and improve plant performance. In this study Accomplish® LM was applied at a rate of 1 qt/ac in-furrow at planting with 6-24-6 starter fertilizer and was compared to 6-24-6 starter fertilizer without Accomplish® LM. Product information is below.



Product information from: https://www.greenbook.net/loveland-products-inc/accomplish-lm

Results:

	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	15.2 A*	257 A	1,335 A
Accomplish LM	15.1 A	258 A	1,333 A
P-Value	0.262	0.215	0.682

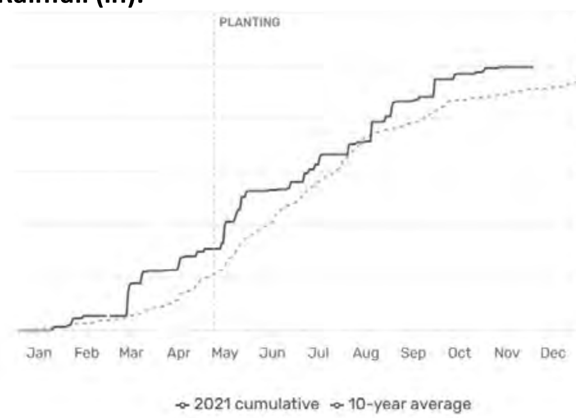
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $8/ac Accomplish LM.

Summary: There was no difference in moisture, yield, or net return between the Accomplish® LM and the untreated check.

Biological Inputs and Amendments for Organic Corn Production

Study ID: 0641047202101
County: Dawson
Soil Type: Cozad fine sandy loam 0-1% slope; Cozad silt loam 0-1% slope
Planting Date: 5/8/21
Harvest Date: 10/27/21
Seeding Rate: 34,000
Row Spacing (in): 36
Hybrid: Beck's® 59R5GH
Reps: 5
Previous Crop: Alfalfa
Tillage: Organic Full Tillage, Disc-Chisel Field Cultivator (April), Rotary Hoe (May), 3 Cultivations (May-June)
Herbicides: ***Pre:*** None ***Post:*** None
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 2,600 lb/ac Cluck dried chicken litter on 6/17/21
Irrigation: Pivot, Total: 8.4"
Rainfall (in):



Soil Tests: (November 2020)

				Ammonium Acetate (ppm)				CEC	% Base Saturation				
pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
7.4	1.7	2.6	26	491	3688	816	248	27.6	0	5	66	25	4

Introduction: This study evaluated several products and combinations of products for organic corn production. The products evaluated are as follows:

- BlueN by Symborg, Inc., contains the bacterium *Methylobacterium symbioticum* to colonize the plant and fix nitrogen and was applied at 5 oz/ac
- L-CBF TerraFed™ by Midwestern BioAg® is a liquid carbon-based molasses soil ammendment derived from sugar cane and was applied at 5 gal/ac
- CX-1 by Midwestern BioAg® is a plant-based compost extract that contains hundreds of different fungal and bacterial species to help with seed germination, plant health, nutrient uptake, and yield and was applied at 3 gal/ac
- Kelpak® by Kelp Products International is a liquid seaweed concentrate and was applied at 1 pt/ac

Results:

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Harvest Standability (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Control	26,800 A	24,267 A	99 A	17.8 A*	173 A	1647 A
BlueN 0.1 Package	27,067 A	24,333 A	98 A	18.1 A	167 A	1568 AB
TerraFed, CX-1, Kelpak	26,067 A	22,733 A	99 A	18.1 A	167 A	1539 B
BlueN, TerraFed, CX-1, Kelpak	26,933 A	24,667 A	99 A	17.7 A	173 A	1582 AB
P-Value	0.478	0.121	0.844	0.281	0.178	0.047

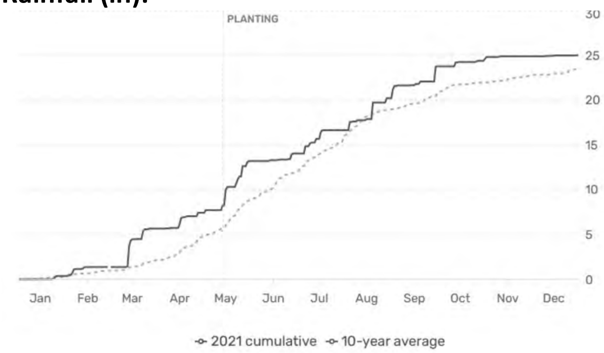
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $9.50/bu organic corn, $19/ac for BlueN, $46/ac for TerraFed, CX-1, and Kelpak, and $59/ac for BlueN, TerraFed, CX-1, and Kelpak.

Summary:

- There were no differences in corn yield or moisture between the products and product combination evaluated.
- Profit for the check treatment was significanty higher due to reduced input costs compared to the TerraFed, CX-1, and Kelpak treatment.

Evaluating Strip-Till and Biological Inputs in Organic Corn Production

Study ID: 0641047202102
County: Dawson
Soil Type: Cozad fine sandy loam 0-1% slope; Cozad silt loam 0-1% slope; Hord silt loam 0-1% slope
Planting Date: 5/13/21
Harvest Date: 11/16/21
Seeding Rate: 34,500
Row Spacing (in): 36
Hybrid: Beck's® 59R5GH
Reps: 5
Previous Crop: Soybean
Tillage: Organic Full Tillage, Disc-Chisel Field Cultivator (April), Rotary Hoe (May), 3 Cultivations (May-June)
Herbicides: None
Seed Treatment: None
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 20 ton/ac Feedlot Manure (74 lb N/ac, 291 lb P/ac, 337 lb K/ac, 83 lb S/ac and 4 lb Zn/ac) on 12/17/20
Irrigation: Pivot, Total: 12.5"
Rainfall (in):



Introduction: In 2020, the grower evaluated three soybean seeding rates in organic soybean production. Canopy cover, weed pressure, weed species, and soybean yield were evaluated. This study was conducted on the same strips and evaluated tillage and biological inputs in an organic corn production system. Winter triticale was planted as a cover crop on October 6, 2020. The triticale was terminated on April 20, 2021, with tillage. Weeds were flamed with an Agricultural Flaming Innovations flamer on June 14, 2021. The entire field had full tillage (control). The strip-till treatment had an additional tillage event with an Orthman 1tRIPr® at 4" depth. The strip-till with biological treatment had full tillage, strip-till at 4" depth and biological products added including TerraFed, CX-1, and Kelpak®.

- TerraFed by Midwestern BioAg® is a liquid carbon-based molasses soil ammendment derived from sugar cane and was applied at 5 gal/ac
- CX-1 by Midwestern BioAg® is a plant-based compost extract that contains hundreds of different fungal and bacterial species to help with seed germination, plant health, nutrient uptake, and yield and was applied at 3 gal/ac
- Kelpak® by Kelp Products International is a liquid seaweed concentrate and was applied at 1 pt/ac

Results:

	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	30,733 AB	17.9 A	201 A	1,878 A
Strip-Till	31,733 A	17.9 A	193 A	1,787 A
Strip-Till with TerraFed, CX-1, Kelpak	30,067 B	18.0 A	196 A	1,772 A
P-Value	0.091	0.246	0.257	0.287

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $9.50/bu organic corn, $33/ac for full tillage, $12/ac for strip-till, and $40/ac for biological products used in the study.

Summary:

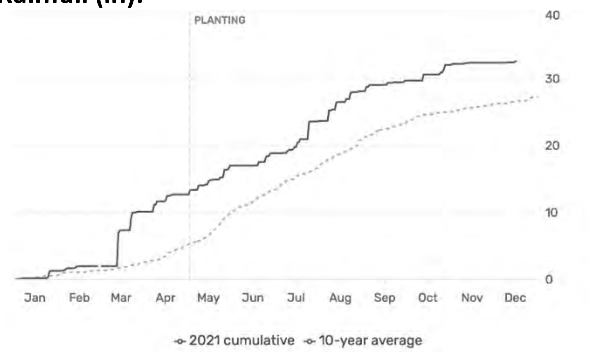
- Stand counts were higher for the strip-till treatment compared to the strip-till with biologicals.
- There were no differences in yield, moisture, or net return between the three treatments evaluated.

COVER CROPS

NRCS DEMO FARMS:

Long-term Evaluation of Cereal Rye Cover Crop

Study ID: 0064099202101
County: Kearney
Soil Type: Colby-Kenesaw silt loam 0-3% slopes; Colby silt loam 3-6% slopes; Hersh fine sandy loam 0-3% slope; Hersh fine sandy loam 3-6% slope; Liberty loamy fine sand 0-3% slope; Kenesaw silt loam 0-1% slope
Planting Date: 5/2/21
Harvest Date: 10/9/21
Seeding Rate: 160,000
Row Spacing (in): 15
Hybrid: Channel® 3521RXF
Reps: 4
Previous Crop: Seed Corn
Tillage: No-till
Herbicides: ***Pre:*** Zidua®, Roundup®, flumioxazin, and dicamba on 4/26/21 ***Post:*** Outlook®, Engenia®, and Roundup® on 6/14/21
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Introduction: This study compared the effects of a cereal rye cover crop on the following cash crop yield. This is the fifth year of the study, with cereal rye and check strips maintained in the same location from year to year. Rye was drilled in 10" rows on September 2, 2020. From January 1 to April 1, 80 head of sheep grazed on the cover crop. The rye was terminated with Zidua®, Roundup®, flumioxazin, and dicamba on April 26; rye was approximately 30" tall at the time of termination. Rye biomass was measured on May 4, 2021. Soybeans were planted in 15" rows with a Kinze® 2600 planter on May 2. The soybeans were post-sprayed with Outlook®, Engenia®, and Roundup® on June 14. Soybean stand counts were taken on June 27 and September 28. Soybeans were harvested on October 9, and yield and moisture were recorded.

Results:

	Rye Biomass (lb/ac)	June 27 Stand Count (plants/ac)	Sept. 28 Stand Count (plants/ac)	Grain Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	-	144,123 A	139,333 A	11.2 B*	92 A	1,085 A
Cover Crop – Rye	2,248	145,865 A	141,075 A	11.4 A	92 A	1,053 B
P-Value	-	0.719	0.572	0.015	0.813	0.015

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean and $30/ac for cover crop seed and drilling cost.

Summary:

- Rye biomass production averaged 2,248 lb/ac.
- At harvest, there were visual differences. The soybeans planted into the rye cover crop strips were taller and had more lodging compared to the soybeans planted into the check.
- Grain moisture was slightly wetter for the soybeans following the rye cover crop.
- There was no difference in soybean stand counts or yield between the soybeans following the rye cover crop and the check.
- Net return was lower for the soybeans following the rye cover crop due to the additional cost of cover crop seed and establishment. It should be noted that the net return does not account for any gains due to grazing sheep.

Summary of Previous Years

2017

In year one (2017), cover crops were drilled on November 1, 2016. Rye was terminated with glyphosate on May 5, 2017. Soybeans were drilled in 10” rows on May 8, 2017.

Results:

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	12.0 B*	80 A	714.25 A
Cover Crop - Rye	12.1 A	81 A	692.20 B
P-Value	0.058	0.682	0.008

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.90/bu soybean and $24.30 cover crop cost.

2018

In year two (2018), cover crops were drilled on October 21, 2017, following soybean harvest. Cattle pastured the rye in March and early April. The rye was terminated with glyphosate on May 6, 2018, at a height of approximately 15”. Corn was planted into the strips on April 28, 2018. Due to poor stand resulting from fertilizer salt injury the field was replanted on May 17, 2018.

Results:

	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	15.5 A*	227 A	733.70 A
Cover Crop - Rye	15.6 A	228 A	713.43 B
P-Value	0.219	0.454	0.014

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.23/bu corn and $24.30 cover crop cost.

2019

In year three (2019), cover crops were drilled on November 1, 2018, following corn harvest. The rye was terminated with glyphosate on May 5, 2019, at a height of approximately 12”. Soybeans were planted into the strips on May 13, 2019.

Results:

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	11.9 A	86 B	694.94 A
Cover Crop - Rye	11.9 A	87 A	674.64 B
P-Value	1	0.017	0.002

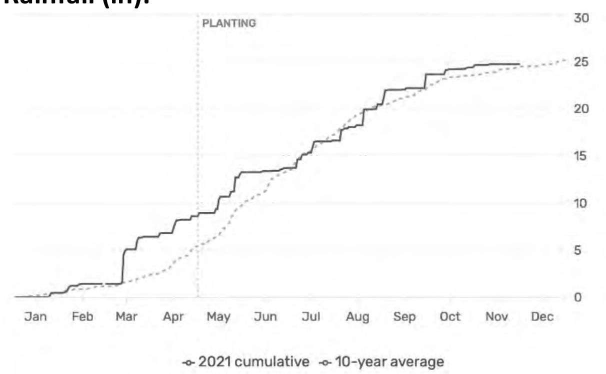
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.10/bu soybean and $30/ac cover crop seed and drilling cost.

2020

In year four (2020), yields were not reported.

Impact of Rye vs. Wheat Cover Crop

Study ID: 0709047202103
County: Dawson
Soil Type: Cozad silt loam 0-1% slope; Cozad silty clay loam 0-1% slope
Planting Date: 5/1/21
Harvest Date: 10/27/21
Seeding Rate: 30,000
Row Spacing (in): 30
Hybrid: Pioneer® P1197AM
Reps: 4
Previous Crop: Soybean
Tillage: Strip-till
Herbicides: ***Burndown:*** 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer 5 Extra®, and 1 qt/ac Atrazine 4L on 5/4/21 ***Post:*** 24 oz/ac Buccaneer 5 Extra®, 3 pt/ac Fearless Xtra®, 3 oz/ac Status®, 3 oz/ac mesotrione on 6/10/21
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac Bifenthrin 2EC and 2 oz/ac Lambda-CY 1EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Fertilizer: 25 gal/ac 32% UAN (89 lb N/ac), 5 gal/ac 12-0-0-26S, and 0.25 gal/ac ReaX™ zinc applied during strip-till on 4/8/21; 1 gal/ac Altura™, 1 gal/ac ReaX™ K, 0.25 gal/ac ReaX™ zinc, and 0.1 gal/ac Pivot Bio PROVEN® with in-furrow starter on 5/1/21; 9 gal/ac 32% UAN (32 lb N/ac) and 1.5 gal/ac 12-0-0-26S via chemigation on 6/13/21, 6/24/21, 7/9/21, and 7/30/21
Note: Field had 20% green snap on 7/9/21
Irrigation: Pivot, Total: 5"
Rainfall (in):



Soil Tests (December 2020, average of 5 samples in the study area):

				Ammonium Acetate (ppm)				CEC	% DPTA			
pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	Zn	Fe	Mn	Cu
7.3	2.72	5.8	55.8	408	2517	304	61	16.4	1.0	10.5	4.5	0.6

Introduction: The purpose of this study is to evaluate a wheat versus cereal rye cover crop. The cover crop was drilled on October 10, 2020, and emerged on November 11, 2021. Both cereal rye (variety not stated) and wheat (Monument) were seeded at 30 lb/ac and both mixes also included 1 lb/ac Turnips, 1 lb/ac Rapeseed, and 1 lb/ac Radish. Cattle grazed from December 1, 2020 to March 1, 2021. Wheat and rye cover crop biomass was collected on April 29, 2021. The remaining species had very little biomass at the time of sampling due to poor emergence or winter termination. Corn was planted on May 1, and the cover crop was terminated on May 4 with the herbicide application. Corn stand counts, yield, and partial profit were determined.

Results:

	Early Season Corn Stand Count (plants/ac)	Cover Crop Biomass (lb/ac)	Grain Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Wheat Cover Crop	28,667 A*	326 B	17.1 A	243 A	1,258 A
Rye Cover Crop	29,000 A	684 A	17.0 A	246 A	1,268 A
P-Value	0.594	0.065	0.571	0.619	0.699

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $6.60/ac wheat cover crop, and $9.60/ac for the rye cover crop. Additional species cost $2.50/ac for turnips, $1.19/ac for the rapeseed, and $2.20/ac for the radish. Drilling costs were $12.50/ac for the drill and $8.50/ac for the tractor. Additional species and drilling costs were the same for both treatments and therefore are not included in the calculation.

Summary:

- The rye cover crop had over twice the biomass of the wheat cover crop when measured on April 29.
- No differences were observed in corn stand count, grain moisture, or yield.
- The cost of the rye cover crop was $3/ac more than the wheat cover crop; however, net return was not significantly different between the two treatments.

Cover Crop Interseeding Studies

These studies evaluated the impact of interseeded cover crops on corn and soybean yield and soil quality. Six sites in 2020 and four sites in 2021 examined the impact of interseeding into corn; two sites in 2021 examined the impact of interseeding into soybean. This three-year on-farm research study is a collaboration of Nebraska Extension, The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg's.

SITES

Twelve site-years of studies were conducted in Seward, York, Clay, and Hamilton counties in 2020-2021 (Figure 1). Site details for 2020 and 2021 are displayed in Table 1. All cover crops were interseeded at the V4-V6 corn growth stages. Cover crop was interseeded into either VC or V2 soybean. Cover crop and weed biomass were measured for all corn sites in late September (Figure 2).

MIXES

2020 Diversity Mix: The diversity mix consisted of 4 lb/ac hairy vetch, 4 lb/ac Pinkeye cowpeas, 1 lb/ac red clover, 1 lb/ac yellow blossom sweet clover, 4 lb/ac Red Ripper cowpeas, 3 lb/ac annual ryegrass, 1 lb/ac Italian ryegrass, 0.5 lb/ac smart radish, 0.5 lb/ac impact forage collards, 4 lb/ac Mancan buckwheat, 2 lb/ac golden flax, and 0.5 lb/ac mini pumpkins. A half rate of the mix was used (13 lb/ac) at a cost of $16.86/ac.

2020 Nitrogen Mix: The nitrogen mix consisted of 4 lb/ac Laredo forage soybean, 2 lb/ac yellow blossom sweet clover, 1.5 lb/ac red clover, 4 lb/ac hairy vetch, 6 lb/ac Red Ripper cowpeas, 4 lb/ac Pinkeye cowpeas, 0.5 lb/ac Nitro radish, 0.5 lb/ac impact forage collards, and 4 lb/ac Mancan buckwheat. A half rate of the mix was used (13 lb/ac) at a cost of $18.16/ac.

2021 Diversity Mix: The diversity mix consisted of 2 lb/ac MT hairy vetch, 2 lb/ac Iron & Clay cowpeas (less aggressive than Red Rippers in 2020), 1 lb/ac red clover, 1 lb/ac yellow blossom sweet clover, 5 lb/ac Winterhawk annual ryegrass (Diploid), 0.51 lb/ac Nitro radish, 0.51 lb/ac impact forage collards, 3 lb/ac Mancan buckwheat, 1.51 lb/ac golden flax, and 0.51 lb/ac Loredo forage soybean. The total rate was 17 lb/ac and cost $22.15/ac.

2021 Nitrogen Mix: The nitrogen mix consisted of 4.8 lb/ac Laredo forage soybeans, 3.3 lb/ac yellow blossom sweetclover, 3.3 lb/ac medium red clover, 4.8 lb/ac MT hairy vetch, 8 lb/ac Iron & Clay cowpeas, 0.43 lb/ac purple top turnip, 0.54 lb/ac impact forage collards, and 6.4 lb/ac Mancan buckwheat. The total rate was 31.5 lb/ac and cost $46.21/ac.

2021 Mix for Soybean: The soybean mix included 26 lbs of hard red winter wheat and 10 lbs of red clover. The total rate was 36 lb/ac and cost $26.50/ac.

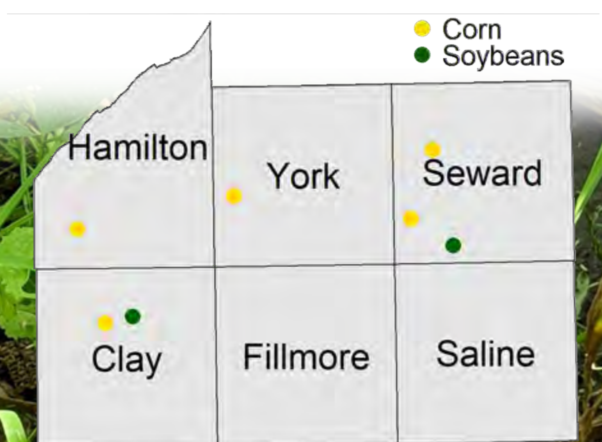


Figure 1. Interseeding study locations.

Table 1. Sites, location, year, cover crop mixtures, interseeding dates, row direction and irrigation status for twelve sites evaluating cover crop interseeding into corn and soybean.

ID	Report ID	County	Cover Crop Mix	Interseeding Date	Row Direction	Irrigation	Crop
2020-1	0145159202001	Seward	Diversity Mix	6/1/20	East-West	SDI	Corn
2020-2	0580035202001	Clay	Nitrogen Mix	6/3/20	North-South	Pivot	Corn
2020-3	0916185202002	York	Custom Mix	6/1/20	North-South	Pivot	Corn
2020-4	0618159202001	Seward	Diversity Mix	6/8/20	East-West	Pivot	Corn
2020-5	0073081202001	Hamilton	Diversity Mix	6/3/20	East-West	Pivot	Corn
2020-6	0918159202001	Seward	Diversity Mix	6/8/20	North-South	Pivot	Corn
2021-2	0580035202101	Clay	Nitrogen Mix	6/2/21	North-South	Pivot	Corn
2021-3	0916185202101	York	Custom Mix	6/6/21	North-South	Pivot	Corn
2021-5	0073081202101	Hamilton	Diversity Mix	6/14-15/21	East-West	Pivot	Corn
2021-6	0918185202101	Seward	Diversity Mix	7/1/21	North-South	Pivot	Corn
2021-7	0618159202101	Seward	Wheat/Red Clover	5/26/21	East-West	Pivot	Soybean
2021-8	0580035202102	Clay	Wheat/Red clover	6/4/21	East-West	Pivot	Soybean

RESULTS AND SUMMARY

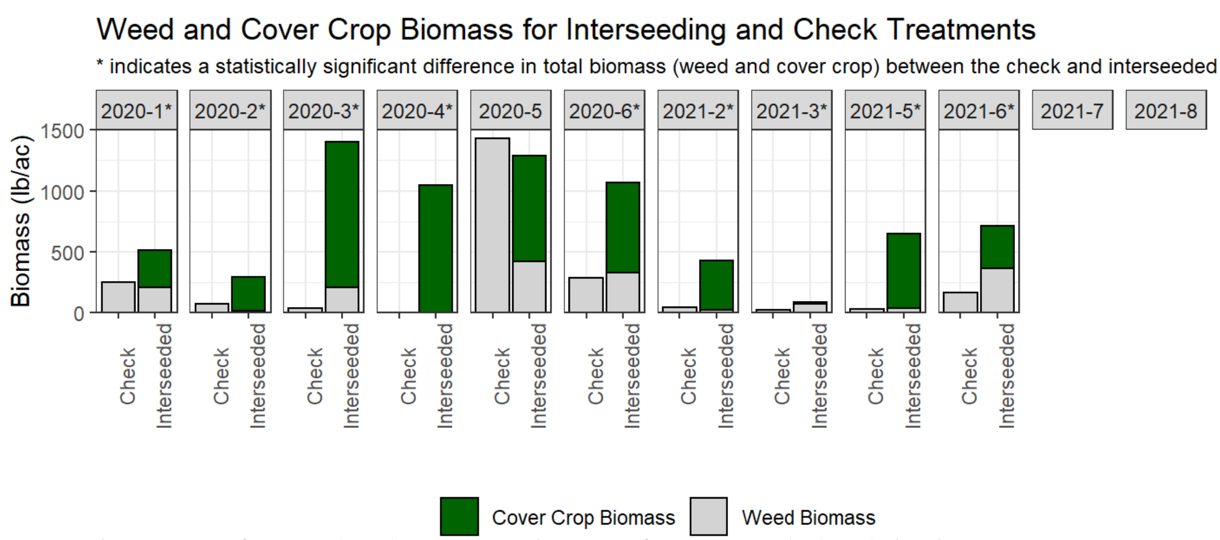


Figure 2. The average for weed and cover crop biomass for interseeded and check treatments. Biomass was not measured for the soybean sites (2021-7 and 2021-8).

Average cover crop biomass accumulated varied by site and year (Figure 2):

- In 2020, there was greater biomass due to aggressive Red Ripper cowpeas and a July 9, 2020, windstorm that opened up the corn canopy. Biomass ranged from 277 lb/ac at site 2020-2 to 2,192 lb/ac at site 2020-4.
- In 2021, Iron and Clay cowpeas replaced the Red Ripper cowpeas in the nitrogen and diversity mixes to reduce aggressive growth. The cover crop in the corn at many of the 2021 sites would have benefited from an irrigation shortly after interseeding to help with establishment during a dry early June. Cover crop biomass ranged from an average of 87 lb/ac at site 2021-3 to 710 lb/ac at 2021-6.
- In nine of ten interseeding corn sites, there was a difference in the total biomass (weed and cover crop) in the interseeded versus the check treatment. Soybean biomass was not measured at 2021-7 to avoid damage to the soybeans prior to harvest and there was no biomass to measure at 2021-8 prior to harvest due to the thick soybean canopy shading out the cover crop.

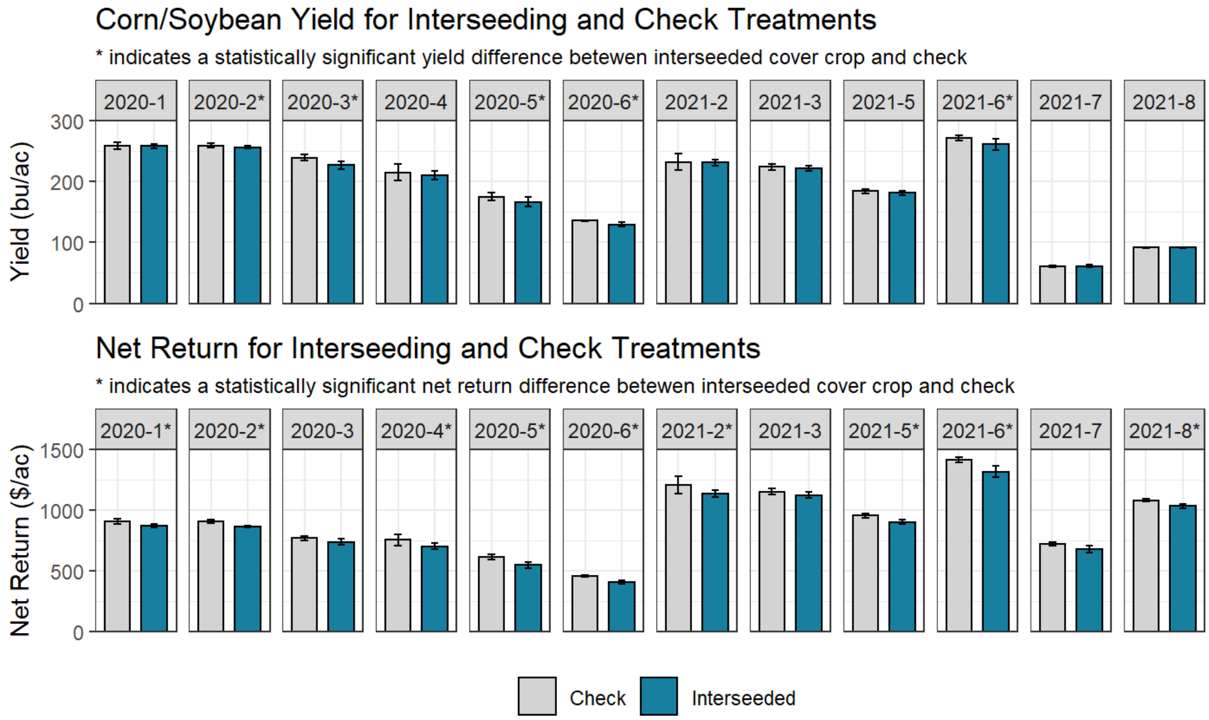


Figure 3. The average for corn and soybean yield for interseeded and check treatments (top), and net return for interseeded and check treatments (bottom).

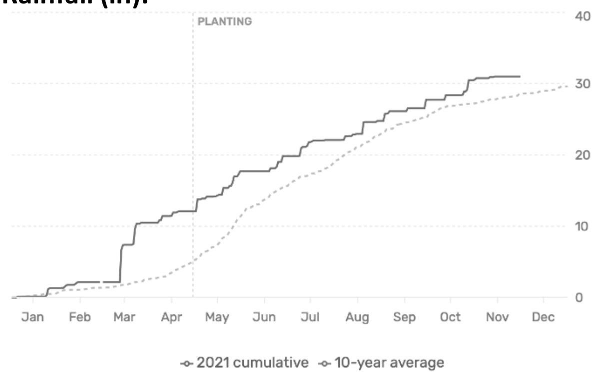
Yield and marginal net return impact varied by site (Figure 3):

- Yield for five of the ten interseeded corn sites was reduced where cover crop was interseeded compared to the check. Overall, corn yields for both 2020 and 2021 were impacted by a July 9 wind event both years at seven of the ten corn locations.
- There were no differences in soybean yield between the interseeded and check treatments.
- Eight of the ten corn locations and one of the two soybean locations showed a lower marginal net return where the cover crop was interseeded compared to the check.

Impact of Interseeding Cover Crop at V4 on Irrigated Corn

Study ID: 0580035202101
County: Clay
Soil Type: Crete silt loam 0-1% slope; Hastings silt loam 1-3% slope
Planting Date: 4/29/21
Harvest Date: 10/16/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1353
Reps: 7
Previous Crop: Corn
Tillage: Strip freshener
Herbicides: ***Pre:*** 1.75 qt/ac Lexar® and 50 oz/ac Roundup® on 4/29/21 ***Post:*** 32 oz/ac Roundup® and 32 oz/ac Liberty® on 6/2/21
Foliar Fungicides: 14 oz/ac Quilt Xcel® at VT
Fertilizer: 170 lb N/ac as anhydrous ammonia in November; 17 gal/ac UAN 32% (60 lb N/ac) through pivot in July

Note: A windstorm on 7/9/21 impacted overall yield and resulted in 25% goose-necked plants with small ears and was rated at 12% green snap via crop insurance adjuster.
Irrigation: Pivot, Total: 10"
Rainfall (in):



Soil Tests (initial soil tests were collected in year 1 on September 2020 in the check and interseeded cover crop strips at 0-8" depth):

	pH	Buffer pH	OM LOI %	Nitrate-N ppm N	lbs N/A	K ppm	Sulfate-S ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Ca ppm	Mg ppm	Na ppm	CEC me/100g	%H Sat	%K Sat	%Ca Sat	%Mg Sat	%Na Sat	Mehlich P-III ppm P
Check	6.7	7.2	3.4	6.2	15	307	13.8	2.32	23.5	43.6	0.57	2050	201	41	12.9	0	6	79	13	1	21
Interseeded	6.7	7.2	3.4	4.3	10	273	10.9	1.96	41.3	30	0.47	1900	183	39	11.9	0	6	80	13	1	21

Figure 1. (left) Sweet clover that survived the burndown and pre-herbicides, May 28, 2021; (middle) interseeded cover crop on June 28, 2021; (right) Cover crop following corn harvest, October 15, 2021.

Introduction: This is the second year of this on-farm research study in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg's. The study evaluated the impact of interseeded cover crops on corn yield and soil quality. There were two treatments: a check where no cover crops were interseeded and an interseeeded nitrogen mix (Figure 1). Following the first year of the study, the sweet clover survived the winter as well as the 2021 pre- and post-herbicide applications. The buckwheat and forage soybean from 2020 reseeded themselves, and cereal rye was also planted in fall 2020. Corn was planted green on April 29. The 2021 interseeded cover crops were planted on June 2, 2021, when corn was V4. The mix consisted of 4.8 lb/ac Laredo forage soybeans, 8 lb/ac Iron and Clay cowpeas, 4.8 lb/ac MT hairy vetch, 6.4 lb/ac Mancan buckwheat, 3.3 lb/ac yellow blossom sweet clover, 3.3 lb/ac medium red clover, 0.43 lb/ac purple top turnip, and 0.54 lb/ac impact forage collards. Corn yield, stand counts, and stalk quality were measured. Cover crop species and biomass were also measured by sampling 18.75 sq ft per treatment on September 27, 2020. A second set of cover crop biomass samples was collected from only the interseeded treatments and sent to Ward Labs for nutrient analysis. Only the carbon and nitrogen results are reported here. The purpose of this analysis is to determine the nitrogen present in the interseeded biomass to determine any potential nitrogen credits for the following year. Soil health tests were collected in year one of the study, and will be collected and reported again in year three. A windstorm on July 9 impacted overall yield; 25% of the field had goose-necked plants resulting in small ears and the crop insurance adjuster rated the field at 12% for green snap.

Results:

Table 1. Stand count, plant health, yield, and net return for no cover crop and interseeded cover crop.

	Stand Count (plants/ac)	Stalk Rot (%)	Greensnap (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	30,714 A*	0 A	1 A	16.9 A	232 A	1,206 A
Interseeded Cover Crop	29,714 A	0 A	3 A	17.0 A	231 A	1,136 B
P-Value	0.172	N/A	0.208	0.838	0.762	0.012

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $46.21/ac for cover crop seed, and $18/ac for drilling.

Table 2. Biomass measurements were collected on September 27, 2021, for the interseeded and check treatments. Plants were sorted into a weed or cover crop category, and weights were reported on a dry matter basis. Average carbon and nitrogen in the interseeded treatment biomass (cover crop and weeds) were determined by Ward Labs using tissue analysis.

	Weed Biomass (lb/ac)	Cover Crop Biomass (lb/ac)	Total Biomass (lb/ac)	Carbon (lb/ac)	Nitrogen (lb/ac)
Check	45 A	-	45 B	-	-
Interseeded Cover Crop	19 A	409	428 A	185	14
P-Value	0.259	N/A	0.0001	N/A	N/A

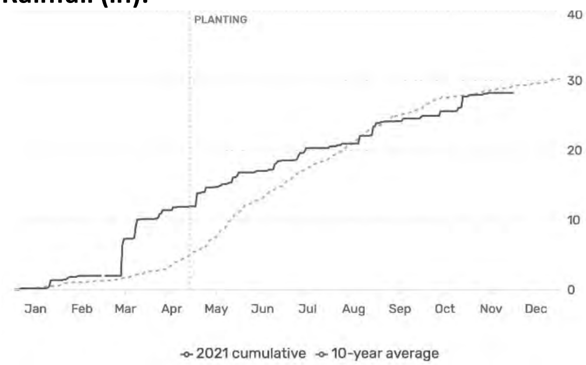
Summary:

- The interseeded cover crop produced approximately 428 lb/ac biomass, of which 19 lb/ac was weeds. The check did not have any cover crop biomass, but had 45 lb/ac weeds.
- There was no difference in stand count or stalk quality between the corn with interseed cover crop and the check.
- There was no yield difference between the corn in the interseeded cover crop and the check. The corn with the interseeded cover crop resulted in a $70/ac lower net return due to the increased cost of seed and drilling.
- In year one of the study (2020), the corn in the interseeded cover crop yielded 3 bu/ac less than the corn with no interseeded cover crop. The corn with interseeded cover crop resulted in a $45/ac lower net return.
- Tissue anlaysis of the biomass in the interseeded cover crop treatment showed an average of 185 lb C/ac and 14 lb N/ac.

Impact of Interseeded Cover Crop at V4 on Irrigated Corn

Study ID: 0916185202101
County: York
Soil Type: Hastings silt loam 0-1% slope
Planting Date: 4/27/21
Harvest Date: 10/19/21
Seeding Rate: 32,000
Row Spacing (in): 36
Hybrid: Pioneer® P1563AM
Reps: 4
Previous Crop: Corn
Tillage: Ridge-till and Cultivate
Foliar Insecticides: 7 oz/ac bifenthrin applied in-furrow
Foliar Fungicides: None
Fertilizer: 185 lb N/ac as anhydrous ammonia on 4/5/21

Note: Wind event on 7/9/21 caused 8-10% green snap and goose-necking
Irrigation: Pivot, Total: 11"
Rainfall (in):



Soil Tests (initial soil tests were collected in year 1 on September 2, 2020, in the check and interseeded cover crop strips at 0-8" depth):

	pH	OM LOI %	Nitrate-N ppm N	lbs N/A	K ppm	Sulfate-S ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Ca ppm	Mg ppm	Na ppm	CEC me/100g	%H Sat	%K Sat	%Ca Sat	%Mg Sat	%Na Sat	Mehlich P-III ppm P
Check	6.45	2.65	3.68	8.8	441	7.8	1.3	29	7.5	0.5	2108	250	33	16.4	14.5	7	65	13	1	12
Interseeded	6.2	2.65	2.4	5.8	411	7.5	1.4	34	9.3	0.5	1943	222	40	16.0	19.8	6.5	61	12	1	11.5
P-Value	0.14	1	0.32	0.30	0.12	0.72	0.60	0.04	0.18	1	0.03	0.06	0.06	0.43	0.29	0.18	0.34	0.25	-	0.79

Introduction: This is the second year of this on-farm research study in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg's and the third year this site has had interseeded cover crops on the same strips. The study evaluated the impact of interseeded cover crops on corn yield and soil quality. This year, the producer was interested in the impact of herbicides with and without residual on cover crop biomass and weed control. Vilify™ is a herbicide with residual weed control and has active ingredients of metolachlor, atrazine, and mesotrione. There were three treatments:

- A check with no cover crops interseeded and weeds controlled with a pre-herbicide consisting of 2 qt/ac Vilify™ (a herbicide with residual weed control) and 24 oz/ac Roundup PowerMAX® on May 11, 2021
- An interseeded cover crop with weeds controlled with a pre-herbicide consisting of 2 qt/ac Vilify™ (a herbicide with residual weed control) and 24 oz/ac Roundup PowerMAX® on May 11, 2021
- An interseeded cover crop with weeds controlled with only 30 oz/ac Roundup PowerMAX® on May 11, 2021, and no herbicide with residual weed control.

The cover crop mix consisted of 1 lb/ac Iron and Clay cowpeas, 2 lb/ac Mung Beans, 1 lb/ac medium red clover, 2 lb/ac yellow sweet clover, 0.3 lb/ac forage collards, 0.3 lb/ac winter camelina, 1 lb/ac buckwheat, and 1 lb/ac flax. The cover crops were interseeded on June 9, 2021, when corn was V4. Corn yield, stand counts, and stalk quality were measured. Cover crop species and biomass were also measured by sampling 27 sq ft per treatment on September 27, 2020. A second set of cover crop biomass samples was collected from only the interseeded treatments and sent to Ward Labs for nutrient analysis. Only the carbon and nitrogen results are reported here. The purpose of this analysis is to determine the nitrogen present in the interseeded biomass to determine any potential nitrogen credits for the following year. Soil health tests were collected in year one of the study and will be collected and reported again in year three.

Results:

Table 1. Stand count, plant health, yield, and net return for no cover crop and interseeded cover crop.

	Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	30,000 A*	1.9 A	4 A	17.4 A	224 A	1,152 A
Interseeded, pre herbicide with residual	29,750 A	5.6 A	1 A	17.1 B	221 A	1,112 A
Interseeded, pre herbicide without residual	29,500 A	3.1 A	3 A	17.3 AB	222 A	1,131 A
P-Value	0.905	0.468	0.618	0.032	0.753	0.205

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $11/ac for Vilify used in the check treatment, $11/ac for Vilify, $15.34/ac for cover crop seed, and $10/ac for drilling for the cover crop with Vilify (total treatment cost of $36.64/ac), and $15.34/ac for cover crop seed and $10/ac for drilling for the cover crop without Vilify (total treatment cost of $25.34/ac).

Table 2. Biomass measurements were collected on September 27, 2021, for the interseeded and check treatments. Plants were sorted into a weed or cover crop category, and weights were reported on a dry matter basis. Average carbon and nitrogen in the interseeded treatment biomass (cover crop and weeds) were determined by Ward Labs using tissue analysis.

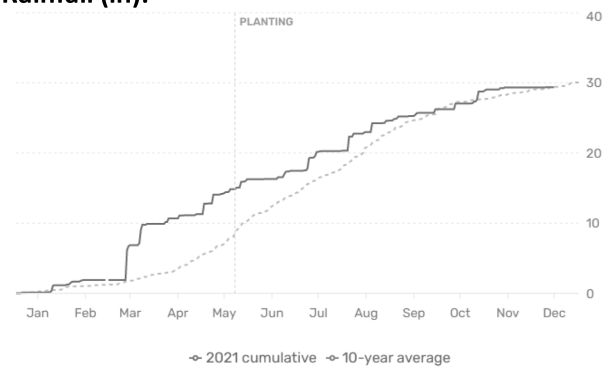
	Cover Crop Biomass (lb/ac)	Weed Biomass (lb/ac)	Total Biomass (lb/ac)	Carbon (lb/ac)	Nitrogen (lb/ac)
Check	-	24 AB	24 B	-	-
Interseeded, pre herbicide with residual	20	19 B	38 B	16	1
Interseeded, pre herbicide without residual	17	119 A	136 A	124	8
P-Value	N/A	0.07	0.031	N/A	N/A

Summary:

- The cover crop treatment without a residual pre herbicide had approximately 100 lb/ac more weeds than the treatments that used a pre-herbicide with residual. The use of the pre-herbicide with a residual did not impact the interseeded cover crop treatments; biomass production was similar at 17 to 20 lb/ac of cover crop.
- There was no difference in stand count or stalk quality between the corn with interseeed cover crop and the check.
- Yield and net return were not impacted by the cover crop treatments.
- In year one of the study (2020), the corn in the interseeded cover crop yielded 12 bu/ac lower than the corn with no interseeded cover crop. The corn with interseeded cover crop resulted in a $30/ac lower net return.
- Tissue anlaysis of the biomass in the interseeded cover crop treatment showed an average of 70 lb C/ac and 5 lb N/ac.

Impact of Interseeding Cover Crop at V4 on Irrigated Corn

Study ID: 0073081202101
County: Hamilton
Soil Type: Hastings silty clay loam 3-7% slopes
Planting Date: 5/22/21
Harvest Date: 10/26/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1306WAM
Reps: 7
Previous Crop: Corn
Tillage: Unknown
Herbicides: ***Pre:*** 1.5 qt/ac Acuron®, 1 qt/ac Aatrex®, and 1 qt/ac Durango® on 5/24/21 ***Post:*** 2.5 oz/ac Status® and 16 oz/ac Liberty® on 6/15/21
Fertilizer: 10 gal of 32% UAN (36 lb N/ac) with herbicide on 5/24/21; 150 lb N/ac as urea around 7/12/21
Note: A wind event on 7/9/21 resulted in goose-necked plants.
Irrigation: Pivot, Total: 3"
Rainfall (in):



Soil Tests (initial soil tests were collected in year 1 on September 3, 2020 in the check and interseeded cover crop strips at 0-8" depth):

	pH	Buffer pH	OM LOI %	Nitrate-N ppm N	Nitrate lb/ac	K ppm	Sulfate-S ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Ca ppm	Mg ppm	Na ppm	CEC me/100g	Mehlich P-III ppm P
Check	5.8	6.6	3.7	3.5	8	294	7.2	2.28	77.2	61.3	0.83	1727	204	18	15.5	7
Interseeded	6	6.6	3.4	1.6	4	286	3.8	1.57	58.4	53.3	0.68	1771	213	17	15.2	6

Figure 1. (left) Newly planted corn with annual ryegrass and sweet clover between the rows that survived winter. These cover crops were killed with pre-herbicide; (right) Prior to corn harvest, the cover crops observed were predominantly cowpeas.

Introduction: This is the second year of this on-farm research study in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg's. The study evaluated the impact of interseeded cover crops on corn yield and soil quality. There were two treatments: a check where no cover crops were interseeded and an interseeeded diversity mix. The sweetclover and ryegrass from the previous year survived winter, and were then killed with pre-herbicide. The diversity mix consisted of 2 lb/ac MT hairy vetch, 2 lb/ac Iron and Clay cowpeas, 1 lb/ac medium red clover, 1 lb/ac yellow blossom sweet clover, 5 lb/ac Winterhawk annual ryegrass, 0.51 lb/ac Loredo forage soybeans, 0.51 lb/ac impact forage collards, 3 lb/ac Mancan buckwheat, 0.51 lb/ac Nitro radish, and 1.51 lb/ac golden flax. The cover crops were interseeded on June 14 and 15, 2021, when corn was V4. Corn yield, stand counts, and stalk quality were measured. Cover crop and weed biomass were measured by sampling 18.75 sq ft per treatment on September 27, 2021. A second set of cover crop biomass samples were collected from only the interseeded treatments, and sent to Ward Labs for nutrient analysis. Only the carbon and nitrogen results are reported here. The purpose of this analysis is to determine the nitrogen present in the interseeded biomass to determine any potential nitrogen credits for the following year. Soil health tests were collected in year one of the study and will be collected and reported again in year three.

Results:

Table 1. Stand count, plant health, yield, and net return for no cover crop and interseeded cover crop.

	Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	33,429 A*	18.9 A	0 A	18.2 B	184 A	956.25 A
Interseeded Cover Crop	32,357 A	32.5 A	3 A	18.8 A	181 A	902.61 B
P-Value	0.293	0.123	0.143	0.001	0.132	0.0004

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $22.15/ac for cover crop seed, and $18/ac for drilling.

Table 2. Biomass measurements were collected on September 27, 2021, for the interseeded and check treatments. Plants were sorted into a weed or cover crop category, and weights were reported on a dry matter basis. Average carbon and nitrogen in the interseeded treatment biomass (cover crop and weeds) were determined by Ward Labs using tissue analysis.

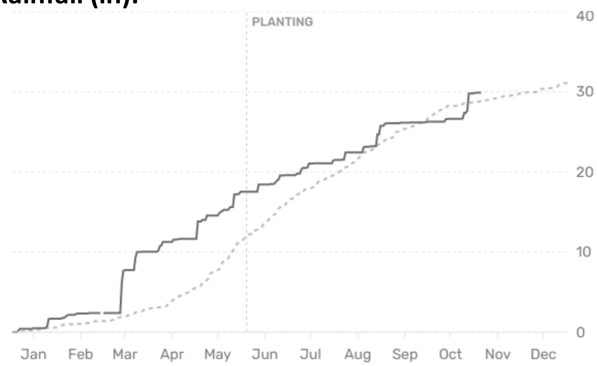
	Weed Biomass (lb/ac)	Cover Crop Biomass (lb/ac)	Total Biomass (lb/ac)	Carbon (lb/ac)	Nitrogen (lb/ac)
Check	28 A	-	28 B	-	-
Interseeded Cover Crop	34 A	615	649 A	264	16
P-Value	0.789	N/A	0.006	N/A	N/A

Summary:

- The interseeded cover crop produced approximately 649 lb/ac biomass, of which 34 lb/ac was weeds. The check did not have any cover crop biomass but had 28 lb/ac weeds.
- There was no difference in stand count or stalk quality between the corn with interseeded cover crop and the check.
- There were no yield differences between the corn with the interseeded cover crop and the check.
- Profit was lower for the interseeded cover crop due to the increased cost of seed and drilling. It should be noted that the profit analysis does not take into account any increase in revenue due to potential for grazing livestock on the cover crops.
- In year one of the study, yield was 8.6 bu/ac lower for the corn, with interseeded cover crop resulting in $65.18/ac lower profit.

Impact of Interseeding Cover Crop at V5 on Irrigated Corn

Study ID: 0918159202101
County: Seward
Soil Type: Hastings silty clay loam 3-7% slopes, eroded; Hastings silty clay loam 7-11% slopes, eroded
Planting Date: 6/3/21
Harvest Date: 11/5/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: NK® 10-82
Reps: 4
Previous Crop: Corn
Tillage: Ridge-till
Herbicides: ***Pre:*** 2 pt/ac Staunch® ll, 6 oz/ac dicamba, and 24 oz/ac Roundup® on 5/25/21; ***Post:*** 4 oz/ac Status® and 2 oz/ac Callisto® on 6/18/21
Soil Applied Insecticide: 9 oz/ac Capture® LFR® at planting
Foliar Fungicides: Headline AMP®
Fertilizer: 25 gal/ac 32% UAN (89 lb N/ac) on 5/25/21; 25 gal/ac 32% UAN (89 lb N/ac) on 6/25/21
Irrigation: Pivot, Total: 6.5”
Rainfall (in):



Soil Tests (initial soil tests were collected in year 1 on September 3, 2020, in the check and interseeded cover crop strips at 0-8” depth):

	pH	Buffer pH	OM LOI %	Nitrate-N ppm N	Nitrogen lb/ac	K ppm	Sulfate-S ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Ca ppm	Mg ppm	Na ppm	CEC me/100g	Mehlich P-III ppm P
Check	6.2	6.7	3.7	2	5	220	4.6	3.55	56.2	35.7	0.57	1904	209	18	15.1	23
Interseeded	6.5	6.7	3.7	1.4	3	193	7.2	3.5	39.3	37.7	0.57	2021	210	19	15.5	15

Figure 1: (left) There was a solid stand of annual ryegrass, sweet clover, and red clover that survived winter. Photo was taken on May 19, 2021; (middle) The corn stand was uneven and had variable growth stages due to heavy cover crop survival and lack of moisture in non-irrigated area. Photo taken July 1, 2021, during interseeding of the 2021 cover crop; (right) Prior to corn harvest, the cover crops observed were predominantly cowpeas.

Introduction: This is the second year of this on-farm research study in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg’s. The study evaluated the impact of interseeded cover crops on corn yield and soil quality. There were two treatments: a check where no cover crops were interseeded and an interseeeded diversity mix (Figure 1). The diversity mix consisted of 2 lb/ac MT hairy vetch, 2 lb/ac Iron and Clay cowpeas, 1 lb/ac medium red clover, 1 lb/ac yellow blossom sweet clover, 5 lb/ac Winterhawk annual ryegrass, 0.51 lb/ac Loredo forage soybeans, 0.51 lb/ac impact forage collards, 3 lb/ac Mancan buckwheat, 0.51 lb/ac Nitro radish, and 1.51 lb/ac golden flax. The cover crops were interseeded on July 1, 2021, when corn was V5-6. Corn yield, stand counts, and stalk quality were measured. Cover crop species and biomass were also measured by sampling 18.75 sq ft per treatment on September 27, 2021. A second set of cover crop biomass samples was collected from only the interseeded treatments and sent to Ward Labs for nutrient analysis. Only the carbon and nitrogen results are reported here. The purpose of this analysis is to determine the nitrogen present in the interseeded biomass to determine any potential nitrogen credits the following year. Soil health tests were collected in year one of the study and will be collected and reported again in year three.

Results:

Table 1. Stand count, plant health, yield, and net return for no cover crop and interseeded cover crop.

	Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	31,000 A*	21 A	0 A	8.7 A	271 A	1,410 A
Interseeded Cover Crop	31,667 A	8 A	1 A	8.8 A	261 B	1,316 B
P-Value	0.529	0.310	0.391	0.518	0.079	0.019

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $22.15/ac for cover crop seed, and $18/ac for drilling.

Table 2. Biomass measurements were collected on September 27, 2021, for the interseeded and check treatments. Plants were sorted into a weed or cover crop category, and weights were reported on a dry matter basis. Average carbon and nitrogen in the interseeded treatment biomass (cover crop and weeds) were determined by Ward Labs using tissue analysis.

	Weed Biomass (lb/ac)	Cover Crop Biomass (lb/ac)	Total Biomass (lb/ac)	Carbon (lb/ac)	Nitrogen (lb/ac)
Check	164 B	-	164 B	-	-
Interseeded Cover Crop	364 A	345	710 A	91	5
P-Value	0.083	N/A	0.022	N/A	N/A

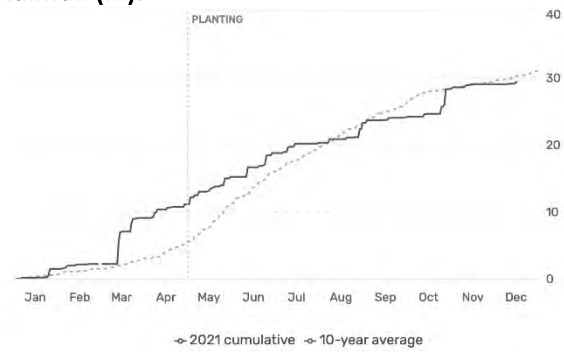
Summary:

- The interseeded cover crop produced approximately 710 lb/ac biomass, of which 364 lb/ac was weeds. The check did not have any cover crop biomass, but had 164 lb/ac weeds.
- Greater weed biomass was observed for the interseeded cover crop treatment compared to the check, despite having the same herbicide program. A possible reason for this is that the sweet clover that had overwintered in the interseeded treatment protected weed seedlings from herbicide and prevented herbicide from reaching the ground as well.
- There was no difference in stand count or stalk quality between the corn with interseeded cover crop and the check.
- The corn in the interseeded cover crop yielded 10 bu/ac lower than the corn with no interseeded cover crop. The corn with the interseeded cover crop resulted in a $93.90/ac lower net return.
- In year one of the study (2020), the corn in the interseeded cover crop yielded 4.8 bu/ac lower than the corn with no interseeded cover crop. The corn with interseeded cover crop resulted in a $51.75/ac lower net return.
- Tissue anlaysis of the biomass in the interseeded cover crop treatment showed an average of 91 lb C/ac and 5 lb N/ac.

Impact of Interseeding Cover Crop at VC on Irrigated Soybeans

Study ID: 0618159202101
County: Seward
Soil Type: Hastings silty clay loam 3-7% slopes; Hastings silty clay loam 7-11% slopes
Planting Date: 4/30/21
Harvest Date: 9/28/21
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Enlist®
Reps: 3
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 6 oz/ac Zidua®, 24 oz/ac glyphosate, and 1 pt/ac Lo-Vol 6 2,4-D on 4/20/21
Post: 32 oz/ac glyphosate on 6/17/21

Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: None
Irrigation: Pivot, Total: 4.5"
Rainfall (in):



Soil Tests (initial soil tests were collected in year 1 in September 2020 in the check and interseeded cover crop strips at at 0-8” depth):

	pH	Buffer pH	OM %	Nitrate-N ppm N	lbs N/A	K ppm	Sulfate-S ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Ca ppm	Mg ppm	Na ppm	CEC me/100g	Mehlich P-III ppm P
Check	7.5	7.2	2.5	2.2	5	277	11.8	3.51	31.5	12.8	0.87	3513	334	18	21.1	38
Interseeded	7.3	7.2	2.5	2.2	5	218	19.5	4.37	29.1	16.7	0.73	2501	335	19	15.9	33

Introduction: This is the second year of this on-farm research study in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg’s. At this site in year one, cover crops were interseeded into corn. In year two, cover crops were interseeded into soybeans. It was not possible to maintain the exact same strips of the check and interseeded cover crops, as soybeans were planted at an angle compared to the corn planting direction. This study evaluated the impact of interseeded cover crops on soybean. A rye cover crop was terminated with glyphosate on April 20, prior to planting soybeans on April 30. There were two treatments: a check where no cover crops were interseeded and an interseeded mix. The mix consisted of 26 lb/ac hard red winter wheat and 10 lb/ac red clover. Additionally, 50,000 seeds/ac of soybeans were added to the mix to replace some of the soybeans that would be killed during the interseeding. The cover crop was interseeded when soybeans were at VC on May 26. Soybean yield and stand counts were measured. During the season, the wheat eventually died from shading; however, the red clover survived through soybean harvest (Figure 1). Cover crop biomass was not collected at this site.

Figure 1. (top left) Wheat and red clover established nicely in the interseeded areas as seen on June 17, 2021; (top right) Soybeans were close to canopy and interseeded wheat is nearly as tall as soybeans as seen on June 28, 2021; (bottom left) Red clover was surviving between the soybean rows; however, wheat died out due to shading. Photo taken September 17, 2021, prior to soybean harvest.; (bottom right) Following harvest of soybeans, surviving red clover was present in the field. The field had been seeded to rye after harvest, but rye had not yet emerged at time the photo was taken on December 2, 2021.

Results:

	Stand Count (plants/ac)	**Moisture (%)**	**Soybean Yield (bu/ac)†**	**Marginal Net Return‡ ($/ac)**
Check	123,333 A*	13.1 A	61 A	719.66 A
Interseeded Cover Crop	109,667 B	13.2 A	61 A	679.15 A
P-Value	0.093	0.547	0.864	0.187

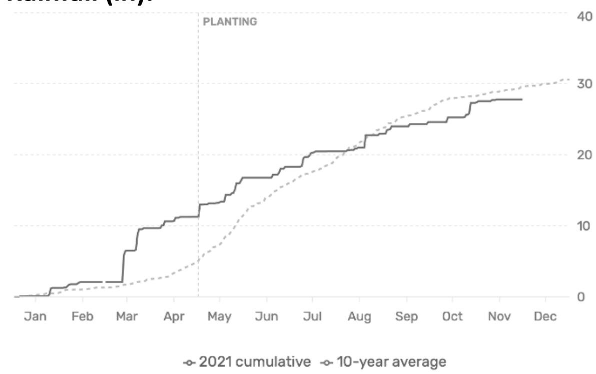
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $26.50/ac for cover crop seed (the cost of additional interseeded soybeans was not included), and $18/ac for interseeding.

Summary:

- Soybean plant stand was higher for the check compared to the interseeded cover crop. This is likely due to the killing of soybeans when the cover crop was interseeded.
- There were no differences in soybean moisture, yield, or net return between the interseeded cover crop treatment and the check.

Impact of Interseeding Cover Crop at V2 on Irrigated Soybeans

Study ID: 0580035202102
County: Clay
Soil Type: Hastings silt loam 1-3% slope; Fillmore silt loam frequently ponded
Planting Date: 5/1/21
Harvest Date: 9/26/21
Seeding Rate: 140,000
Row Spacing (in): 30
Variety: Pioneer® 33A53X
Reps: 3
Previous Crop: Corn
Tillage: No-till
Herbicides: ***Pre:*** 32 oz/ac Roundup®, Valor®, and Zidua® PRO on 5/1/21 ***Post:*** 32 oz/ac Roundup® and 12 oz/ac clethodim on 6/7/21
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: None
Irrigation: Pivot, Total: 10"
Rainfall (in):



Introduction: This on-farm research study is in collaboration with The Nature Conservancy, Upper Big Blue NRD, NRCS, and Kellogg's. This study evaluated the impact of interseeded cover crops on soybean. Soybeans were planted into a rye cover crop on May 1. The rye cover crop was terminated with glyphosate on the same day. This study had two treatments: a check where no cover crops were interseeded and an interseeeded mix. The mix consisted of 26 lb/ac hard red winter wheat and 10 lb/ac red clover. The cover crop was interseeded when soybeans were at V2 on June 4. Initially, there was good cover crop growth; however, after the soybeans canopied, the cover crop died. By harvest, no cover crop remained. Soybean yield and stand counts were measured. Cover crop biomass was not measured at this site.

Figure 1. (left) interseeded cover crop on June 18, 2021; (middle) interseeded cover crop June 28, 2021; (right) wheat residue remains under a lush soybean canopy on Sept. 1, 2021.

Results:

	Stand Count (plants/ac)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	128,167 A*	12.3 A	92 A	1,082 A
Interseeded	129,667 A	12.3 A	91 A	1,033 B
P-Value	0.511	0.802	0.368	0.005

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $26.50/ac for cover crop seed, and $18/ac drilling.

Summary:

- The interseeded cover crop did not impact soybean stand counts, moisture, or yield.
- Due to the additional cost of the cover crop seed and establishment, the net return was $49/ac lower for the interseeded cover crop treatment.

Effects of Grazing Cover Crops in a Three-Year Non-irrigated Rotation
5-year summary report

Study ID: 0720129202001
County: Nuckolls
Soil Type: Hastings silt loam 0-1% slope
Reps: 4

Introduction

In rainfed systems, adding cover crops into the rotation can decrease crop yields if precipitation is limited; however, the use of cover crops for forage may offset monetary costs while retaining soil benefits. This study evaluated three treatments: grazed cover crop (or stubble, depending on the year of crop rotation), non-grazed cover crop, and non-grazed wheat stubble. This is a three-year, no-till crop rotation of wheat, corn, and soybean. Cover crops were only planted following the wheat phase of the rotation. Watermark™ Soil Moisture Sensors were installed to determine treatment impacts for each growing season.

Year 1 (2017 crop)

In year one of the study, cover crop treatments were planted on August 14, 2016, following wheat harvest and consisted of a mix of winter peas, spring triticale, oats, collards, and purple top turnip. Cover crop biomass measured on October 19, 2016, was 3,401 lb/ac and consisted mainly of grass and turnip (Table 1).

Table 1. Cover crop composition (% of biomass on DM basis).

Grass	53.5%
Winter Pea	1.5%
Collards	8.7%
Turnip Tops	20.9%
Turnip Bottoms	14.5%
Other	0.9%

The grazed treatment was grazed in the fall of 2016. Starting in November 2016, 28 (1,100 lb) first-calf heifers grazed 9.6 acres for 22 days, resulting in the cover crop carrying 2.4 animal unit months (AUM)/ac. Post-grazing 2,177 lb/ac of biomass were still present. Baseline soil samples were collected in April 2017, prior to planting corn (Table 2).

Table 2. Soil analysis taken prior to corn planting in April 2017.

	---0 to 8 inches---			
	Soil pH	**OM %**	**Nitrate-N ppm**	**Nitrogen lb N/A**
Cover Crop – Non-grazed	5.52 A	3.1 A	5.4 B	9.3 B
Cover Crop/Stubble – Grazed	5.68 A	3.1 A	7.3 B	12.6 B
Stubble – Non-grazed	5.40 A	3.1 A	12.9 A	24.5 A
P-Value	0.38	0.90	0.01	<0.01

	---0 to 4 inches---				
	Solvita CO_2-C (ppm)	**Total Biomass (ng/g)**	**Total Bacteria Biomass (ng/g)**	**Total Fungi Biomass (ng/g)**	**Diversity Index**
Cover Crop – Non-grazed	133 A	4,225 A	2,187 A	351 A	1.44 A
Cover Crop/Stubble – Grazed	161 A	3,927 AB	2,142 A	333 A	1.44 A
Stubble – Non-grazed	128 A	3,046 B	1,605 A	306 A	1.50 A
P-Value	0.19	0.09	0.12	0.90	0.90

*Values with the same letter are not significantly different at a 90% confidence level.

During March through May 2017, prior to planting corn, the soil moisture in the cover crop treatments was around 35% depleted (the typical trigger point for irrigation on these soil types), whereas the wheat stubble treatments remained near field capacity (full soil moisture profile). Corn was planted in 2017 across all treatments. In May 2017, 8” of rain recharged the soil profile and all treatments had a full 4’ soil moisture profile at the beginning of June. Therefore, the cover crop treatments did not result in lower beginning moisture, which could limit yield potential. The grazed treatments began to show greater soil moisture depletion than the ungrazed treatments as time progressed. In June 2017, it was observed that the grazed treatments had Palmer amaranth emerge where the cattle created trails walking along the electric fence; Palmer amaranth was controlled with dicamba herbicide. For the 2017 corn crop, no significant yield differences occurred (Table 3). Corn yield where the cover crop was planted and not grazed (213 bu/ac) did not differ from where it was grazed (211 bu/ac).

Table 3. 2017 corn yield results.

	Stand Count (plants/ac)	Moisture (%)	Test Weight	Corn Yield (bu/ac)†
Cover Crop—Non-grazed	22,500 A	15.0 A	61 A	213 A
Cover Crop/Stubble—Grazed	22,167 A	14.9 A	61 A	211 A
Stubble—Non-grazed	22,500 A	15.2 A	61 A	218 A
P-Value	0.952	0.129	0.267	0.141

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture for corn.

Year 2 (2018 crop)

In year two of the study, following corn harvest in the fall of 2017, no cover crops were planted. In the previously established grazed cover crop treatment, 11 bulls grazed on the corn stalks (9.6 acres) for 18 days. The two previously non-grazed treatments remained non-grazed. Soybeans were planted in 2018 across all treatments. In August, the grazed treatment showed greater moisture stress than the non-grazed treatments (Figure 1).

Figure 1. August 3, 2018, image with grazed treatment (cover crop in 2016 and stubble in 2017) showing greater moisture stress.

Table 4. 2018 soybean yield results.

	Stand Count (plants/ac)	Test Weight	Moisture (%)	Soybean Yield† (bu/ac)
Cover Crop—Non-grazed	120,750 A*	55 A	10.7 B	50 A
Cover Crop/Stubble—Grazed	120,500 A	55 A	11.0 A	40 B
Stubble—Non-grazed	117,750 A	55 A	10.6 C	52 A
P-Value	0.629	0.397	0.0002	0.0004

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture for soybeans.

For the 2018 soybean crop, there were no differences in test weight or stand counts between the three treatments (Table 4). Grain moisture was significantly higher for the grazed cover crop treatment, followed by the non-grazed cover crop treatment, then the non-grazed wheat stubble. Yield of the non-grazed treatments was 10-12 bu/ac higher than for the grazed cover crop treatment.

Year 3 (2019 crop)

Following soybean harvest in October of 2018, Overland wheat was planted on October 22, 2018, at a seeding rate of 120 lb/ac and row spacing of 7.5". The field received 10 gal/ac 10-34-0 at planting and 80 lb N/ac as a spring topdress application. Wheat was harvested on July 26, 2019, and yield and grain moisture were recorded. For the 2019 wheat crop, there was no difference in test weight or yield (Table 5). Grain moisture was slightly different with the grazed cover crop treatment being wetter than the ungrazed wheat stubble treatment. The wet 2019 season delayed wheat harvest to July 26, 2019. The cover crop was planted on September 4, 2019, due to the rain and wet field. Three-year follow-up soil analysis for nutrient and soil health (Table 6) were taken August 5, 2019 (following wheat harvest and prior to planting cover crops).

Table 5. 2019 wheat yield results.

	Test Weight (lb/bu)	Moisture (%)	Wheat Yield (bu/ac)†
Cover Crop – Non-grazed	59 A*	10.3 AB	84 A
Cover Crop/Stubble – Grazed	59 A	10.4 A	84 A
Stubble – Non-grazed	59 A	10.2 B	83 A
P-Value	0.483	0.067	0.613

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre adjusted to 13% moisture.

Table 6. Three-year follow up soil analysis taken prior to cover crop planting August 5, 2019.

	----------0 to 8 inches----------			
	Soil pH	OM %	Nitrate-N ppm	Nitrogen lb N/A
Cover Crop – Non-grazed	5.7 A*	3.3 A	6.6 A	16.0 A
Cover Crop/Stubble – Grazed	5.5 AB	3.2 A	6.3 A	15.0 A
Stubble – Non-grazed	5.5 B	3.1 A	6.0 A	14.5 A
P-Value	0.090	0.105	0.395	0.390

*Values with the same letter are not significantly different at a 90% confidence level.

	Solvita CO_2-C (ppm)	Total Biomass (ng/g)	Total Bacteria Biomass (ng/g)	Total Fungi Biomass (ng/g)	Diversity Index	Soil Health Calculation
	----------0 to 4 inches----------					
Cover Crop – Non-grazed	59	2860	1073	183	1.06	10.00
Cover Crop/Stubble – Grazed	44	3498	1524	298	1.44	7.87
Stubble – Non-grazed	63	2760	1287	198	1.30	9.69
	----------4 to 8 inches----------					
Cover Crop – Non-grazed	31	906	353	4	0.94	5.89
Cover Crop/Stubble – Grazed	29	1526	569	53	1.22	5.53
Stubble – Non-grazed	21	977	354	12	1.06	4.65

3-Year Soil Physical Properties Changes

Sampling for soil physical properties including bulk density was completed on August 5, 2019. Neither cover crops nor grazing had a significant effect on soil bulk density in the top 2 inches. The average bulk density for the grazed cover crops was 1.08 g/cm^3, for ungrazed cover crops was 1.09 g/cm^3, and the ungrazed wheat stubble was 1.06 g/cm^3. There was no effect of grazing or cover crop in the 2-4" depth of soil. The average bulk density for the soil in the 2-4" depth was 1.31 g/cm^3 for the grazed cover crop treatment, 1.28 g/cm^3 for the ungrazed cover crop treatment, and 1.28 g/cm^3 for the ungrazed wheat stubble treatment.

Soil cone index value is a measurement of how easy it is to penetrate the soil. Figure 2 shows no significant effect on soil cone index value at any of the soil depths. The ungrazed cover crop tended to have a lower soil cone index value, but it was not significantly different from the other two treatments.

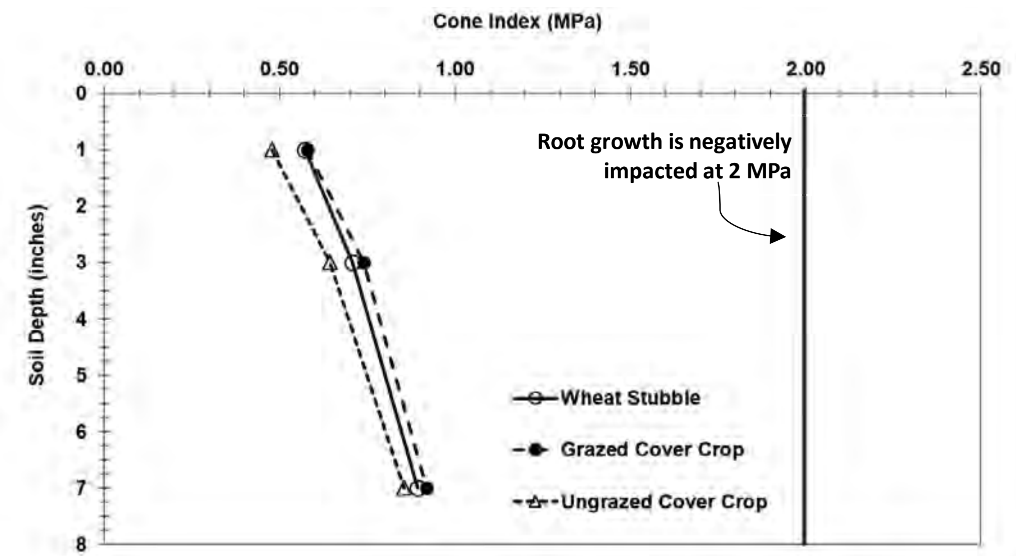
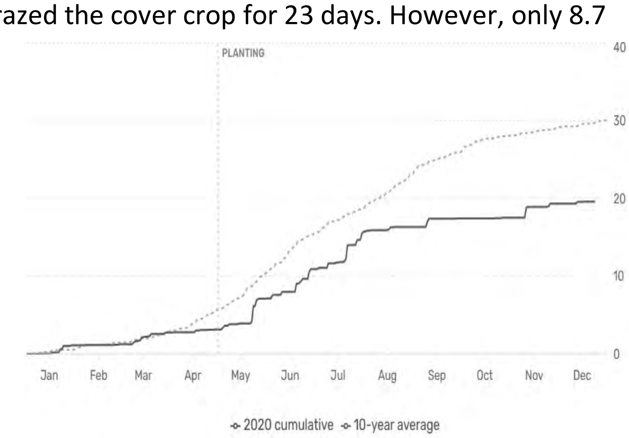


Figure 2. Three-year follow up soil cone index values by treatment taken August 5, 2019. The line on the far right represents where root growth is negatively impacted, because roots are no longer able to easily penetrate through the soil.

Year 4 (2019 Cover Crop and 2020 Corn)

Following wheat harvest, 20 ton/ac manure was applied, then a cool-season cover crop was planted on September, 3, 2019. Cover crop contained 10 lb/ac winter peas, 25 lb/ac winter triticale, 25 lb/ac black oats, 1.3 lb/ac collards, and 1.3 lb/ac turnip. Nine bulls grazed the cover crop for 23 days. However, only 8.7 AUM were available which was less than the 19.0 AUM in 2016 due to the wet fall, late planting, and minimal growth. Cover crop was 8" at time of termination by 32 oz Roundup®, 8 oz/ac dicamba, 0.5 lb/ac atrazine, and 4 oz/ac Balance® Flexx on 3/20/20. Manure application on a wet field resulted in deep ruts. This may have impacted corn emergence and stand counts the following spring.



For the corn crop, 190 lb/ac N as anhydrous ammonia was applied on March, 15, 2020. Pioneer® P1244 was planted no-till on May, 1, 2020 at a seeding rate of

25,000 seeds/ac in 30” rows. Six gallons of starter fertilizer (10-34-0) was applied in-furrow at planting. Post-emergent herbicides included 0.5 lb/ac atrazine, 30 oz/ac DiFlexx® DUO, and 32 oz/ac of Roundup. On August, 20, 2020, Headline AMP® at 10 oz/ac was applied for southern rust. Harvest occurred on October, 13, 2020. All treatments had a full soil moisture profile at the beginning of the 2020 growing season. By the end of August, all treatments had reached 50% depletion (Figure 3). There were no differences amongst treatments for stand counts, percent stalk rot, percent moisture, and test weight. The corn in the ungrazed wheat stubble yielded more than the cover crop treatments (Table 7). Economic analysis can be viewed in Table 8. This study will continue for two more years.

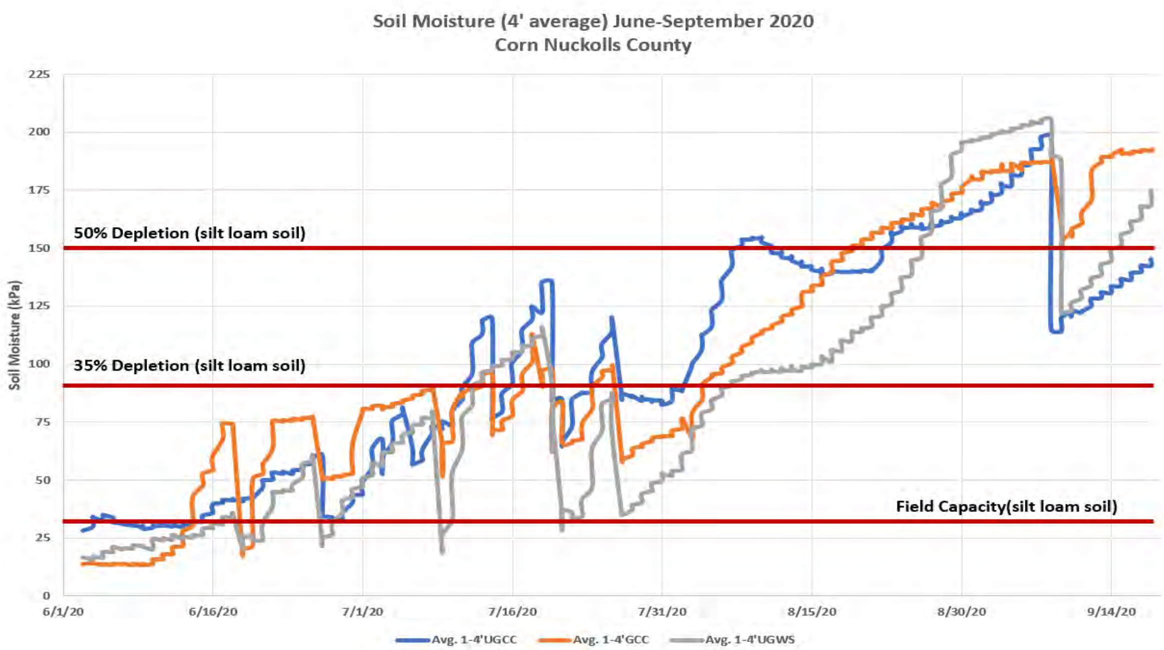


Figure 3. Soil moisture depletion for June-September 2020 corn in Nuckolls County. All treatments began the season with soil moisture at or above field capacity. The ungrazed cover crop (UGCC) and grazed cover crop (GCC) treatments reached 50% depletion by mid-August with the ungrazed wheat stubble (UGWS) reaching 50% depletion toward the end of August.

Table 7. 2020 corn yield results.

	Stand Count (plants/ac)	Stalk Rot (%)	Moisture (%)	Test Weight	Corn Yield (bu/ac)†
Cover Crop—Non-grazed	16,875 A	0 A	13.8 A	60.1 A	215 B
Cover Crop/Stubble—Grazed	18,000 A	0 A	13.6 A	60.3 A	216 B
Stubble—Non-grazed	18,125 A	2.5 A	13.6 A	60.2 A	227 A
P-Value	0.4355	0.454	0.2648	0.9201	0.0057

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture for corn.

Year 5 (2021 Soybeans)

Following corn harvest, no cover crops were planted. In the previously established grazed cover crop treatment, cattle grazed on the corn stalks. The two previously established non-grazed treatments remained non-grazed. Soybeans were planted in 15" row spacing on May 5, 2021 across all treatments. The variety was Pioneer® 25A04 and the rate was 140,000 seeds/ac. This location had good rain in 2021, so there was no moisture stress observed across treatments as was observed in 2018. The soybeans were harvested on September 21 and 22, 2021.

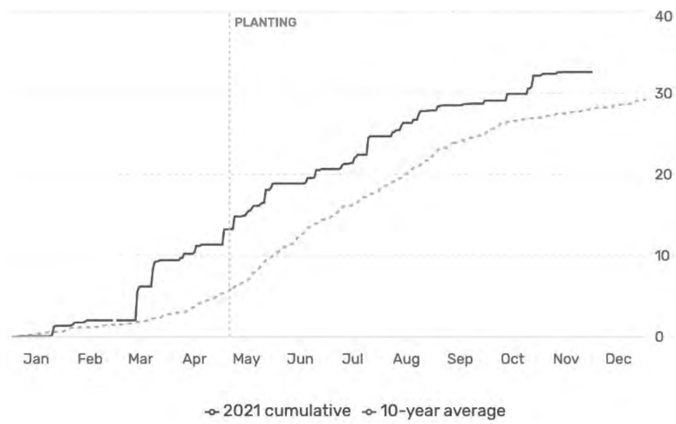


Table 8. 2021 soybean yield results.

	Stand Count (plants/ac)	Moisture (%)	Soybean Yield (bu/ac)†
Cover Crop—Non-grazed	109,333 A*	10.4 A	63 A
Cover Crop/Stubble—Grazed	103,333 A	10.4 A	67 A
Stubble—Non-grazed	112,000 A	10.4 A	66 A
P-Value	0.498	0.756	0.200

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13% moisture.

Summary:

- For the 2021 soybean crop, there were no differences in stand counts, moisture or yield between the three treatments.
- The field was planted to wheat in fall 2021; the study will continue in 2022.

Multi-Year Economic Analysis (2016 cover crop to 2020 corn crop)

2016 Cover Crop: Cost for spraying wheat stubble was $18/ac. Costs for the non-grazed cover crop treatments were $46.64/ac ($28.64/ac for seed and $18/ac for drilling). Costs for grazed cover crop treatments were $61.94/ac ($46.64/ac for the cover crop seed and planting, $5/ac for fencing, and $10.30/ac for water). Water cost was calculated assuming hauling water (1,000 gal) 15 miles every two days at $2 per loaded mile and $6 per $1,000 gal. Costs for the grazed cover crop treatments equaled $30.97/AUM (animal unit months). Value of the forage is estimated to be $84.80/ac (based on rental rates of $53/pair/month [1.25 AUMs] or $42.40 AUM).

2017 Corn: The economic analysis had no input differences for any of the treatments for corn production. UNL Corn Budget 21 (EC872, 2017 Nebraska Crop Budgets, revised Nov. 2016) was the closest that fit this operation, so a total cost/ac of $459.60/ac and a market year average price of $3.15/bu was used. In the previously established grazed cover crop treatment, cattle grazed on the corn stalks. A $5/ac cornstalk rental rate value was assessed to this 9.6 acre area. This rate assumes water, fencing, and the care of the animals.

2018 Soybean: The inputs were the same for the soybeans planted into all the previous treatments. UNL Budget 56 (EC872, 2018 Nebraska Crop Budgets, revised Nov. 2017) was used, which states a $315.82/ac total cost. A market year average price of $7.40/bu was used.

2019 Wheat: The inputs were the same for the wheat planted into all the previous treatments. UNL Budget 70 (EC872, 2019 Nebraska Crop Budgets, revised Nov. 2018) was used which stated a $247.04/ac total cost. A market year average price of $3.65/bu was used.

2019 Cover Crop: Cost for spraying the wheat stubble was $18 ($9/ac application and $9/ac herbicide cost). Costs for the non-grazed cover crop treatments were $49.42/ac ($31.42/ac for seed and $18/ac for drilling). Costs for grazed cover crop treatments were $64.00/ac ($49.42/ac for the cover crop seed and planting, $5/ac for fencing, and $9.58/ac for water). Water cost was calculated based on hauling water (5.75 water trips at $16/trip, which included cost of water).

Costs for the grazed cover crop treatments equaled $54.78/AUM (49.42*9.6=474.43/8.66AUM from what was grazed=54.78). Value of the forage was estimated to be $84.80/ac (based on rental rates of $53/pair/month [1.25 AUMs] or $42.40 AUM). Forage production was limited in the fall of 2019 compared to 2016 due to a wet summer that delayed wheat harvest, which, in turn, delayed cover crop planting. A cool fall led to less growth. Nine bulls grazed the cover crop for 23 days. However, only 8.7 AUM were available which was less than the 19.0 AUM in 2016 due to the wet fall, late planting, and minimal growth.

2020 Corn: The economic analysis had no input differences for any of the treatments for corn production. UNL Corn Budget 23 (EC872, 2020 Nebraska Crop Budgets, revised Nov. 2019) was the closest that fit this operation, so a total cost/ac of $452.10 and a market year average price of $3.51 was used. In the previously established grazed cover crop treatment, cattle grazed on the corn stalks. A $5/ac cornstalk rental rate value was assessed to this 9.6 acre area. This rate assumes water, fencing, and the care of the animals.

2021 Soybean: The inputs were the same for the soybeans planted into all the previous treatments. UNL Budget 58 (EC872, 2021 Nebraska Crop Budgets, revised Nov. 2020) was used, which states a $410.69 total cost. A market year average price of $11.80/bu soybean was used.

Table 7. Three crop year economic analysis summary of this study, presented in $/ac.

	2016 Cover	**2017 Corn**	**2018 Soy**	**2019 Wheat**	**3-Year Total**
Cover Crop—Non-grazed	-$46.64	$211.35	$54.18	$59.56	**$278.45**
Cover Crop/Stubble—Grazed	$22.86	$210.05	-$19.82	$59.56	**$272.65**
Stubble—Non-grazed	-$18.00	$227.10	$68.98	$55.91	**$333.99**
	2019 Cover	**2020 Corn**	**2021 Soy**	**2022 Wheat**	**6-Year Total**
Cover Crop—Non-grazed	-$49.42	$304.23	$743.40	TBD	*$1276.66*
Cover Crop/Stubble—Grazed	$20.80	$311.13	$790.60	TBD	*$1395.18*
Stubble—Non-grazed	-$18.00	$342.99	$778.80	TBD	*$1437.78*

Incorporation of Winter Terminated and Winter Hardy Cover Crop in a Corn-Soybean-Wheat Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0656127202101
County: Nemaha
Reps: 12 (4 per area)
Tillage: No-till
Irrigation: None

Introduction

This study is being conducted on a soil health demonstration farm as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative, and involves the farmer, the Nebraska On-Farm Research Network, and the USDA NRCS. Two treatments, winter terminated cover crops and winter hardy cover crops, were used in this five-year study (2016-2021), this is the final year of this study. This study did not have a no cover crop control. The crop rotation is corn, soybean, and wheat, with all three crops present each year. The field was divided into three portions so that all phases of the crop rotation were present each year (Figure 1).

- Area A primarily consists of Judson silt loam, 2 to 6 percent slopes
- Area B primarily consists of Judson silt loam, 0 to 2 percent slopes
- Area C primarily consists of Ackmore silt loam, occasionally flooded.

The results here are presented over the five years for each of these areas of the field.

Winter hardy mix (left) and winter terminated mix (right). Picture taken on April 2nd, 2020.

Sub-field area A (Judson silt loam, 2 to 6 percent slopes)

Year 1 – Corn (2017 Crop)

Planting Date: 4/11/17
Harvest Date: 9/19/17
Population: 33,000
Row Spacing (in): 30
Hybrid: Pioneer P0636AM
Herbicides: ***Pre:*** 64 oz/ac FulTime®, 16 oz/ac Range Star®, and 3.2 oz/ac ABSORB 100 ***Post:*** 32 oz/ac Buccaneer® 5 Extra, 2 oz/ac Bellum™, and 3.2 oz/ac N-Tense™
Seed Treatment: PPST 250
Foliar Fungicides: 8 oz/ac Quilt Xcel®
Fertilizer: 12-40-60-10-1-1 dry and 175 lb N/ac as UAN 32% spring pre-plant, and 1 gal/ac NResponse™ foliarly applied
Cumulative Rainfall (in): 20

In year one, cover crops were drilled on September 29, 2016. The winter terminated treatment was a mix of oats, turnips, and common rapeseed, whereas the winter hardy treatment consisted of cereal rye, turnips, and common rapeseed. For uniformity, both cover crop mixes were sprayed with glyphosate on April 12, 2017. This terminated the winter hardy treatment and controlled weeds and brassicas, which had overwintered in the winter terminated cover crop treatment. In 2017, corn planted after winter terminated cover crops had a higher yield, higher test weight, and was drier than the winter hardy cover crops (Table 1). There were no differences in harvest stand counts for the corn following the winter terminated and winter hardy cover crops (Table 1). The corn following the winter hardy mix was three days slower to tassel than the corn following the winter terminated mix (Figure 1).

Table 1. 2017 corn stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/acre)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated	30,355 A*	54 A	18.0 B	183 A	546.97 A
Winter Hardy	30,023 A	52 B	19.1 A	168 B	498.00 B
P-Value	0.802	0.0209	0.0034	0.0003	0.0003

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.15/bu corn and $30.07 cost for cover crop seed and drilling in both treatments.

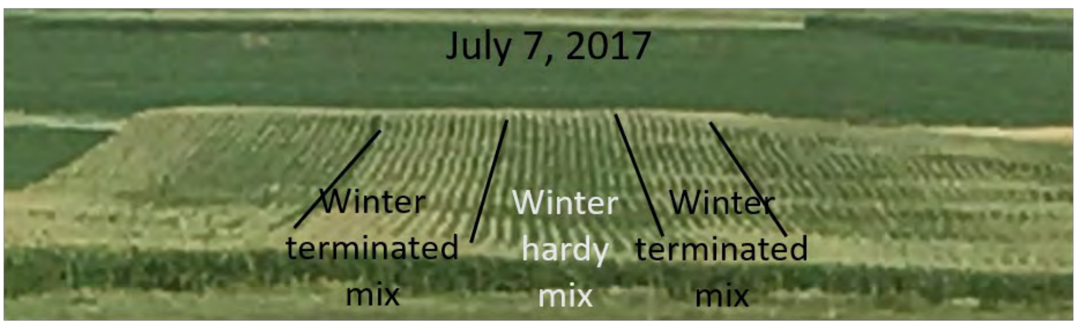


Figure 1. Corn crop following winter hardy and winter terminated cover crops. Picture taken on July 7, 2017.

Year 2 – Soybeans (2018 Crop)

Planting Date: 5/7/18
Harvest Date: 9/17/18
Row Spacing (in): 15
Variety: Pioneer® 24T19R
Herbicides: ***Pre:*** 6 oz/ac Sonic®, 16 oz/ac generic Dual, 16 oz/ac 2,4-D 6#, 8 oz/ac Absorb 100, and 16 oz/ac Buccaneer 5 Extra® on 4/17/18 ***Post:*** 16 oz/ac Shafen Star, 8 oz/ac Clethodim 2EC, 32 oz/ac Buccaneer 5 Extra®, 8 oz/ac Absorb 100, and 4 oz/ac N-Tense™ on 6/16/18
Seed Treatment: PPST 2030
Foliar Insecticides: 3.84 oz/ac Lambda-Cy 1 EC aerial applied on 7/26/18
Foliar Fungicides: 10.5 oz/ac Azoxyprop Xtra aerial applied on 7/26/18
Fertilizer: 1 gal/ac NResponse™ on 6/16/18; 1 gal/ac Kugler KS2075 (20% N, 7.5% P, 5% S) aerial applied on 7/26/18
Cumulative Rainfall (in): 27

In year two, cover crops were drilled on August 1, 2017. The winter terminated treatment was a mix of 30 lb/ac oats, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 17, 2018. Soybeans planted after winter terminated cover crops had a higher yield, lower test weight, and higher net return than the winter hardy cover crops (Table 2).

Table 2. 2018 soybean stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight	Moisture (%)	Soybean Yield† (bu/ac)	Marginal Net Return‡ ($/ac)
Winter Terminated	120,744 A*	56 B	11.3 A	65 A	452.80 A
Winter Hardy	120,246 A	56 A	11.2 A	59 B	410.75 B
P-Value	0.872	0.096	0.200	0.002	0.002

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture for soybeans.
‡Marginal net return based on $7.40/bu soybean, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 3 – Wheat (2019 Crop)

In year three, wheat was planted following soybean harvest. No measurements were made on wheat yields in the winter terminated and winter hardy cover crop strips.

Year 4 – Corn (2020 Crop)

Planting Date: 4/8/20
Harvest Date: 9/15/20
Population: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P0589AM
Herbicides: ***Pre:*** 1 lb/ac Atrazine, 40 oz/ac Resicore®, 32 oz/ac glyphosate, 1 qt/100 gal N-Tense on 4/2/20
Post: 40 oz/ac Resicore®, 32 oz/ac glyphosate, and 1 qt/100 gal N-Tense
Fertilizer: NPSZ starter fertilizer (10 lb N/ac, 40 lb N/ac, 40 lb N/ac, 6 lb S/ac, and 2 lb Zn/ac); 150 lb N/ac as 32% UAN, 46 lb N/ac as urea side-dress
Cumulative Rainfall: 25”

In year four, cover crops were drilled on August 1, 2019. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 17, 2019 and removed on December 12, 2019. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2, 2020. In previous years, corn and soybeans in this portion of the field yielded lower when they followed the winter hardy cover crop. This was not the case this year. In 2020, there were no differences in corn population, moisture, test weight, yield, or net return (Table 3).

Table 3. 2020 corn stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	31,556 A*	53 A	21.1 A	213 A	719.79 A
Winter Hardy Cover Crop	30,352 A	53 A	20.9 A	208 A	701.16 A
P-Value	0.182	0.704	0.330	0.212	0.173

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.51/bu corn, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 5 – Soybeans (2021 Crop)

Planting Date: 4/25/21
Harvest Date: 9/21/21
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Pioneer® P27A17X
Herbicides: ***Pre:*** 6 oz/ac Authority® First, 16 oz/ac metolachlor, 16 oz/ac 2,4D LV 6, 16 oz/ac Buccaneer 5 Xtra®, and 6.4 oz/ac Absorb 100 ***Post:*** 32 oz/ac Enlist One®, 40 oz/ac glufosinate, 2 qt/100 gal Cornbelt® EN-Pack™, 2 lb/ac AMS, and 1 lb/ac DriGuard

Fertilizer: 11-40-60-6-2
Cumulative Rainfall: 23"

In year five, cover crops were drilled in September, 2020, after corn harvest. The winter terminated treatment was a mix of 30 lb/ac oats, 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac rye, 3 lb/ac turnips 3 lb/ac radishes. Cattle were put out on the cover crop on November 7, and removed December 11, 2020. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 10, 2021. In 2021, there were also no differences in soybean population, moisture, test weight, yield, or net return (Table 4).

Table 4. 2021 soybean stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	**Moisture (%)**	**Soybean Yield (bu/ac)†**	**Marginal Net Return‡ ($/ac)**
Winter Terminated Cover Crop	123,236 A*	11.0 A	67 A	758 A
Winter Hardy Cover Crop	123,974 A	10.9 A	66 A	751 A
P-Value	0.925	0.695	0.727	0.808

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $21.30/ac for winter terminated cover crop seed, $18.30/ac for winter hardy cover crop seed, and $14.40/ac for drilling cost.

Multi-Year Soil Health Assessment (2016 to 2021)

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

Table 5. Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016)*						
Winter hardy	1.30	-	1.22	59	-[3]	19.5
Winter terminated	1.12	-	1.32	59	-	20.8
2018 *(2 composite samples collected for all replications of a treatment, samples collected on Oct. 31, 2018)*						
Winter hardy	0.932	27.5 A	1.22 A	50.1 A	-	18.5
Winter terminated	0.743	24.7 A	1.26 A	50.6 A	-	18.5
P-Value	-	0.406	0.341	0.500		-
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019)*						
Winter hardy	0.631 A	29.5 A	1.28 A	48.4 A	4.12 A	20.2 A
Winter terminated	2.259 A	28.1 A	1.20 A	49.7 A	4.38 A	21.4 A
P-Value	0.338	0.594	0.433	0.350	0.604	0.186
2020 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020)*						
Winter hardy	2.52 A	15.6 A	1.24 A	57.4 A	3.25 A	22.4 A
Winter terminated	4.85 A	15.7 A	1.25 A	57.9 A	3.00 A	22.5 A
P-Value	0.337	0.772	0.862	0.767	0.182	0.391
2021 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021)*						
Winter hardy	3.433 A	24.5 A	1.22 A	40.0 A	3.00 A	21.2 A
Winter terminated	0.567 A	21.7 A	1.26 A	40.2 A	2.75 A	21.4 A
P-Value	0.226	0.392	0.695	0.886	0.495	0.761

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
[3]No test was completed in 2016 for soil moisture and 2016 and 2018 for Soil Respiration.
*Values with the same letter are not significantly different at a 90% confidence level.

Sub-field area B (Judson silt loam, 0 to 2 percent slopes)

Year 1 – Soybeans (2017 Crop)

Planting Date: 4/30/17
Harvest Date: 9/20/17
Population: 175,000
Row Spacing (in): 15
Variety: Pioneer 24T19R
Herbicides: ***Pre:*** 5 oz/ac Sonic®, 2 oz/ac Blanket® 4F, 14 oz/ac 2,4-D LV, and 3.2 oz/ac ABSORB 100 ***Post:*** 32 oz/ac Buccaneer® 5 Extra, 16 oz/ac Flexstar®, 6.4 oz/ac Clethodim®, 3.2 oz/ac ABSORB 100, and 10.5 oz/ac AzoxyProp Xtra
Cumulative Rainfall (in): 20

In year one, cover crops were drilled on September 29, 2016. The winter terminated treatment was a mix of oats, turnips, and common rapeseed, whereas the winter hardy treatment consisted of cereal rye, turnips, and common rapeseed. For uniformity, both cover crop mixes were sprayed with glyphosate on April 12, 2017. This terminated the winter hardy treatment and controlled weeds and brassicas, which had overwintered in the winter terminated cover crop treatment. In 2017, soybeans had no difference in yield, test weight, moisture, or net return following the winter terminated and winter hardy cover crops (Table 6).

Table 6. 2017 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	102,178 A*	56 A	10.6 A	62 A	518.84 A
Winter Hardy Cover Crop	102,178 A	56 A	10.6 A	61 A	516.42 A
P-Value	1	0.4886	1	0.7345	0.735

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.90/bu soybean and $30.07 cost for cover

Year 2 – Wheat (2018 Crop)

In year two, following soybean harvest in 2017, wheat was planted in this area. No yield measurements were collected for the winter terminated and winter hardy cover crop strips.

Year 3 – Corn (2019 Crop)

Planting Date: 4/10/19
Harvest Date: 9/19/19
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P0688AM™
Herbicides: ***Pre:*** 40 oz/ac Resicore®, 32 oz/ac Buccaneer® 5 EXTRA, 16 oz/ac Detonate® on 4/2/19 ***Post:*** 3.2 oz/ac Meso Star and 32 oz/ac Buccaneer® 5 EXTRA on 6/5/19
Foliar Insecticides: 3.84 oz/ac Lambda-Cyhalothrin 1 EC on 7/28/19 aerial applied
Foliar Fungicides: 6.4 oz/ac AzoxyProp Xtra on 6/5/19 with herbicide; 10.5 oz/ac AzoxyProp Xtra on 7/28/19 aerial applied
Fertilizer: 150 lb/ac NPSZ (18 lb/ac N, 67.5 lb/ac P, 7.5 lb/ac S, and 1.5 lb/ac Zn), 75 lb/ac potash, and 7 lb/ac boron 15% on 2/5/19; 150 lb N/ac as 32% UAN on 4/2/19; 6.4 oz/ac N-TENSE™ on 6/5/19; 46 lb N/ac as 46% urea on 6/27/19
Cumulative Rainfall (in): 35

In year three, following wheat harvest, cover crops were drilled on August 1, 2018. The winter terminated treatment was a mix of 30 lb/ac oats and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye and 1 lb/ac turnip. Cattle grazed the cover crop from November 1 to November 26. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2, 2019. In 2019, there were no differences in corn population, moisture, test weight, yield, or net return (Table 7).

Table 7. 2019 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plans/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	29,952 A*	57 A	17.7 A	217 A	805.04 A
Winter Hardy Cover Crop	29,429 A	57 A	17.8 A	214 A	792.55 A
P-Value	0.207	0.552	0.891	0.277	0.216

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.83/bu corn, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 4 – Soybeans (2020 Crop)

Planting Date: 5/7/20
Harvest Date: 9/23/20
Population: 145,000
Row Spacing (in): 15
Variety: Pioneer® P27A17X
Herbicides: ***Pre:*** 6 oz/ac Authority® First, 16 oz/ac Me-Too-Lachor™, 16 oz/ac Dicamba HD®, and 6.4 oz/ac Absorb 100 ***Post:*** 32 to 40 oz/ac Buccaneer® 5 EXTRA, 16 oz/ac Battle Star®, 7 oz/ac Clethodim, 1 qt/100 gal Absorb 100, and 1 qt/100 gal N-TENSE™
Fertilizer: NPSZ starter fertilizer (10 lb N/ac, 40 lb N/ac, 40 lb N/ac, 6 lb S/ac, and 2 lb Zn/ac)
Cumulative Rainfall: 35”

In year four, cover crops were drilled September 27, 2019. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 17, 2019, and removed December 12, 2019. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 23, 2020. There were no differences in soybean stand counts, yield, moisture, test weight, or net return between the winter terminated and winter hardy cover crop (Table 8). However, aerial imagery normalized difference vegetation index (NDVI) analysis showed higher values for soybean in the winter terminated strips (Figures 2A and 2B). Even though yields were not different, soybeans following winter hardy cover crops were not as large or canopied as soybeans following winter terminated cover crop.

Table 8. 2020 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	127,187 A*	56 A	12.6 A	76 A	694.02 A
Winter Hardy Cover Crop	117,338 A	56 A	12.8 A	73 A	669.34 A
P-Value	0.179	0.527	0.268	0.452	0.419

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $9.50/bu soybean, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

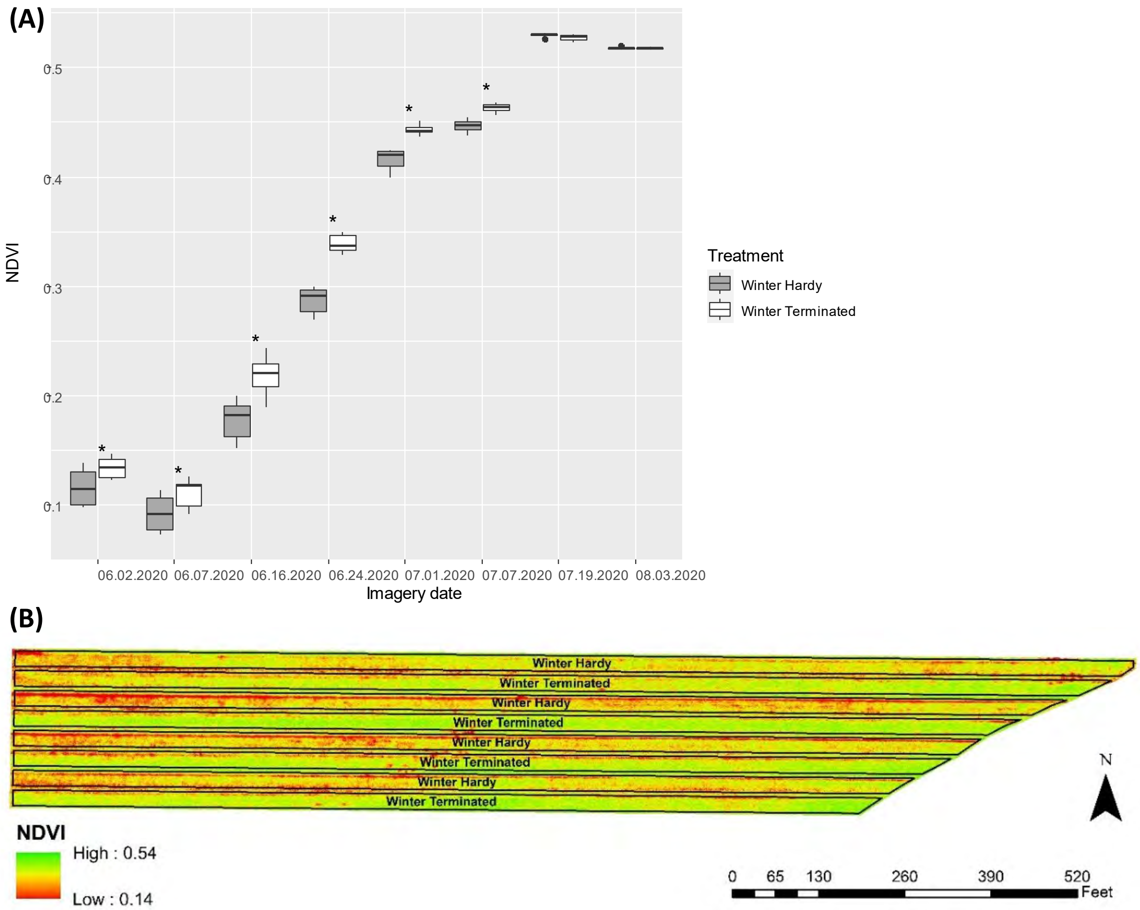


Figure 2. (A) Normalized difference vegetation index (NDVI) values from aerial imagery for the soybean crop following winter hardy and winter terminated cover crops. Asterisk (*) within each date indicates significant difference ($p < 0.10$) between treatments at a 90% confidence level. (B) Aerial imagery from July 1 displayed as soybean normalized difference vegetation index (NDVI). Strips with winter hardy and winter terminated cover crop are indicated.

Year 5 – Wheat (2021 Crop)

In year five, following soybean harvest in 2020, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Multi-Year Soil Health Assessment (2016 to 2021)

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

Table 9. Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016)*						
Winter hardy	1.30	-	1.22	59	-[3]	19.5
Winter terminated	1.12	-	1.32	59	-	20.8
2018 *(2 composite samples collected for all replications of a treatment; samples collected on Oct. 31, 2018)*						
Winter hardy	0.86 A	29.4 A	1.20 A	49.0 A	-	18.5 A
Winter terminated	1.71 A	26.5 A	1.38 A	49.5 A	-	18.0 A
P-Value	0.350	0.777	0.113	0.500		0.5
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019)*						
Winter hardy	0.72 A	22.6 A	1.19 A	48.83 A	2.88 A	19.5 A
Winter terminated	0.62 A	26.4 A	1.26 A	48.98 A	2.38 A	19.5 A
P-Value	0.599	0.195	0.284	0.638	0.308	1.000

Table 1 Continued

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2020 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020)*						
Winter hardy	10.87 A	13.3 A	1.29 A	58 A	2.62 B	18.5 A
Winter terminated	7.59 A	15.2 A	1.29 A	58 A	3.00 A	17.6 A
P-Value	0.2560	0.605	0.928	1.000	0.0577	0.628
2021 *(1 samples per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021)*						
Winter hardy	4.72 A	21.3 A	1.39 A	39.9 A	3.25 A	21.1 A
Winter terminated	1.88 A	19.2 A	1.35 A	39.7 A	2.38 A	21.1 A
P-Value	0.527	0.139	0.492	0.789	0.0689	0.275

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
[3]No test was completed in 2016 for soil moisture and 2016 and 2018 for Soil Respiration.
*Values with the same letter are not significantly different at a 90% confidence level.

Sub-field area C (Ackmore silt loam, occasionally flooded)

Year 1 – Wheat (2017 Crop)

In year one, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Year 2 – Corn (2018 Crop)

Planting Date: 4/17/18
Harvest Date: 9/14/18
Row Spacing (in): 30
Hybrid: Pioneer® 0363AM
Herbicides: ***Pre:*** 3 qt/ac FulTime® NXT, 16 oz/ac 6# 2,4-D, and 16 oz/ac Buccaneer 5 Extra® on 4/4/18 ***Post:*** 3 oz/ac Bellum™, 32 oz/ac Buccaneer 5 Extra®, and 3.2 oz/ac N-Tense™ on 6/4/18
Seed Treatment: PONCHO®/VOTiVO®
Foliar Insecticides: 3.84 oz/ac Lambda-Cy 1EC aerial applied on 7/7/18; 3.84 oz/ac Lambda-Cy 1 EC aerial applied on 7/26/18
Foliar Fungicides: 6 oz/ac AzoxyProp Xtra on 6/4/18; 10.5 oz/ac AzoxyProp Xtra aerial applied on 7/7/18; 10.5 oz/ac AzoxyProp Xtra aerial applied on 7/26/18
Fertilizer: 150 lb/ac N as 32% UAN on 4/4/18; 1 gal/ac NResponse™ on 6/4/18; 82.8 lb/ac N as Urea on 6/11/18; 1 gal/ac Kugler KQ-KRN™ (28% N) aerial applied on 7/7/18;1 gal/ac Kugler KS2075 (20% N, 7.5% P, 5% S) aerial applied on 7/26/18
Cumulative Rainfall: 27"

In year two, cover crops were drilled August 1, 2017. The winter terminated treatment was a mix of 30 lb/ac oats, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 4, 2018. There were no differences in corn yield, moisture, test weight, harvest stand counts, or net return between the winter terminated or winter hardy cover crop treatment (Table 10).

Table 10. 2018 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plans/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	29,710 A*	56 A	20.7 A	243 A	759.43 A
Winter Hardy Cover Crop	29,515 A	56 A	20.9 A	240 A	748.71 A
P-Value	0.677	0.226	0.516	0.281	0.283

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.23/bu corn, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 3 – Soybeans (2019 Crop)

Planting Date: 4/26/19
Harvest Date: 9/26/19
Seeding Rate: 140,000
Row Spacing (in): 30
Variety: Pioneer® P23A32X
Herbicides: ***Pre:*** 6 oz/ac Sonic®, 24 oz/ac Metalica, 16 oz/ac 2,4-D LV6, and 32 oz/ac Buccaneer® 5 Extra with 6.4 oz/ac Absorb 100 on 4/9/19 ***Post:*** 16 oz/ac Metalica, 16 oz/ac Shafen Star, 8 oz/ac SeCURE EC, and 32 oz/ac Buccaneer® 5 Extra with 9.6 oz/ac Absorb 100 on 6/19/19
Foliar Insecticides: 3.84 oz/ac Lambda-Cyhalothrin 1 EC aerial applied on 8/15/19
Foliar Fungicides: 10.5 oz/ac AzoxyProp Xtra aerial applied 8/15/19
Fertilizer: 100 lb/ac NPSZ (12 lb/ac N, 45 lb/ac P, 5 lb/ac S, and 1 lb/ac Zn) and 100 lb/ac potash on 2/5/19
Cumulative Rainfall: 35”

In year three, cover crops were drilled September 15, 2018. The winter terminated treatment was a mix of 30 lb/ac oats and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye and 1 lb/ac turnip. Cattle were put out on the cover crop on November 1 and removed November 26. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 9, 2019. There were no differences in soybean yield, moisture, test weight, or net return between the winter terminated and winter hardy cover crop. Soybean stand counts taken at harvest were lower for the soybean following winter hardy cover crop (Table 11).

Table 11. 2019 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	100,519 A*	56 A	12.6 A	84 A	652.21 A
Winter Hardy Cover Crop	93,884 B	56 A	12.9 A	86 A	670.35 A
P-Value	0.099	0.629	0.447	0.693	0.719

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 4 – Wheat (2020 Crop)

In year four, following soybean harvest in 2019, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Year 5 – Corn (2021 Crop)

Planting Date: 4/13/21
Harvest Date: 9/20/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1089AM
Herbicides: ***Pre:*** 40 oz/ac Resicore®, 16 oz/ac Buccaneer 5 Xtra®, 4 oz/ac Cornbelt® N-TENSE™, and 1 lb/ac DriGuard ***Post:*** 40 oz/ac Resicore®, 32 oz/ac Buccaneer 5 Xtra®, 4 oz/ac Cornbelt® N-TENSE™, and 1 lb/ac DriGuard
Foliar Fungicides: 10.5 oz/ac Azoxyprop Xtra on 8/4/21
Fertilizer: 180-40-60-6-2, 120 lb N/ac as 32% UAN with herbicide application
Cumulative Rainfall: 23”

In year five, cover crops were drilled in September, 2020 after soybean harvest. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 7, and removed on Decmber 10, 2020. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2nd, 2021. In 2021, there were no differences in corn population, moisture, test weight, yield, or net return (Table 12).

Table 12. 2021 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	**Moisture (%)**	**Corn Yield (bu/ac)†**	**Marginal Net Return‡ ($/ac)**
Winter Terminated Cover Crop	30,629 A*	15.3 A	221 A	1,115 A
Winter Hardy Cover Crop	30,023 A	15.1 A	218 A	1,100 A
P-Value	0.664	0.150	0.275	0.356

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $21.30/ac for winter terminated cover crop seed mix, $18.30/ac for winter hardy cover crop seed mix, and $14.40/ac for drilling cost.

Multi-Year Soil Helath Assessment (2016 to 2021)

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

Table 13. Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016)*						
Winter hardy	1.30	-	1.22	59	2.00	19.5
Winter terminated	1.12	-	1.32	59	2.00	20.8
2018 *(2 composite samples collected for all replications of a treatment; samples collected on Oct. 31, 2018)*						
Winter hardy	0.86 A	29.4 A	1.20 A	49.0 A	3.00	18.5 A
Winter terminated	1.71 A	26.5 A	1.38 A	49.5 A	3.00	18.0 A
P-Value	0.350	0.777	0.113	0.500	N/A	0.5
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019)*						
Winter hardy	2.00 A	25.7 A	1.30 A	49.5 B	2.9 A	19.8 A
Winter terminated	9.94 A	22.95 A	1.34 A	48.8 A	2.5 A	19.5 A
P-Value	0.258	0.302	0.299	0.007	0.520	0.2152
2020 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020)*						
Winter hardy	19.6 A	12.2 A	1.26 A	60 A	3.38 A	21.6 A
Winter terminated	17.8 A	12.0 A	1.28 A	59 A	3.38 A	20.6 A
P-Value	0.938	0.907	0.773	0.225	1.000	0.320
2021 *(1 samples per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021)*						
Winter hardy	12.05 A	22.2 A	1.33 A	41.4 A	2.38 A	21.4 A
Winter terminated	6.57 A	26.1 A	1.29 A	48.4 A	3.12 A	21.2 A
P-Value	0.483	0.0626	0.535	0.425	0.103	0.391

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
[3]No test was completed in 2016 for soil moisture and 2016 and 2018 for Soil Respiration.
*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating winter hardy cover crop in a corn-soybean-wheat rotation resulted in neutral effects on soybean and corn yields on most years and sub-field areas. Decreases in corn and soybeans yields following winter hardy cover crops were observed only in sub-field area A (Judson silt loam, 2 to 6 percent slopes).
- In years when winter hardy had negative effect on corn and soybean yields, marginal net return was also lower than winter terminated cover crop.
- It does appear that winter hardy cover crop biomass could delay the growth/development in corn and soybean.
- There were no differences in soil health parameters between the treatments in 2018, 2019, 2020 and 2021 with the exception of soil temperature, which in 2019 was higher for the winter hardy cover crop treatment.

Incorporation of Dormant and Interseeded Cover Crop in an Irrigated Corn-Soybean-Field Pea Rotation
NRCS Soil Health Management Demonstration Field 4-year summary report

Study ID: 0815093202101
County: Howard
Reps: 6
Tillage: Strip-till
Irrigation: Pivot

Soil Type: Kenesaw silt loam 1-6% slopes; Valentine-Thurman Choose Soil Texture 0-17% slopes; Thurman loamy fine sand 0-2% slope; Thurman loamy fine sand 2-6% slopes; Kenesaw silt loam 0-1% slope

Introduction

This study is being conducted on a soil health demonstration farm as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Helth Initiative and involves the farmer, the Nebraska On-Farm Research Network, and the USDA NRCS. This study is examining three treatments: 1) dormant (post-harvest) seeded cover crops and interseeded cover crops, 2) dormant (post-harvest) seeded cover crops, and 3) no cover crop check. The three treatments were applied consistently during this four-year study (2018-2021).

Year 1 - Corn (2018 Crop)

Planting Date: 5/17/18
Harvest Date: 10/6/18
Population: 35,000
Row Spacing(in): 30
Hybrid: Pioneer 0157 AMXT
Previous Crop: Corn
Herbicides: ***Pre:***32 oz/ac glyphosate on 5/10/18 ***Post:*** 32 oz/ac glyphosate and 5 oz/ac Status® on 6/1/18
Seed Treatment: Herculex® XTRA, Poncho® 1250 + VOTiVO®, AcreMax® Xtreme
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: Average of 78.6 lb/ac variable rate 11-52-0 and average of 78.4 lb/ac variable rate 0-0-60 preplant; 5 gal/ac 32% UAN, 5 gal/ac 12-0-0-26, and 5 gal/ac 10-34-0 on 5/17/18; numerous fertigation applications from V4 to brown silk, totaling 200 lb/ac of N
Irrigation Total: 8.82"

In the fall of 2017, both the dormant seeded treatment strips and the dormant and interseeded treatment strips had a cover crop mix. The mix consisted of 40 lb/ac Elbon cereal rye, 1 lb/ac rapeseed/canola, 3 lb/ac winter oats, and 6 lb/ac hairy vetch. The cover crop was terminated on May 10 with glyphosate. During the 2018 growing season, the interseeded cover crop treatment strips were planted with a cover crop mix on June 26 using a Hiniker interseeder, at the V4 corn growth stage. The interseeding mix consisted of 6 lb/ac cowpea, 6 lb/ac soybean, 0.5 lb/ac crimson clover, 5 lb/ac sunnhemp, 2 lb/ac hairy vetch, 3 lb/ac buckwheat, 0.5 lb/ac chicory, 0.5 lb/ac flax, 0.5 lb/ac rapeseed/canola, 6 lb/ac Elbon cereal rye, and 6 lb/ac spring oats. Corn was harvested on October 6, 2018, and evaluated for yield and moisture. There was no yield or grain moisture difference between the treatments (Table 1). The net return was higher for the check treatment than the dormant and interseeded treatments because of cover crop planting and seed costs (Table 1).

Table 1. 2018 corn yield, moisture, and marginal net return for check, dormant and interseeded treatments.

	Moisture (%)	Yield† (bu/ac)	Marginal Net Return‡ ($/ac)
Check	19.1 A*	203 A	654.96 A
Cover Crop – Dormant Seeded	18.8 A	205 A	624.81 AB
Cover Crop – Dormant + Interseeded	18.8 A	209 A	586.09 B
P-Value	0.280	0.674	0.048

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.23/bu corn. Interseeded cover crop seed cost $37.50/ac. The dormant seeded cover crop seed in 2017 prior to this growing season cost $24/ac. A typical custom rate for the Hiniker interseeder is not available; therefore, both seeding methods (dormant drilled and interseeded) are estimated to be $14.40/ac. The interseeded cover crop treatment this year also was preceded by a dormant seeded cover crop; therefore, both the dormant and interseeded seed and seeding costs were incurred by this treatment this year.

Year 2 – Soybeans (2019 Crop)

Planting Date: 5/3/19
Harvest Date: 10/8/19
Seeding Rate: 174,000
Row Spacing (in): 30
Variety: Pioneer® P24A00X
Herbicides: ***Pre:*** 32 oz/ac Buccaneer 5 Extra®, and 8 oz/ac Outlook® on 5/5/19 ***Post:*** 6 oz/ac clethodim, 18 oz/ac Buccaneer 5 Extra®, and 4 oz/ac Outlook® on 6/4/19; 48 oz/ac Buccaneer 5 Extra®, and 10 oz/ac Outlook® on 6/24/19
Seed Treatment: Lumisena™ and ExerGol® Energy SB
Foliar Insecticides: 2 oz/ac Serpent™ and 2 oz/ac Fanfare™ through pivot on 7/19/19; 2 oz/ac Serpent™ and 2 oz/ac Fanfare™ through pivot on 8/2/19
Fertilizer: 5 gal/ac 10-34-0+1z on 5/3/19
Irrigation Total: 3.92"

In year two, soybeans were grown, so interseeding of cover crops was not conducted during the 2019 growing season. On October 14, 2018, the dormant season seeded cover crop strips were direct seeded with a drill. The cover crop mix included 20 lb/ac Elbon cereal rye, 20 lb/ac winter wheat, 10 lb/ac triticale, 1 lb/ac annual ryegrass, 5 lb/ac winter oats, 3 lb/ac hairy vetch, 0.5 lb/ac camelina, and 3 lb/ac winter lentil. Soybeans were planted on May 3 with 30" row spacing. The cover crop mixes were terminated May 5, 2019, by herbicide on both the dormant seeded cover crop and the previous year's interseeded cover crop. Cover crops were 8-10" tall at the time of termination. Thistle caterpillars caused a large amount of defoliation of the soybeans in this field during June 2019. At harvest there was no yield or grain moisture difference between the treatments (Table 2). The net return was higher this year for the interseeded treatment than the dormant seeded treatment. This is because the cover crops interseeded in the summer of 2018 already had the cover crop seed and planting costs accounted for in the previous year's analysis; therefore, there were no additional costs of cover crop seed or planting in this analysis (Table 2).

Table 2. Soybean yield, moisture, and marginal net return for dormant and interseeded cover crop and no cover crop treatments.

Treatment	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	13.5 A*	84 A	681.00 AB
Cover Crop – Dormant Seeded	13.8 A	87 A	661.85 B
Cover Crop – Dormant + Interseeded	13.5 A	89 A	724.21 A
P-Value	0.738	0.119	N/A

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $31.19/ac for seed mix for dormant seeded treatment, and $14.40/ac for driling for dormant seeded treatment. Interseeded cover crop costs were accounted for in the previous year's report, therefore they are not included in this analysis.

Year 3 – Field Peas (2020 Crop)

In year three, following soybean harvest, cover crops were drilled on October 16, 2019. Cover crop mix consisted of 20 lb/ac Elbon cereal rye, 20 lb/ac winter wheat, 10 lb/ac triticale, 1 lb/ac annual ryegrass, 5 lb/ac winter oats, 3 lb/ac hairy vetch, 0.5 lb/ac camelina, and 3.0 lb/ac winter lentil. Cover crop was chemically terminated on April 26, 2020. Field peas were planted on April 10, and harvested on July 18, 2020. Due to flooded areas resulting in crop death and late season weed pressure, no yield measurements were made for the check and dormant and interseeded treatments. The field was shredded in the fall to address late-season weed seed development in the areas that were drown out and had a failed crop.

Year 4 – Corn (2021 Crop)

Planting Date: 5/22/21
Harvest Date: 10/11/21
Seeding Rate: 37,000
Row Spacing (in): 30
Hybrid: Pioneer® P0446Q
Herbicides: ***Pre:*** 10 oz/ac Verdict® and 42 oz/ac Buccaneer® on 5/7/21; 32 oz/ac Liberty® on 6/7/21
Foliar Insecticides: 6 oz/ac Bifenthrin and 2 oz/ac Warrior® 7/24/21
Foliar Fungicides: 10 oz/ac Trivapro® on 7/24/21
Fertilizer: 100 lb/ac 0-0-60, 20 gal/ac 10-34-0-1 Zn, and 65 gal/ac 28-0-0-5
Irrigation Total: 12"

In crop year four, after field pea harvest, on July 25, 2020, a cover crop mix was drilled on both the dormant season seeded treatment strips and the interseeded treatment strips. The mix consisted of 3 lb/ac proso millet, 5 lb/ac grain sorghum, 5 lb/ac black oats, 5 lb/ac winter barley, 1 lb/ac flax, 4 lb/ac safflower, 5 lb/ac cowpeas, 3 lb/ac buckwheat, 0.5 lb/ac forage collards, 0.5 lb/ac rapeseed, 3 lb/ac sunn hemp, and 3 lb/ac sunflower. The cover crop was terminated in the treatment areas on May 7, 2021. Cover crop biomass measured on April 12, was on average 3,454 lb/ac for both cover crop treatment areas (Table 3). During the 2021 growing season, the interseeded cover crop treatment strips were planted with a cover crop mix on June 15, using a Hiniker interseeder. The interseeding mix consisted of 10 lb/ac annual ryegrass, 3 lb/ac red clover, 1 lb/ac rapeseed/canola, 3 lb/ac flax, 5 lb/ac buckwheat. There were no yield differences between the treatments (Table 3). Grain moisture was lower in the check treatment (Table 3).

In addition to soil health assessments (Table 7) and yield results, weed biomass and density in the interseeded cover crop and check treatments were measured in 2021, four years after experimental plots were established. The interseeded cover crop treatment seedbank had a significant increase in the proportion of pigweeds but a significant decrease in the number of other broadleaf weeds present (Table 4). Additionally, the interseeded cover crop seedbank was primarily composed of Palmer amaranth with low relative abundance of other species. In contrast, the check seedbank was dominated by scarlet pimpernel and was less dominated by the presence of Palmer amaranth (Table 5). Despite the significant increase in pigweed in the cover crop treatment area seedbank, no differences in the number of weeds or emerged pigweed occurred during the growing season (Table 6).

Table 3. Cover crop biomass, green cover, and corn yield, moisture, and marginal net return for dormant and interseeded cover crop and no cover crop treatments. Cover crop biomass and green cover measured on April 12th 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	0 B*	1.16 B	17.5 B	244 A	1271 B
Cover Crop – Dormant Seeded	3317 A	19.20 A	17.9 A	245 A	1230 A
Cover Crop – Dormant + Interseeded	3590 A	22.90 A	18.1 A	247 A	1249 AB
P-Value (dormant to check)	<0.0001	<0.0001	0.0022	0.9152	0.0277

†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $31.19/ac for seed mix for dormant seeded treatment, and $14.58/ac for drilling for dormant seeded treatment. Interseeded cover crop seed cost $37.50/ac.
*Values with the same letter are not significantly different at a 90% confidence level.
Green cover using the Canopeo measurement tool.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and number of species identified for interseeded cover crop and check treatments. Seedbank was collected on April 12, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from collection date until November 1, 2021, with two periods of drying and resifting soil to stimulate new germination flushes. Seedlings were identified by species and counted to quantify the size and composition of the soil seedbank. Total number of weeds, pigweeds, grasses, and other broadleaves are reported in weeds per m^2, which was determined from the number of emerged seedlings.

	Total weeds (weeds/m^2)†	Species Identified	Pigweeds (weeds/m^2)	Grasses (weeds/m^2)	Broadleaves (weeds/m^2)
Check	3197 A*	12.0 A	686 B	539 A	2422 A
Interseeded Cover Crop	4178 A	13.3 A	3124 A	297 A	773 B
P-value	0.361	0.616	0.00401	0.569	0.00812

† Total weeds, pigweeds, grasses, and broadleaves are estimated in weeds/m^2, which is derived from the number of seedlings that emerged from the soil seedbank.
*Values with the same letter are not significantly different at a 90% confidence level.

Table 5. Weed seedbank species composition for top five most abundant species in cover crop mix and check treatments. Seedbank was collected April 12, 2021, and permitted to freely germinate in the greenhouse until November 1, 2021.

Check – Species	Percentage of Total	Interseeded Cover Crop – Species	Percentage of Total
Scarlet pimpernel	47.1%	Palmer amaranth	67.3%
Palmer amaranth	15.9%	Scarlet pimpernel	10.0%
Barnyard grass	10.3%	Redroot pigweed	6.2%
Carpetweed	10.2%	Carpetweed	5.4%
Eastern black nightshade	5.1%	Green foxtail	2.9%

Table 6. In-season measurements were taken for weed density, pigweed density, and weed biomass at early (at crop emergence and before post-emergence herbicide application) and late season (before canopy closure and 4+ weeks after post-emergence herbicide application) for interseeded cover crop and check treatments. Measurements are reported in weeds per m^2 and grams of biomass per m^2.

	Early Season Weed Density (weeds/m^2)	Early Season Pigweed Density (weeds/m^2)	Weed Biomass (g/m^2)
Check	10.7 A*	6.5 A	0.141 A
Interseeded Cover Crop	23.9 A	15.5 A	0.0151 A
P-Value	0.384	0.284	0.561

*Values with the same letter are not significantly different at a 90% confidence level.

Multi-Year Soil Health Assessment (2019 to 2021)

Soil health measures were collected in 2019 and 2021.

Table 7. Soil physical, chemical, and biological properties for cover crop and no cover crop treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2019 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 29, 2019)*						
Check	4.01 A*	16.50 A	1.24 A	37.33 A	2.42 A	15.28 A
Dormant Seeded	2.46 A	15.21 A	1.28 A	37.00 A	2.33 B	15.52 A
Dormant + Interseeded	5.00 A	13.33 A	1.24 A	37.17 A	3.42 A	14.88 A
P-Value	0.660	0.262	0.904	0.690	0.064	0.715
2021 *(2 samples per treatment replication, n=12 per treatment; samples collected on Nov. 29, 2021)*						
Check	8.70 A	16.2 A	1.50 A	43.4 A	1.67 A	17.6 B
Dormant Seeded	6.07 A	17.7 A	1.49 A	43.1 A	1.99 A	22.0 A
Dormant + Interseeded	12.19 A	17.0 A	1.46 A	43.5 A	1.79 A	19.4 AB
P-Value	0.238	0.741	0.9053	0.5992	0.653	0.0806

[1]Soil respiration (Modified Solvita burst).

[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (averaged from 1-3; 1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

Soil assessment was not completed in 2018 as it was originally planned for every other year interval.

*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Interseeding cover crops resulted in neutral effects on corn yields.
- Total soil health score was higher for the cover crop strips in 2021.
- Interseeded cover crops resulted in a significant increase in the proportion of pigweeds in the seedbank but a significant decrease in the number of other broadleaf weeds present.
- The interseeded cover crop seedbank was primarily composed of Palmer amaranth with a low relative abundance of other species, while the check seedbank was dominated by scarlet pimpernel and was less dominated by Palmer amaranth.
- Despite significant increases in pigweeds in the interseeded cover crop seedbank, there were no differences in the number of weeds or pigweeds emerged, as measured in the field during the growing season.

Incorporation of Cover Crop in an Irrigated Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 4-year summary report

Study ID: 0708077202101
County: Greeley
Reps: 6
Tillage: No-till

Soil Type: Hersh fine sandy loam 3-6% slopes; Gates silt loam 6-11% slopes; Gates silt loam 11-17% slopes
Irrigation: Pivot

Introduction

This study is being conducted on a soil health demonstration farm as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative and involves the farmer, the Nebraska On-Farm Research Network, and the USDA NRCS. Two treatments, a no cover crop check and a cover crop mix, were applied and the treatment areas were maintained throughout the four-year study time frame (2018-2021).

Year 1 – Corn (2018 Crop)

In crop year one, a cover crop mix including cereal rye, forage collards, purple top turnips, rapeseed, and kale was drilled following soybean harvest on October 23, 2017, on the cover crop treatment areas. Following cover crop termination, corn was planted on May 9, 2018. The corn was harvested on November 15, 2018. The weigh wagon yield measurements were not analyzed for the check and cover crop mix treatments areas.

Year 2 - Soybeans (2019 Crop)

Planting Date: 5/15/19
Harvest Date: 10/16/19
Seeding Rate: 140,000
Row Spacing (in): 30
Variety: Asgrow® AG21X7
Herbicides: ***Pre:*** 5.0 oz/ac Zidua® PRO, and 32 oz/ac Roundup® on 5/5/19 ***Post:*** 22 oz/ac FeXapan®, and 32 oz/ac Roundup® on 6/28/19
Seed Treatment: Vault® SP inoculant
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 40 lb P/ac, 40 lb K/ac on 6/8/19

In crop year two, the cover crop was drilled following corn harvest on November 17, 2018, on the cover crop treatment areas. The cover crop mixture was comprised of 50 lbs/ac cereal rye, 1 lbs/ac forage collards, 1 lbs/ac turnips, 1 lbs/ac rapeseed, and 1 lbs/ac kale. Soybeans were planted green into the cover crop on May 15, 2019. The cover crop was terminated on June 1, 2019, with a herbicide application. Cover crops were 10" tall at the time of termination. Soybeans were harvested in November 2019. The year was very wet with 21" of rain from planting to August 26, 2019. There were no differences in soybean yield, moisture, or test weight between the cover crop treatment and no cover crop check (Table 1). Marginal net return was lower for the cover crop treatment due to the additional cost of cover crop seed and drilling (Table 1).

Table 1. 2019 soybean yield, moisture, and marginal net return for cover crop mix and no cover crop treatments.

	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
No Cover Crop	57 A*	10.0 A	55 A	444.82 A
Cover Crop Mix	57 A	9.9 A	54 A	397.26 B
P-Value	0.180	0.530	0.514	0.010

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $25/ac cover crop seed cost, and $14.40/ac for drilling.

Year 3 – Cereal Rye (2020 Crop)

Planting Date: 11/1/19
Harvest Date: 7/25/20
Seeding Rate: 110 lb/ac
Row Spacing (in): 7.5
Variety: Rye (VNS)
Herbicides: ***Pre:*** None ***Post:*** None
Seed Treatment: None
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 20 lb/ac N as 32% UAN and 10 lb/ac S as thiosulfate through the pivot
Irrigation Total: 6"

In crop year three, following soybean harvest, cereal rye (VNS), for grain/seed production, was drilled in November, 2019, and harvested between July 13-July 25, 2020. There were no differences in rye test weight, moisture, yield, and marginal net return between the treatments (Table 2). Multiple rain and wind events in late July delayed/interrupted harvest, and the last wind storm flattened the rye on the east half of the field. The farmer had to combine one way going east to west across the treatment strips. This destroyed the yield sampling process. Farmer was only able to collect yield data on 3 of the 6 treatment strips.

Table 2. 2020 cereal rye (VNS) test weight, moisture, yield, and net return for cover crop mix and no cover crop treatments.

	Test Weight (lb/bu)	**Moisture (%)**	**Rye Yield (bu/acre)†**	**Marginal Net Return‡ ($/ac)**
Check	53.70 A*	12.4 A	42.2 A	253 A
Cover Crop Mix	53.77 A	12.4 A	40.0 A	240 A
P-Value	0.7538	1.0000	0.1993	0.1993

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15% moisture.
‡Marginal net return based on $6.01/bu cereal rye. Costs of cover crop drilled after rye harvest ($20/ac) were not included on the analysis.

Year 4 – Soybeans (2021 Crop)

Planting Date: 5/8/21
Harvest Date: 10/16/21
Seeding Rate: 100,000
Row Spacing (in): 15
Variety: Asgrow® 27X01
Previous Crop: Soybean
Herbicides: ***Pre:*** 12 oz/ac 2,4-D LV6 and 6 oz/ac Fierce® on 4/28/21 ***Post:*** 22 oz/ac XtendiMax® on 6/25/21
Seed Treatment: Vault® IP and Acceleron®
Fertilizer: 75 lb/ac MAP 11-52-0 and 50 lb/ac potash on 4/24/21
Note: White mold in lower areas of the field
Irrigation Total: 9"

In crop year four, following rye harvest, cover crops were drilled in August, 2020. The cover crop mix consisted of oats, sorghum, pearl millet, radish, forage collards, rapeseed, buckwheat, mustard, sunn hemp, mung bean, winter pea, and soybean. The cover crop was chemically terminated on April 28, 2021. Biomass was measured April 12, 2021, and on average was 1,074 lb/ac for both the cover crop and the check treatments (Table 3). Check strips had volunteer rye growing. Soybeans were planted on May 8, 2021, and harvested on October 16, 2021. There were no differences in soybean yield and marginal net return between the treatments (Table 3).

In addition to soil health assessment (Table 7) and crop yield results, weed biomass and density in the cover crop and check treatments were measured in 2021, four years after experimental plots were established. A significant increase in the proportion of pigweeds in the seedbank occurred in the cover crop treatment (Table 4). The check seedbank was primarily dominated by green foxtail whereas the cover crop seedbank had a relatively even distribution of the top 5 most abundant species (Table 5). No differences in weed density or biomass occurred between the two treatments, despite the large number of pigweed seeds in the cover crop seedbank (Table 6).

Table 3. 2021 soybean yield, moisture, marginal net return and biomass and "green cover" measurements for the cover crop treatments and volunteer rye in the no cover crop treatment areas. Cover crop biomass and green cover were measured on April 12th, 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	1021 A*	24.1 A	11.53 B	70.9 A	837 A
Cover Crop Mix	1127 A	24.5 A	11.62 A	73.1 A	822 A
P-Value	0.454	0.918	0.0925	0.1553	0.378

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $11.80/bu soybean, $25/ac cover crop seed cost, and $14.58/ac for drilling.
Green cover assessed using the Canopeo measurement tool.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and number of species identified for cover crop mix and check treatments. Seedbank was sampled on April 16, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment area. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from the collection date until November 1, 2021, with two periods of drying and resifting soil to stimulate new germination flushes. Seedlings were identified by species and counted to quantify the size and composition of the soil seedbank. Total number of weeds, pigweeds, grasses, and other broadleaves are reported in weeds per m^2, which was determined from the number of emerged seedlings.

	Total weeds (weeds/m^2)†	Species Identified	Pigweeds (weeds/m^2)	Grasses (weeds/m^2)	Broadleaves (weeds/m^2)
Check	1599 A*	15.2 A	65 B	1075 A	785 A
Cover Crop Mix	1308 A	15.5 A	242 A	803 A	454 A
P-Value	0.501	0.928	0.0504	0.142	0.212

† Total weeds, pigweeds, grasses, and broadleaves are estimated in weeds/m^2, which is derived from the number of seedlings that emerged from the soil seedbank.
*Values with the same letter are not significantly different at a 90% confidence level.

Table 5. Weed seedbank species composition for top five most abundant species in the cover crop mix and check treatments. Seedbank was collected on April 16, 2021, and permitted to freely germinate in the greenhouse until November 1st, 2021.

Check – Species	Percentage of Seedbank	Cover Crop Mix – Species	Percentage of Seedbank
Green foxtail	52.9%	Smooth crabgrass	24.0%
Marestail	17.1%	Redroot pigweed	13.8%
Field pennycress	15.3%	Marestail	11.7%
Yellow foxtail	6.90%	Palmer amaranth	8.94%
Eastern black nightshade	5.21%	Large crabgrass	8.38%

Table 6. Weed density, pigweed density, and weed biomass at early (at crop emergence and before post-emergence herbicide application) and late (before canopy closure and 4+ weeks after post-emergence herbicide application) season for cover crop mix and check treatments.

	Early Season Weed Density (weeds/m^2)	Early Season Weed Biomass (g/m^2)	Late Season Weed Density (weeds/m^2)	Late Season Weed Biomass (g/m^2)
Check	27.3 A*	0.280 A	15.7 A	0.840 A
Cover Crop Mix	3.56 A	0.009 A	1.40 A	0.007 A
P-Value	0.375	0.227	0.520	0.103

*Values with the same letter are not significantly different at a 90% confidence level.

Multi-Year Soil Health Assessment (2017 to 2021)

Baseline and soil health measures were collected in 2017, 2019, 2020, and 2021.

Table 7. Soil physical, chemical, and biological properties for cover crop and no cover crop treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 18, 2019)*						
Check	5.19 A*	22.7 A	1.32 A	51.2 A	2.96 A	14.0 A
Cover Crop Mix	7.23 A	20.3 A	1.34 A	51.5 A	3.03 A	13.8 A
P-Value	0.682	0.374	0.726	0.352	0.854	0.6302
2019 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 22, 2019)*						
Check	2.03 A	13.25 A	1.41 A	44.16 B	2.44 A	12.9 A
Cover Crop Mix	6.45 A	14.56 A	1.27 A	46.06 A	2.86 A	13.3 A
P-Value	0.267	0.488	0.179	0.098	0.296	0.477
2020 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 20, 2020)*						
Check	6.32 A	20.1 A	1.28 A	47.0 A	2.57 A	13.9 B
Cover Crop Mix	5.19 A	18.2 A	1.34 A	47.1 A	2.64 A	16.8 A
P-Value	0.7222	0.4355	0.3813	0.8661	0.9255	0.0001
2021 *(1 sample per treatment replication, n=6 per treatment; samples collected on Dec. 1, 2021)*						
Check	4.88 A	15.1 A	1.70 A	43.8 A	1.69 A	14.2 B
Cover Crop Mix	6.25 A	16.5 A	1.74 A	44.4 A	1.90 A	16.5 A
P-Value	0.695	0.4574	0.5904	0.11343	0.5126	0.020

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (averaged from 1-3; 1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
Soil assessment was not completed in 2018 as it was originally planned for every other year interval.
*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating cover crop in a corn-soybean-small grain rotation resulted in neutral effects on soybean and small grain yields.
- Total soil health score was higher in the cover crop treatment area in 2020 and 2021.
- No differences in weed density or biomass were observed in 2021, four years after the treatment strips were established.

Incorporation of Monoculture Rye vs Multispecies Cover Crop in Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0732167202101
County: Stanton
Tillage: No-Till
Reps: 5

Soil Type: Nora-Crofton complex 6-11% slopes, eroded; Moody silty clay loam 2-6% slopes
Irrigation: None

Introduction

This study is being conducted on a soil health demonstration farm as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative and involves the farmer, the Nebraska On-Farm Research Network, and the USDA NRCS. Two treatments are being evaluated in this five-year study (2017-2021): a monoculture cereal rye cover crop versus a multi-species cover crop mix. These treatment plots were maintained throughout the project time frame.

Years 1 and 2 – Soybeans and Wheat (2017-2018 Crops)

Planting Date: 10/24/17
Harvest Date: 7/16/18 and 7/21/18
Population: 1,000,000 seeds/ac
Row Spacing (in): 7.5
Variety: Redfield
Herbicides: Pre: None Post: None
Seed Treatment: Cruiser®
Fertilizer: Spring top-dress on 3/30/18; 300 lb/ac ammonium nitrate (102 lb N/ac), 40 lb/ac potash, 40 lb/ac ammonium sulfate (8 lb N/ac, 10 lb S/ac)
Cumulative Rainfall (in): 43

In year one, cover crops were drilled in October 2016. The single species cover crop was 50 lb/ac rye. The cover crop mix consisted of 35 lb/ac Elbon Rye, 0.5 lb/ac Bayou Kale, 0.5 lb/ac Impact forage collards, 0.5 lb/ac Trophy rape, 0.5 lb/ac purple top turnip, 0.5 lb/ac African cabbage, 3.5 lb/ac hairy vetch, 30 lb/ac Austrian winter pea, and 2 lb/ac winter lentil. Cover crops were terminated on May 14, 2017, and soybeans were planted on May 25, 2017, and harvested on September 29, 2017. The soybean yield data was not analyzed for crop year 2017.

In year 2, wheat was planted in October 2017. A summer hail event on June 23, 2018, decreased total yeild significantly. Wheat yield was obtained for each treatment using yield monitor data with a 15’ buffer applied to the treatments. There was no difference in wheat yield or moisture for the monoculture versus cover crop mix (Table 1).

Table 1. 2018 wheat moisture and yield for single species and multi-species treatments.

	Moisture (%)	Wheat Yield† (bu/ac)
Single species Cover Crop	14.2 A*	35 A
Multi species Cover Crop	14.6 A	33 A
P-Value	0.591	0.366

†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13.5% moisture.
*Values with the same letter are not significantly different at a 90% confidence level.

Year 3 - Corn (2019 Crop)

Planting Date: 5/17/19
Harvest Date: 11/4-5/19
Seeding Rate: 30,919
Row Spacing (in): 20
Hybrid: Golden Harvest® 09Y24-3220A E-Z Refuge
Herbicides: 8 oz/ac 2,4-D, 40 oz/ac glyphosate

Seed Treatment: Avicta® 500 FS
Fertilizer: 5 gal/ac 8-20-8-4-2 on 5/17/19; 150 lb/ac urea and 20 lb/ac AMS on 5/22/19
Cumulative Rainfall (in): 32

In year three, cover crops were drilled on July 27, 2018, following wheat harvest. The single species cover crop was 50 lb/ac cereal rye. The cover crop mix was 30 lb/ac cereal rye, 3 lb/ac red clover, 2 lb/ac rapeseed/canola, and 6 lb/ac hairy vetch. Cover crops were terminated on May 16, 2019, and corn was planted on May 17, 2019. The corn yield was very close to a statistically significant difference, with the monoculture cereal rye cover crop area having a higher yield than the multispecies cover crop area (Table 2). This did result in the monoculture cereal rye cover crop area having a higher net return (Table 2).

Table 2. 2019 corn yield, moisture, and marginal net return for single species and multi species treatments.

	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Single species Cover Crop	20.3 A*	192 A	708.03 A
Multi species Cover Crop	19.9 A	179 A	655.90 B
P-Value	0.317	0.101	0.085

†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 15.5% moisture.
‡Marginal net return based on $3.83/bu corn, $27.33/ac for the rye seed and drilling, and $31.34/ac for the mix seed and drilling.
*Values with the same letter are not significantly different at a 90% confidence level.

Year 4 – Soybeans (2020 Crop)

Planting Date: 4/30/20
Harvest Date: 10/9/20
Population: 133,650
Row Spacing (in): 20
Variety: Golden Harvest® GH2041X
Herbicides: ***Pre:*** 1.5 pt/ac Stalwart® C, 1.0 pt/ac Clash™, 32 oz/ac Buccaneer®, 3.0 oz/ac Tronido™ on 5/14/20
Post: 12 oz/ac fomesafen, 0.4 oz/ac Cadet®, 32 oz/ac Buccaneer®, 10.0 oz/ac clethodim, 1.0 pt/ac Helmet on 6/26/20
Seed Treatment: CruiserMaxx®, Vibrance®
Foliar Fungicides: 10 oz/ac Quilt Xcel® Fertilizer: 5 gal/ac 5-18-5 on 4/30/20
Cumulative Rainfall (in): 22

In year four, cover crops were drilled in November following corn harvest in 2019. The monoculture cover crop was 50 lb/ac cereal rye. The cover crop multi-species mix was 30 lb/ac cereal rye, 10 lb/ac winter barley, 3 lb/ac red clover, 1 lb/ac rapeseed, 4 lb/ac hairy vetch, and 0.5 lb/ac camelina. Cover crops were terminated on May 14, and soybeans were planted on April 30 and harvested on October 9, 2020. Soybeans planted in the multispecies treatment area had a higher yield than those in the single species area (Table 3). These observations are in agreement with the crop vigor analysis (NDVI) that showed higher values in the multispecies area (Figure 1).

Table 3. 2020 soybean moisture and yield, cover crop biomass and green cover for single species and multispecies cover crop treatment areas. Cover crop biomass and green cover were measured May 6, 2020.

	Cover crop Biomass (lbs/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Single species Cover Crop	85.3 A*	3.303 A	8.25 A*	48.3 B	431 B
Multispecies Cover Crop	14.9 B	0.703 B	7.63 B	55.4 A	495 A
P-Value	<.0001	0.0002	0.032	0.0497	0.0589

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $9.50/bu soybean, $27.33/ac for the rye seed and drilling, and $31.34/ac for the mix seed and drilling.
Green cover using the Canopeo measurement tool.

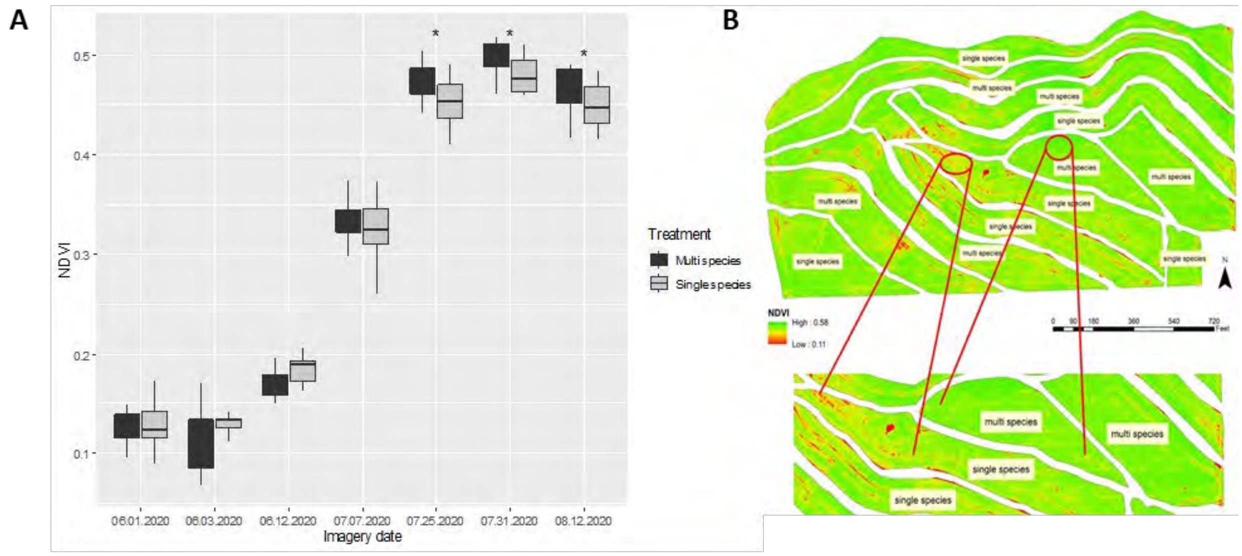


Figure 1. (A) Normalized difference vegetation index (NDVI) values from aerial imagery for the soybean crop following single species and multi-species cover crops. Asterisk (*) within each date indicates significant differences (p < 0.10) between single species and multi-species cover crop areas at a 90% confidence level. (B) Aerial imagery from July 31 displayed as soybean normalized difference vegetation index (NDVI). Areas with single and multi-species cover crop are indicated.

Year 5 – Corn (2021 Crop)

Planting Date: 5/11/21
Harvest Date: 10/8-12/21
Seeding Rate: 31,000
Row Spacing (in): 20
Hybrid: Golden Harvest® 16-52222A E-Z Refuge
Herbicides: ***Pre:*** 1.5 pt/ac atrazine, 3.5 oz/ac Bellum™, 2 pt/ac Stalwart® C, 0.5 pt/ac 2,4-D LV6 Ester, and 12 oz/ac Absorb 100 on 5/13/21 ***Post:*** 0.5 pt/ac atrazine, 3 oz/ac Bellum™, 19.2 oz/ac Padlock Plus, and 32 oz/ac Buccaneer 5 Extra® on 6/13/21
Seed Treatment: Cruiser® Complete
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 6/13/21
Fertilizer: 182 lb/ac urea on 6/18/21; 35 ton/ac manure on 10/15/21
Note: Wind damage on 7/10/21; hail damage on 8/31
Cumulative Rainfall (in): 34

In year five, cover crops were drilled on October 17, 2020, following soybean harvest. The monoculture cover crop was 50 lb/ac cereal rye. The cover crop multi-species mix was 30 lb/ac cereal rye, 10 lb/ac winter barley, 3 lb/ac red clover, 1 lb/ac rapeseed, 4 lb/ac hairy vetch, and 0.5 lb/ac camelina. Cover crops were terminated on May 5, and corn was planted on May 11 and harvested on October 8-10, 2021. There was wind damage on July 10, and hail damage on August 31. There was no difference in corn moisture, yield, or marginal net return for the monoculture versus cover crop mix areas (Table 4).

Table 4. 2021 corn yield, moisture, and marginal net return for single species and multi-species treatments.

	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Single species Cover Crop	19.4 A*	200 A	1015 A
Multi species Cover Crop	18.2 A	200 A	1007 A
P-Value	0.1158	0.8548	0.7265

†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $27.33/ac for the rye seed and drilling, and $31.34/ac for the mix seed and drilling.
*Values with the same letter are not significantly different at a 90% confidence level.

Multi-Year Soil Health Assessment (2016 to 2020)

Baseline and soil health measures were collected in 2016, 2019, 2020, and 2021.

Table 5. Soil physical, chemical, and biological properties for single species and multi-species cover crop treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(2-5 composite samples collected for all replications of a treatment; samples collected on Nov. 14, 2016)*						
Single species	3.13 A*	26.7 A	1.02 A	48.3 A	3.33 A	19.7 A
Multi species	8.50 A	27.6 A	1.17 A	48.2 A	2.33 B	17.2 B
P-Value	0.762	0.734	0.103	0.991	<0.001	0.0903
2018 *(2-5 composite samples collected for all replications of a treatment; samples collected on Nov. 20, 2018)*						
Single species	-[3]	-	1.07 A	29.8 A	3.25 A	18.8 A
Multi species	-	-	1.11 A	31.5 A	2.62 A	19.5 A
P-Value			0.710	0.139	0.239	0.149
2019 *(1 sample per treatment replication, n=5 per treatment; samples collected on Nov. 5, 2019)*						
Single species	12.24 A	25.63 A	1.13 A	36.24 A	3.13 A	19.9 A
Multi species	18.88 A	25.11 A	1.10 A	36.61 A	3.22 A	19.8 A
P-Value	0.356	0.766	0.5083	0.454	0.879	0.885
2020 *(1 sample per treatment replication, n=5 per treatment; samples collected on Nov. 4, 2020)*						
Single species	12.7 A	23.1 A	1.17 A	45.1 A	3.19 A	19.6 A
Multi species	13.6 A	22.7 A	1.11 A	46.5 A	3.64 A	17.9 B
P-Value	0.873	0.615	0.201	0.449	0.252	0.023
2021 *(1 sample per treatment replication, n=5 per treatment; samples collected on Nov. 9, 2021)*						
Single species	5.38 A	27.4 A	1.11 A	45.3 A	2.19 A	20.7 B
Multi species	1.23 A	31.4 A	1.13 A	45.7 A	2.57 A	21.6 A
P-Value	0.311	0.116	0.740	0.645	0.345	0.0297

[1]Soil respiration (Modified Solvita burst).

[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

Soil assessment was not completed in 2017 and 2018 as it was originally planned for every other year interval.

[3]No test was completed in 2018 for soil moisture and infiltration.

*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating single or multi-species cover crop in a corn-soybean-small grain rotation resulted in neutral effects on corn and small grain yields. Soybean planted in the multi-species cover crop treatment area had a higher yield than the single species treatment area.
- Total soil health score was higher for the single-species treatment both in 2016 and 2020, but higher in the multi-species treatment in 2021.

Incorporation of Cover Crop in a Non-Irrigated Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 4-year summary report

Study ID: 0913037202101
County: Colfax
Reps: 6

Soil Type: Moody silty clay loam terrace, 0-2% slopes; Moody silty clay loam 6-11% slopes, eroded
Irrigation: None
Tillage: No-till

Introduction

This study is being conducted on a soil health demonstration field as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative and involves the farmer, the Nebraska On-Farm Research Network, and the USDA NRCS. The field involved had been under no-till management for ~20 years. Two treatments are being evaluated in this five-year study: cover crop mix and no-cover crop check. These plots were maintained throughout the project timeline (2017-2021).

Year 1 – Corn (2018 Crop)

In year one, corn was planted in the field on all treatment strips. No treatment strip specific corn yields measurements were compiled.

Year 2 – Soybeans (2019 Crop)

Planting Date: 5/14/19
Harvest Date: 10/14/19
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Legend®25X924N
Herbicides: ***Pre:*** 6 oz/ac Zidua® PRO, 40 oz/ac Roundup®, and 8 oz/ac Dicamba on 5/10/19 ***Post:*** 7.25 oz/ac Marvel™, 32 oz/ac Roundup®, and 6 oz/ac Select Max® on 6/28/19
Foliar Insecticides: 2.8 oz/ac Leverage® on 7/30/19
Foliar Fungicides: 4 oz/ac Priaxor® on 7/30/19
Cumulative rainfall (in): 34

In year two, the cover crop was drilled on November 19, 2018. The cover crop mix was 8 lb/ac winter wheat, 8 lb/ac winter rye, 8 lb/ac triticale, 1 lb/ac Dwarf Essex rapeseed, 5 lb/ac winter oats, 8 lb/ac winter barley, 1 lb/ac camelina, 1 lb/ac hairy vetch, 2.5 lb/ac winter Morton lentil and 1 lb/ac Dixie crimson clover. The cover crop was terminated with herbicides on May 10, 2019, at a height of 10-18". There were no differences in soybean moisture or yield (Table 1). Marginal net return was lower for the cover crop treatment due to the additional cost of seed and drilling (Table 2).

Table 1. 2019 soybean yield, moisture, and marginal net return for cover crop mix and no cover crop treatments.

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	11.8 A*	68 A	549.30 A
Cover Crop Mix	11.9 A	68 A	514.83 B
P-Value	0.607	0.994	0.002

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $20.11/ac cover crop seed, and $14.40 for cover crop drilling.

Year 3 – Wheat (2020 Crop)

Planting Date: 10/15/19
Harvest Date: 7/21/20
Population: 105 lb/ac
Row Spacing (in): 7.5
Hybrid: Valiant

Herbicides: ***Pre:*** 0.5 pt/ac 2,4-D and 0.8 oz/ac Affinity® Broadspec on 5/6/20 ***Post:*** None
Foliar Fungicides: 6.8 oz/ac Prosaro®
Fertilizer: 100 lb/ac 11-52-0 on 10/24/19; 30 gal/ac 32% UAN on 4/8/20
Cumulative rainfall (in): 25

In year three, wheat was planted following soybean harvest on the cover crop and check strips. There were no differences in wheat moisture, yield, or marginal net return between the treatments (Table 2).

Table 2. 2020 wheat moisture, yield, and net return for single species and multispecies cover crop treatments.

	Moisture (%)	Wheat Yield (bu/acre)†	Marginal Net Return‡ ($/acre)
Check	13.3 A*	82.4 A	358 A
Cover Crop Mix	13.0 A	84.8 A	369 A
P-Value	0.1089	0.4397	0.4397

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13.5% moisture.
‡Marginal net return based on $4.35/bu wheat. Costs of cover crop drilled after wheat harvest was not included in the analysis.

Year 4 – Corn (2021 Crop)

Planting Date: 4/30/21
Harvest Date: 11/1 – 11/4/2021
Seeding Rate: 30,000
Row Spacing (in): 30
Hybrid: Golden Harvest® G13H15
Herbicides: ***Pre:*** Burndown: 44 oz/ac Roundup PowerMAX®, 1 pt/ac 2,4-D, and 2.5 qt/ac Ravine™ ***Post:*** 3 oz/ac Bellum™, 1 pt/ac Medal® II, 2.5 oz/ac Status®, and 32 oz/ac Roundup®
Foliar Insecticides: 2 oz/ac Baythroid® XL on 4/30/21
Foliar Fungicides: 10 oz/ac Headline AMP® on 7/27/21
Fertilizer: 4,000 gal of Hog Manure on 7/25/20; 7.5 gal/ac 6-24-6 and 10 gal/ac 32% UAN (35.5 lb N/ac) on 4/30/21; Average of 40 gal/ac 32% UAN (142 lb N/ac) applied through VRT Y-drop on 7/1/21
Cumulative rainfall (in): 35

In year four, following the wheat harvest on August 6, 2020, a cover crop mix of 15 lbs/ac cereal rye, 2 lbs/ac radish, 0.5 lbs/ac forage collards, 5 lbs/ac winter peas, 3 lbs/ac winter lentils, 1.5 lbs/ac sun hemp, 3 lbs/ac buckwheat, 10 lbs/ac spring oats, 1 lbs/ac pearl millet, and 0.5 lbs/ac camelina was drilled on the cover crop treatment strips. Cover crop biomass collected on April 9, 2021, was 2600 lb/ac (Table 3). Volunteer wheat grew throughout the field (biomass = 1372 lb/ac) including on the check strips. Cover crop species that did not winter terminate and the volunteer wheat was terminated with herbicides on April 30, 2021. Corn was planted on April 30, 2021, and harvested on November 1, 2021. Corn yield showed a decrease of 5 bu/ac following cover crop (Table 3). Marginal net return was lower for the cover crop treatment due to the additional cost of seed, drilling, and yield reduction (Table 3).

In addition to soil health assessments (Table 6) and yield results, weed biomass and density in the cover crop and check treatments were measured in 2021, four years after experimental plots were established (Table 4 & Table 5). No differences in the cover crop area and the check area seedbank were observed and the composition of the most abundant species in the respective seedbanks was similar as well.

Table 3. Cover crop biomass, green cover, and corn moisture, yield, and net return for check and cover crop mix treatments. Cover crop biomass and green cover were measured on April 9, 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	1372 B	23.6 B	18.64 A*	264 A	1371 A
Cover Crop Mix	2679 A	62.2 A	18.57 A	259 B	1309 B
P-Value	<0.0001	<0.0001	0.1540	0.001	< 0.0001

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $5.20/bu corn, $20.11/ac cover crop seed, and $14.40 for cover crop drilling.
Green cover assessed using the Canopeo measurement tool.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and average number of species identified per replicate in the field for cover crop mix and check treatments strips. Seedbank was collected on April 9, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from the collection date until November 1, 2021, with two periods of drying and resifting soil to stimulate new germination flushes. Seedlings were identified by species and counted to quantify the size and composition of the soil seedbank. Total number of weeds, pigweeds, grasses, and other broadleaves are reported in weeds per m^2, which was determined from the number of emerged seedlings.

	Total weeds (weeds/m^2)†	Average Number of Species Identified	Pigweeds (weeds/m^2)	Grasses (weeds/m^2)	Broadleaves (weeds/m^2)
Check	168 A*	2 A	21.6 A	0.00 A	137 A
Cover Crop Mix	164 A	3 A	19.6 A	24.2 A	121 A
P-Value	0.960	0.264	0.891	1.00	0.715

† Total weeds, pigweeds, grasses, and broadleaves are estimated in weeds/m^2, which is derived from the number of seedlings that emerged from the soil seedbank.
*Values with the same letter are not significantly different at a 90% confidence level.

Table 5. Weed seedbank species composition for top five most abundant species in cover crop mix and check treatments. Seedbank was collected April 9, 2021 and permitted to freely germinate in the greenhouse until November 1, 2021.

Check – Species	Percentage of Seedbank	Cover Crop Mix – Species	Percentage of Seedbank
Common woodsorrel	65.6%	Common woodsorrel	63.2%
Common waterhemp	29.7%	Common waterhemp	22.8%
Marestail	1.56%	Hardstem bulrush	7.04%
Buffalo bur	1.56%	Marestail	5.21%
Carpetweed	1.56%	Buffalo bur	1.80%

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2019, and 2021.

Table 6. Soil physical, chemical, and biological properties for cover crop and no cover crop treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 30, 2017)*						
Check	15.58 A*	25.5 A	1.04 A	50.4 A	3.85 A	16.2 A
Cover Crop Mix	6.87 B	25.5 A	1.03 A	50.0 A	4.10 A	18.1 A
P-Value	0.0808	0.986	0.785	0.354	0.1817	0.342
2019 *(1 sample per treatment replication, n=6 samples per treatment; samples collected on Nov. 5, 2019)*						
Check	2.09 A	23.61 A	1.14 A	40.85 A	3.33 A	17.4 A
Cover Crop Mix	4.93 A	24.60 A	1.13 A	40.93 A	2.67 A	18.6 A
P-Value	0.422	0.336	0.478	0.794	0.102	0.295
2021 *(1 sample per treatment replication, n=6 samples per treatment; samples collected on Nov. 17, 2021)*						
Check	9.97 A	26.2 A	1.17 A	44.3 A	1.17 A	16.9 B
Cover Crop Mix	2.64 A	26.0 A	1.12 A	44.0 A	1.33 A	19.7 A
P-Value	0.109	0.948	0.421	0.750	0.611	0.0235

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
Soil assessment was not completed in 2018 and 2020 as it was only completed every other year interval.
*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating cover crop in a corn-soybean-small grain rotation resulted in neutral effects on soybean and small grain yields and decrease in corn yield.
- Trends of increased total soil health score were observed in both check and cover crop mix treatment areas. In 2021, the soil health score was higher for the cover crop mix compared to the check.
- No differences were observed in the weed seedbank collected in 2021, after the cover crop and check treatment strips were established and maintained for 4 years.

Incorporation of Small Grain and Cover Crop in a Corn-Soybean Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0933053202101
County: Dodge
Tillage: No-till
Reps: 8 (4 per area)

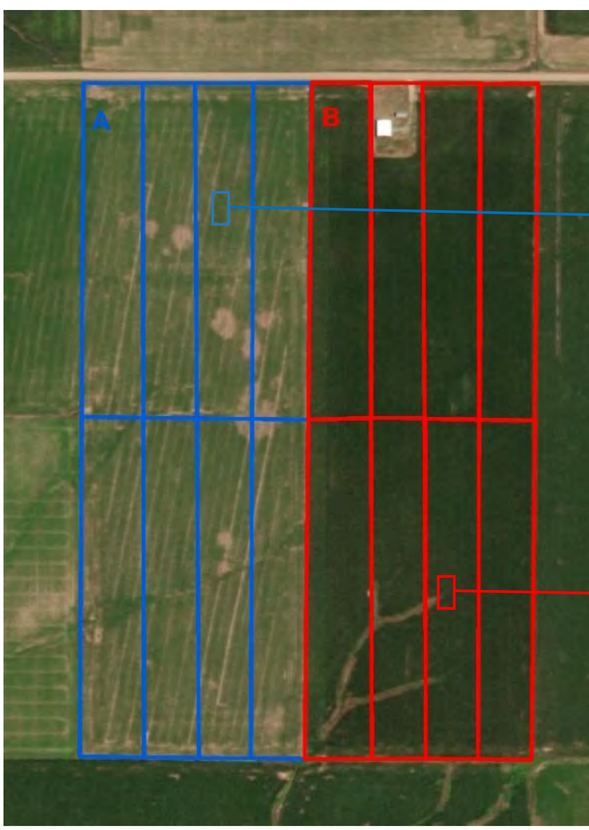
Soil Type: Belfore silty clay loam 0-2% slope; Moody silty clay loam 2-6% slopes
Irrigation: None

Introduction

This study is being conducted on a soil health demonstration field as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative, and involves the farmer, the Nebraska On-Farm Research Network, and the USDA-NRCS. The traditional crop rotation for this producer is a corn and soybean crop rotation with a cover crop following soybeans and no-till residue management. There is interest in intensifying the cropping system by incorporating a cool-season cash crop such as winter wheat and increasing the amount of time living plants are growing in the field. The two treatments, a check and an intensified system, were used in this five-year study (2017-2022). The check treatment is a corn and soybean rotation with a cover crop following corn and soybeans. The intensive cropping system is a corn, soybean, small grain rotation with cover crop following each cash crop. Both phases of the rotation (corn-soybean) are present each year in this field. The field was divided into two portions (Figure 1).

- Area A primarily consists of Moody silty clay loam, 2 to 6 percent slopes and Nora silty clay loam, 6 to 11 percent slopes, eroded
- Area B primarily consists of Belfore silty clay loam, 0 to 2 percent slopes

The results here are presented over the five years for each of these areas of the field.



Intensified system. Picture taken on April 22, 2020.

Intensified system. Picture taken on May 5, 2020.

Sub-field area A (Moody and Nora silty clay loam)

Year 1 – Soybeans (2017 Crop)

Planting Date: 5/10/17
Harvest Date: 10/17/17
Population: 140,000
Row Spacing (in): 15
Variety: Channel® 2617
Fertilizer: 147.03 lb/ac MESZ® on 11/6/16
Herbicides: ***Burndown:*** 44 oz/ac Roundup® on 4/12/17 ***Pre:*** Sonic® and Hel-Fire® on 4/22/17 ***Post:*** 32 oz/ac Roundup® & AMS on 6/3/17; 32 oz/ac Roundup®, Flexstar®, Section® Three, and Zaar® on 6/25/17

In year one, cereal rye was planted October 10, 2016. Cover crop terminated April 12, 2017. Soybeans were planted across both, check and intensive plots, on May 10, 2017 and harvested on October 17, 2017. In 2017, soybeans had no difference in yield following check or intensive system.

Table 1. 2017 soybean moisture, yield, and net return for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Check	12.9 A*	61.3 A	545 A
Intensive System	12.1 B	64.2 A	571 A
P-Value	0.0331	0.127	0.153

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.90/bu soybeans in both treatments.

Year 2 – Corn and Wheat (2018 Crop)

Corn
Planting Date: 5/7/18
Harvest Date: 11/1/18
Herbicides: ***Pre:*** 42 oz/ac Roundup® 4/28/18

Wheat
Planting Date: 10/16/17
Harvest Date: 8/6/18
Population: 75 lb/ac
Hybrid: Certified SY Wolf
Herbicides: ***Pre:*** 32 oz/ac Roundup® prior to wheat planting

In year two, following soybean harvest October 2017, in the check plots a cover crop mix of 30 lbs/ac rye, 3.5 lbs/ac radish, 5lbs/ac hairy vetch, 1lbs/ac crimson clover was drilled on October 18, 2017. This cover crop mix was terminated on April 28, 2018, with a 42 oz/ac Roundup® burndown application, then corn was planted on May 7, 2018, and harvested on November 1, 2018. In the intensive system plots, wheat was planted on October 16, 2017, and harvested on August 6, 2018. As this was the first time the farmer had planted or harvested wheat, it was not successful as far as weed control and harvest yield. A post-harvest application of Roundup® was applied. No measurements were made on wheat yields in the intensive system strips.

Table 2. 2018 corn and wheat moisture and yield for check and intensive system treatments.

Treatment	Crop	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	Corn	14.5	181.4	546.4
Intensive System	Wheat	-	-	

†Bushels per acre corrected to 15.5% (corn) and 13.5% (wheat) moisture.
‡Marginal net return based on $3.23/bu corn and $25/ac cost for cover crop seed and $14.40 drilling for check treatment.

Year 3 – Soybeans (2019 Crop)

Planting Date: 5/14/19
Harvest Date: 10/14/19
Population: 140,000
Row Spacing (in): 7
Variety: Channel® 2617
Herbicides: ***Burndown:*** 42 oz/ac Roundup® on 4/23/19 ***Pre:*** Zidua®, Roundup® and Zaar® on 5/10/19 ***Post:*** 31 oz/ac Roundup®,11 oz/ac Sinister®, Zaar®, 74.85 oz/ac FirstRate®, and 39.85 oz/ac Warrant® on 7/1/19
Insecticide: 3.99 oz/ac Artic® 3.2 EC on 7/20/19

In year three, 20 lbs/ac rye, 2lbs/ac radishes, 0.5lbs/ac African cabbage, 8 lbs/ac winter pea, 5 lbs/ac common vetch, 3 lbs/ac sunnhemp, 5 lbs/ac buckwheat, 10lbs/ac spring oats cover crop mix was drilled on August 7, 2018, following wheat (intensive plots) and 65 lbs/ac rye drilled on November 7, 2018 following corn (check plots) harvest. All plots were sprayed on April 23, 2019 prior to soybean planting. Soybeans were planted on May 14, 2019 and harvested on October 14, 2019. In 2019, soybean yield was higher in the check plots compared to intensive system plots.

Table 3. 2019 soybean moisture and yield for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	13.1 B*	49.1 A	371 A
Intensive System	13.3 A	46.7 B	329 B
P-Value	0.0471	0.087	0.0096

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $35/ac cost for cover crop seed for intensive treatment, $12.5/ac cost for cover crop seed for check treatment and $14.40 drilling for drilling cost.

Year 4 – Corn (2020 Crop)

Planting Date: 4/28/20
Harvest Date: 10/14/20
Population: 29,000
Row Spacing (in): 30
Hybrid: Channel® 217-41 DroughtGard® VT2P RIB Complete, DEKALB® DKC62-98 VT2P RIB
Herbicides: ***Pre:*** 32 oz/ac Roundup PowerMAX® with AMS on 4/23/20 burndown; 1.5 qt/ac Harness® Xtra®, 3 oz/ac Balance® Flexx, 1.3 qt/ac Roundup PowerMAX® on 4/30/20 ***Post:*** 16 oz/ac ZAAR®, 32 oz/ac Roundup®, 3 oz/ac Laudis®, and 8 oz/ac atrazine on 6/11/20
Seed Treatment: BAS250
Fertilizer: 176 lb/ac MESZ®, 12-40-0-10S-1Zn, 50 lb/ac 0-0-60 Potash applied on 12/26/19; 421 lb/ac UAN 32-0-0 on 4/30/20
Cumulative Rainfall (in): 25

In year four, 3-way mix cover crops (35 lb/ac winter rye, 2 lb/ac rapeseed, and 1 lb/ac red clover) were drilled on October 15, 2019, following soybean harvest on both plots (intensive and check). Cover crop was terminated on April 23, 2020. Then corn was planted on April 28, 2020, and harvested on October 14, 2020. Corn planted in the intensive system had higher yield than the check strips. These observations are in agreement with the crop vigor analysis (NDVI) that showed higher values in the intensive system strips, during the growing season.

Table 4. 2020 cover crop biomass, green cover, corn moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 22, 2020, prior to termination.

	Cover crop Biomass (lb/ac)	Green cover (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)	Corn NDVI on Jul 28, 2020
Check	602 A*	10.55 A	14.7 A	183 B	602 B	0.450 B
Intensive System	507 A	7.28 B	14.3 A	202 A	668 A	0.462 A
P-Value	0.2160	0.0031	0.168	0.00413	0.00115	0.00113

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
Green cover determined using the Canopeo measurement tool.
‡Marginal net return based on $3.51/bu corn, $25/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 5 – Soybeans (2021 Crop)

Planting Date: 5/13/21
Harvest Date: 10/5/21
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Brevant® 269EE
Herbicides: ***Burndown:*** 30.55 oz/ac Roundup PowerMAX® on 4/26/21 ***Pre:*** 8.02 oz/ac 2,4-D LV6, 6 oz/ac Zidua® Pro, and 16 oz/ac Zaar® on 4/26/21 ***Post:*** AMS, CVA® Elite HSCOG, Liberty®, Outlook®, and Resource® on 7/2/21
Seed Treatment: seed was pre-treated prior to planting, products used are for early season insect control to help with germination, actual products used are unknown
Foliar Insecticides: Leverage® 360 on 8/3/21
Foliar Fungicides: Masterlock®and Delaro® on 8/3/21
Cumulative Rainfall (in): 40

In year five, a VNS cereal rye cover crop (65 lb/ac) was drilled on November 4, 2020, following corn harvest on all plots (intensive and check). Cover crop was chemically terminated on April 26, 2021. Then soybeans were planted on April 13, 2021, and harvested on October 5, 2021.

Table 5. 2021 cover crop biomass, green cover, soybean moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 22, 2020.

	Cover Crop Biomass (lbs/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac) †	Marginal Net Return‡ ($/ac)
Check	131 A*	4.94 A	14.4 A	82 A	943 A
Intensive System	102 A	4.77 A	13.7 A	83 A	955 A
P-Value	0.374	0.872	0.5606	0.4022	0.402

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
Green cover determined using the Canopeo measurement tool.
‡Marginal net return based on $11.80/bu soybean, $12.75/ac cost for cover crop seed and $14.40 drilling for both treatments.

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2019, 2020 and 2021.

Table 6. Soil physical, chemical, and biological properties for check and intensive system treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm³)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 14, 2020)*						
Check	0.015 A*	24.5 A	1.21 A	41.9 A	3.67 A	12.6 A
Intensive System	0.480 A	23.5 A	1.06 A	42.5 A	3.92 A	15.2 A
P-Value	0.551	0.3471	0.315	0.500	0.678	0.272
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 6, 2019)*						
Check	1.84 A	26.8 A	1.06 A	39.92 A	3.12 A	14.9 B
Intensive System	3.20 A	25.8 A	1.06 A	39.95 A	3.00 A	18.5 A
P-Value	0.2692	0.591	0.869	0.718	0.638	0.0721
2020 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2020)*						
Check	1.36 A	28.7 A	1.14 A	44.1 A	2.94 A	17.8 B
Intensive System	3.46 A	28.7 A	1.14 A	44.0 A	2.94 A	18.6 A
P-Value	0.117	0.969	0.992	0.781	1.00	0.055
2021 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2021)*						
Check	4.66 A	29.3 A	1.15 A	46.0 A	3.06 A	20.3 B
Intensive System	5.83 A	30.5 A	1.09 A	45.8 A	3.00 A	21.5 A
P-Value	0.824	0.625	0.276	0.693	0.896	0.0923

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
Soil assessment was not completed in 2018 as it was originally planned for every other year interval.
*Values with the same letter are not significantly different at a 90% confidence level.

Sub-field Area B (Belfore silty clay loam)

Year 1 – Corn (2017 Crop)

Planting Date: 5/6/17
Harvest Date: 10/28/17
Population: 38,000
Row Spacing (in): 30"
Hybrid: Channel® 213-19 VT2 Rib
Herbicides: ***Pre:*** 8.02 oz/ac 2-4D burndown on 04/05/17, 44 oz Roundup® with Firezone® burndown on 04/12/17 ***Post:*** 32 oz Roundup® – spot spray on 06/03/17
Seed Treatment: VT2PRIB
Fertilizer: 147.03 lb/ac MESZ, 12-40-0-10S-1Zn, on 11/09/2016, 443.65 lb/ac UAN 32-0-0 on 05/09/2017

In year one, cover crop (35 lbs/ac winter rye) was drilled across both, check and intensive plots, on October 4, 2016, following soybean harvest. The cover crop was terminated on April 12, 2017. Corn was planted on May 6, 2017, and harvested on October 28, 2017. In 2017, there was no difference in corn yield and moisture between the check or intensive system.

Table 1. 2017 corn moisture, yield, and net return for check and intensive system treatments.

	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	16.4 A*	190 A	571 A
Intensive System	16.5 A	196 A	589 A
P-Value	0.346	0.326	0.412

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.15/bu corn, $12.50/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 2 – Soybeans (2018 Crop)

In year two, following corn harvest in 2017, cover crop (50 lbs/ac of winter rye) was drilled on November 7, 2017, in the check and intensive plots. The cover crop was terminated on April 25, 2018. Soybeans were planted in both treatment strips on May 9, 2018, and harvested on October 20, 2018. In 2018, there was no difference in soybean yield between the check or intensive system.

Table 2. 2018 soybean moisture and yield, for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	11.5 A*	54.2 A	368 A
Intensive System	11.4 B	56.9 A	388 A
P-Value	0.0972	0.2136	0.476

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $7.40/bu soybean, $18.50/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 3 – Corn and Wheat (2019 Crop)

Corn
Planting Date: 5/12/2019
Harvest Date: 11/1/2019
Population: 29,000
Row Spacing (in): 30
Hybrid: Channel® 212-48 VT Double Pro RIB
Herbicides: ***Burndown:*** 42 oz/ac Roundup® 4/23/19 ***Post:*** Harness®, Balance® Flexx, Laudis®, and StrikeLock®
Fertilizer: 162 lb/ac MESZ® on 4/19/19, 442.40 lb/ac 32-0-0 on 5/11/19

Wheat
Planting Date: 10/22/2018
Harvest Date: 7/26/2019
Herbicides: Huskie® on 5/15/19
Fungicide: 21.3 oz/ac Caramba® on 6/10/19
Fertilizer: MESZ on 4/19/19; potash, 20-0-0, 34-0-0, and 367.50 lb/ac lime top-dressed on 4/13/19

In year three, in the check plots, following soybean harvest, cover crops were drilled on October 24, 2018. The cover crop planted was a mix of 35 lbs/ac rye, 2 lbs/ac rapeseed, and 1 lbs/ac red clover. Cover crop was terminated on April 23, 2019, then corn was planted on May 12 and harvested on November 1, 2019. In the intensive system plots, wheat was planted following soybean harvest on October 22, 2018. Wheat was harvested and the straw was baled and removed on July 30, 2019 (intensive system plots).

Table 3. 2019 corn and wheat moisture and yield for check and intensive system treatments.

Treatment	Crop	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	Corn	17.5	167.2	606.4
Intensive System	Wheat	11.7	48.2	174.9

†Bushels per acre corrected to 15.5% (corn) and 13.5% (wheat) moisture.
‡Marginal net return based on $3.83/bu corn, $19.50/ac cost for cover crop seed and $14.40 drilling (check treatment) and $3.63/bu wheat (intensive treatment).

Year 4 – Soybeans (2020 Crop)

Planting Date: 5/6/20
Harvest Date: 9/27/20
Population: 140,000
Row Spacing (in): 15
Variety: Mycogen® 289E Enlist E3™
Herbicides: ***Pre:*** 16 oz/ac ZAAR™, 6 oz/ac Zidua® PRO, 43.98 oz/ac Roundup PowerMAX® on 5/13/20 ***Post:*** 31.5 oz/ac Liberty®, 7.25 oz/ac Section® Three, 5.90 oz/ac Superb® HC, 45 oz/ac Warrant®, 2 oz/ac Resource® on 6/26/20
Seed Treatment: Acceleron® E-007 SAT
Cumulative Rainfall (in): 25

In year four, an 8-way cover crop mix (20 lb/ac cereal rye, 2 lb/ac radish, 3 lb/ac sunhemp, 5 lb/ac African cabbage, 8 lb/ac winter pea, 5 lb/ac common vetch, 5 lb/ac buckwheat, and 10 lb/ac spring oats) was drilled on August 3, 2019 following wheat harvest (intensive system plots) and 65 lb/ac cereal rye cover crop was drilled on September 29 following corn harvest (check plots). The cover crops were terminated on May 13, 2020. Prior to cover crop termination, soybeans were planted on May 6, 2020, and harvested on September 27, 2020. Soybean planted in the check system had a higher yield than the intensive system strips. These observations are in agreement with the crop vigor analysis (NDVI) that showed higher values in the check strips.

Table 4. 2020 crop biomass and green cover, soybean moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on May 5, 2020.

	Cover crop Biomass (lbs/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)	Soybean NDVI on Jul 28, 2020
Check	358 B*	10.7 B	13.5 A	35.7 A	313 A	0.451 A
Intensive System	896 A	22.1 A	12.5 A	34.7 B	280 B	0.426 B
P-Value	0.0048	0.0196	0.00498	0.00887	0.00012	0.0463

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
Green cover using the Canopeo measurement tool.
‡Marginal net return based on $9.50/bu soybean, $12.50/ac cost for cover crop seed and $14.40 drilling (check treatment) and $35.0/ac cost for cover crop seed and $14.40 drilling (intensive treatment).

Year 5 – Corn (2021 Crop)

Planting Date: 4/30/21
Harvest Date: 10/17/21
Seeding Rate: 31,000
Row Spacing (in): 30
Hybrid: Channel® 210-79 DGVT2
Herbicides: ***Burndown:*** 32 oz/ac Roundup PowerMAX® and 8.07 oz/ac Destiny® HC on 4/24/21 ***Pre:*** 3.2 oz/ac Balance® Flexx, 1.5 qt/ac Harness® Xtra 6.0, and 19.04 oz/ac NutriSphere-N® HV on 5/6/21
Seed Treatment: Channel® Protexus® and Acceleron®
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 176 lb/ac of MESZ and 176 lb/ac potash on 12/16/20; 150 lb N/ac as 32% UAN on 5/6/21
Cumulative Rainfall (in): 40

In year five, a 3-way cover crop mix (35 lb/acre cereal rye, 2 lb/ac rapeseed and 1 lb/ac red clover) was drilled on September 29, 2020, in the check and intensive plots. Cover crop was chemically terminated in late April 2021 prior to planting corn on April 30, 2021. Corn was harvested on October 17, 2021.

Table 5. 2021 cover crop biomass, green cover, corn moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 17, 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	736 A*	38.9 A	14.4 A	222 A	1128 A
Intensive System	779 A	43.2 A	14.4 A	230 A	1168 A
P-Value	0.836	0.420	0.820	0.311	0.311

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
Green cover using the Canopeo measurement tool.
‡Marginal net return based on $5.20/bu corn, $22.0/ac cost for cover crop seed and $14.40 drilling for both treatments.

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2019, 2020 and 2021.

Table 6. Soil physical, chemical, and biological properties for check and intensive system treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 14, 2020)*						
Check	1.424 A*	24.8 A	1.04 A	43.5 A	3.17 A	16.7 A
Intensive System	1.449 A	24.8 A	1.07 A	42.8 A	3.17 A	16.3 A
P-Value	0.12567	0.968	0.614	0.510	1.0000	0.802
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 6, 2019)*						
Check	2.42 A	27.4 A	1.10 A	39.88 A	4.00 A	18.5 A
Intensive System	7.90 A	25.5 A	1.13 A	39.90 A	3.88 A	19.0 A
P-Value	0.223	0.251	0.602	0.718	0.895	0.252
2020 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2020)*						
Check	22.1 A	26.1 A	1.21 A	44.2 A	3.38 A	20.1 A
Intensive System	16.7 A	26.4 A	1.15 A	44.4 A	3.00 A	20.2 A
P-Value	0.748	0.784	0.177	0.628	0.377	0.792
2021 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2021)*						
Check	0.815 A	29.0 A	1.20 A	46.4 A	2.88 A	21.4 A
Intensive System	2.762 A	27.8 A	1.27 A	46.2 A	2.81 A	22.4 A
P-Value	0.202	0.303	0.42	0.726	0.909	0.133

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
Soil assessment was not completed in 2018 as it was originally planned for every other year interval.
*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating a cool-season cash crop such as winter wheat in a corn-soybean rotation resulted in a decrease (1 – 2.4 bu/acre) or neutral effects in soybean yields.
- Incorporating a cool-season cash crop such as winter wheat in a corn-soybean rotation resulted in a increase (20 bu/ac) or neutral effects in corn yields.
- Trends of increased total soil health scores over time were observed in both intensive system treatment areas and check treatment areas.

Incorporation of Cover Crop in an Irrigated Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0914093202101
County: Howard
Reps: 7
Tillage: No-till

Soil Type: Holdrege silty clay loam 7-11% slopes, eroded
Irrigation: Pivot

Introduction

This study is being conducted on a soil health demonstration field as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative and involves the farmer, the Nebraska On-Farm Research Network, and the USDA/NRCS. Two treatments are being evaluated in this five-year study: a cover crop mix and a no-cover crop check. The prescribed plot management was maintained throughout the project timeline (2017-2021).

Year 1 – Corn (2017 Crop)

In year one, cover crops were drilled after corn harvest in 2016. The cover crop mix was kale, trophy rape, purple turnips, forage collards, hairy vetch, and rye. Cover crop that did not winter terminate were terminated with herbicides on May, 2017. Soybeans were planted on May 26, 2017, and harvested on October 15, 2017. No yield measurements were available representing the cover crop and no cover crop strips due to the harvest angle.

Year 2 – Corn (2018 Crop)

In year two, following soybean harvest in October, 2017, a cover crop mix of 33 lbs/ac cereal rye, 0.8 lbs/ac turnip, 1.6 lbs/ac canola, 0.6 lbs/ac African cabbage, 0.5 lbs/ac forage collards, 1.1 lbs/ac sunflower, 1.6 lbs/ac hairy vetch, 1.1 lbs/ac radish, 1 lbs/ac safflower and 1 lbs/ac winter lentil was drilled. The cover crop that did not winter terminate was terminated with herbicides in May, 2018. Corn was planted after cover crop termination, on May 7, 2018 and harvested on September 11, 2018. Corn experienced hail damage on August 16, 2018. No yield measurements were available representing the cover crop and no cover crop strips.

Year 3 – Soybeans (2019 Crop)

Planting Date: 5/16/19
Harvest Date: 9/30/19
Seeding Rate: 180,000
Row Spacing (in): 30
Variety: AgriGold® G2405RX
Herbicides: ***Pre:*** 25 oz/ac BroadAxe®XC and 48 oz/ac Gramoxone® SL ***Post:*** 12.8 oz/ac Engenia® and 32 oz/ac Buccaneer® 5 Extra
Foliar Insecticides: 2 oz/ac Warrior II with Zeon Technology®
Fertilizer: 108 lb/ac 11-52-0, 87 lb/ac 0-0-22-22 S11 Mg, and 23 lb/ac 98% lime
Cumulative Rainfall (in): 33

In year three, the cover crop mix was Barkant turnips, African cabbage, impact forage collards, dwarf Essex rapeseed, eco-till radish, peredovick sunflowers, finish safflowers, VNS hairy vetch, viceray lentils, and rye. The cover crop was seeded after corn harvest on September 21, 2018. Cover crops that did not winter terminate were terminated with herbicides on May 14, 2019. Soybeans were planted on May 16 in 30" row spacing and harvested on September 30, 2019. Soybeans experienced damage from heavy thistle caterpillar infestations. Aerial imagery and normalized difference vegetation index (NDVI) analysis showed soybeans following the no cover crop treatments had greater leaf senescence and were more mature (Figure 1). Due to visual differences observed in imagery and crop senescence, additional grain quality samples were collected. The treatments did not result in differences in soybean moisture, yield, or net return (Table 1). Yield data was compiled by the treatment area.

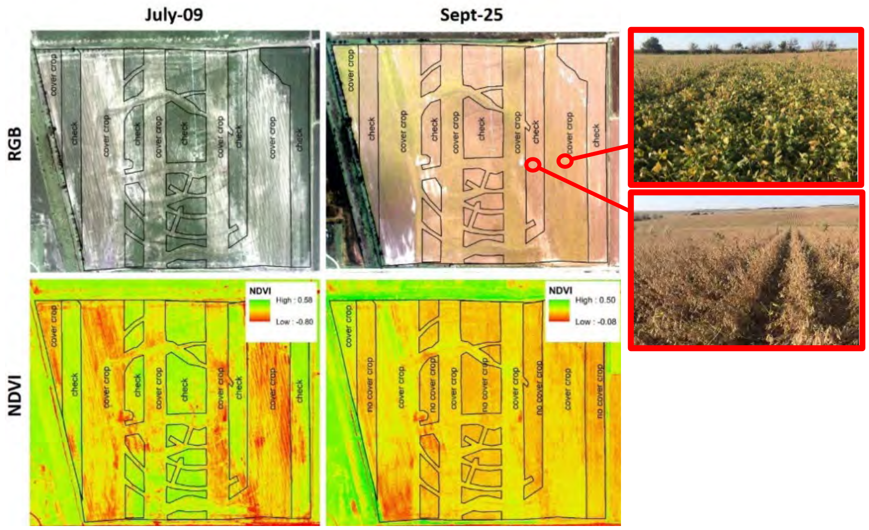


Figure 1. Aerial imagery from July 9 (left) and September 25 (right) displayed as true color (top) and normalized difference vegetation index (NDVI) (bottom). Strips with cover crop and no cover crop are indicated. Far-right inset images are pictures taken on September 26 in cover crop and no cover crop treatments.

Table 1. 2019 soybean yield, yield components, oil, moisture, and marginal net return for cover crop mix and no cover crop treatments.

	Pods/ plant	Grain/ plant	Linoleic (%)	Saturated fat (%)	Protein (%)	Oil (%)	Fiber (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	48.5 A	103 A	6.7 A	10.6 A	34.0 A	19.6 A	4.9 A	15.0 A	67.9 A	549.67 A
Cover Crop Mix	49.9 A	107 A	6.6 A	11.1 A	35.1 A	19.2 A	4.8 A	16.8 A	69.5 A	524.69 A
P-Value	0.897	0.771	0.880	0.397	0.385	0.175	0.178	0.210	0.779	0.605

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $24/ac cover crop seed, and $14.40 drilling.

Year 4 – Cereal Rye (2020 Crop)

Planting Date: 10/9/19
Harvest Date: 7/23/20
Seeding Rate: 72 lb/ac
Row Spacing (in): 7.5
Variety: Rye
Fertilizer: 117 lb/ac 11-52-0, 86 lb/ac lb K-mag, 27 lb/ac pell lime, 2 lb/ac 36% zinc
Irrigation: Pivot, Total: 6” on cover crops
Cumulative Rainfall (in): 23

In year four, following soybean harvest, cereal rye for grain/seed was drilled across both cover crop and no cover crop treatments on October 9, 2019, and harvested on July 23, 2020. Yield was compiled by the treatment area. There were no differences in rye test weight, moisture, yield, and marginal net return between the treatments.

Table 2. 2020 rye moisture, yield, and net return for cover crop mix and no cover crop treatments.

	Moisture (%)	Rye Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Check	14.5 A	40.9 A	246 A
Cover Crop Mix	14.5 A	42.4 A	255 A
P-Value	0.965	0.35144	0.35144

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15% moisture.
‡Marginal net return based on $6.01/bu cereal rye. Costs of cover crop drilled after rye harvest were not included on the analysis.

Year 5 – Corn (2021 Crop)

Planting Date: 4/26/21
Harvest Date: 10/25-10/29
Seeding Rate: 31,000
Row Spacing (in): 30
Hybrid: AgriGold® A6652VT2RIB
Herbicides: ***Pre:*** 2 qt/ac Lexar® EZ, 8 oz/ac DiFlexx™, 32 oz/ac Durango® DMA on 5/4/21 ***Post:*** 10 oz/ac Diflexx™ and 32 oz/ac Durango® DMA on 6/18/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/22/21
Fertilizer: 117 lb/ac 11-52-0, 85 lb/ac K-Mag®, 3 lb/ac of Zinc, 26 lb/ac of Pel-lime applied by variable rate on 4/1/21; 60 gal/ac UAN, 2 gal/ac Thio-Sul® on 5/4/21
Irrigation: Pivot, Total: 12"
Cumulative Rainfall (in): 27

In year five, cover crop mix (winter rye, radish, rapeseed, turnips, kale, lentils, Austrian winter peas, and vetch) was seeded after rye harvest in July. Cover crops that did not winter terminate were terminated with herbicides in April, 2021. Cover crop biomass was measured on April 15 (1224 lb/ac). Check strips had volunteer rye throughout the field (biomass = 1520 lb/ac). Corn was planted on April 26, and harvested on October 25-29, 2021. Yield data was compiled by treatment area. The treatments did not result in differences in corn moisture and yield (Table 3).

In addition to soil health assessment and yield results, weed biomass and density in the cover crop and check treatments were measured in 2021, five years after experimental plots were established. No differences in the seedbank were observed and the composition of the most abundant species was similar between the treatments. Despite no differences in the seedbank, early season weed biomass measured in the field was significantly reduced by the cover crop treatment. This reduction did persist later in the growing season.

Table 3. 2021 corn moisture, yield, net return and cover crop biomass and green cover for the cover crop mix and check treatments. Cover crop biomass measured on April 15 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Yield (bu/acre)	Marginal Net Return ($/acre)
Check	1520 A	43.4 A	18.5 B	222 A	1156 A
Cover Crop Mix	1224 A	33.4 B	18.6 A	217 A	1089 B
P-Value	0.1012	0.01465	0.0640	0.1194	0.0099

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $24/ac cover crop seed, and $14.40 drilling.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and number of species identified for cover crop mix and check treatments. Seedbank was collected on April 15, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from collection date until November 1, 2021, with two periods of drying and resifting soil to stimulate new germination flushes. Seedlings were identified by species and counted to quantify the size and composition of the soil seedbank. Total number of weeds, pigweeds, grasses, and other broadleaves are reported in weeds per m^2, which was determined from the number of emerged seedlings.

	Total weeds (weeds/m^2)†	Species Identified	Pigweeds (weeds/m^2)	Grasses (weeds/m^2)	Broadleaves (weeds/m^2)
Check	3415 A*	12.5 A	869 A	1404 A	1792 A
Cover Crop Mix	2580 A	15.2 A	581 A	666 A	1526 A
P-Value	0.344	0.296	0.492	0.137	0.715

† Total weeds, pigweeds, grasses, and broadleaves are estimated in weeds/m^2, which is derived from the number of seedlings that emerged from the soil seedbank.
*Values with the same letter are not significantly different at a 90% confidence level.

Table 5. Weed seedbank species composition for top five most abundant species in cover crop mix and check treatments. Seedbank was collected April 15, 2021, and permitted to freely germinate in the greenhouse until November 1, 2021.

Check – Species	Percentage of Seedbank	Cover Crop Mix – Species	Percentage of Seedbank
Green foxtail	24.8%	Common lambsquarters	27.0%
Common woodsorrel	20.3%	Green foxtail	18.1%
Common lambsquarters	15.4%	Redroot pigweed	14.2%
Common waterhemp	11.8%	Common woodsorrel	9.4%
Redroot pigweed	8.3%	Marestail	9.1%

Table 6. In-season measurements were taken for weed density, pigweed density, and weed biomass at early (at crop emergence and before post-emergence herbicide application) and late season (before canopy closure and 4+ weeks after post-emergence herbicide application) for cover crop and check treatments. Measurements are reported in weeds per m^2 and grams of biomass per m^2.

	Early Season Weed Density (weeds/m^2)	Early Season Pigweed Density (weeds/m^2)	Early Season Weed Biomass (g/m^2)	Late Season Weed Density (weeds/m^2)	Late Season Pigweed Density (weeds/m^2)	Late Season Weed Biomass (g/m^2)
Check	38.7 A*	3.25 A	0.454 A	29.8 A	19.5 A	0.423 A
Cover Crop	29.2 A	22.0 A	0.028 B	17.7 A	10.6 A	0.263 A
P-Value	0.749	0.104	0.0720	0.562	0.973	0.726

*Values with the same letter are not significantly different at a 90% confidence level.

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2018, 2019, 2020, and 2021.

Table 7. Soil physical, chemical, and biological properties for cover crop and no cover crop treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=7 per treatment; samples collected on Nov. 16, 2017)*						
Check	7.07 A*	24.1 A	1.08 A	48.3 A	5.04 A	12.8 A
Cover Crop Mix	13.11 A	26.7 A	1.11 A	48.6 A	4.79 A	12.9 A
P-Value	0.446	0.525	0.457	0.724	0.391	0.750
2018 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 28, 2018)*						
Check	-	30.1 A	1.19 A	48.5 A	-	13.8 A
Cover Crop Mix	-	31.3 A	1.21 A	48.8 A	-	14.5 A
P-Value	-	0.422	0.654	0.799	-	0.286
2019 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 29, 2019)*						
Check	0.59 A	21.51 A	1.16 A	47.71 A	3.64 A	14.1 B
Cover Crop Mix	0.62 A	23.33 A	1.15 A	46.69 A	4.43 A	16.0 A
P-Value	0.781	0.616	0.817	0.521	0.297	0.00205
2020 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 8, 2020)*						
Check	36.1 A	10.1 A	1.04 A	54.3 A	3.83 A	18.6 B
Cover Crop Mix	33.7 A	11.6 A	1.09 A	53.3 A	3.42 A	20.3 A
P-Value	0.886	0.138	0.396	0.497	0.259	0.0212

Table 7 Continued.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2021 *(1 sample per treatment replication, n=7 per treatment; samples collected on Nov. 30, 2021)*						
Check	0.985 A	24.0 B	1.34 A	43.4 A	3.05 A	18.9 B
Cover Crop Mix	0.499 A	26.8 A	1.34 A	43.4 A	3.12 A	20.4 A
P-Value	0.37	0.0196	0.986	0.9738	0.845	0.00327

[1]Soil respiration (Modified Solvita burst).

[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- This project included a field-wide conversion to and application of no-till management beginning in 2017.
- Incorporating cover crops in a corn-soybean-small grain rotation resulted in neutral effects on corn, soybean, and small grain yields.
- Total soil health score was higher in the cover crop strips in 2019 and 2020. There is also a trend of increases in soil health scores over time.
- No differences in the seedbank were detected in the treatments. Early-season weed biomass was significantly reduced by the cover crop treatment, but no effects were observed on weed density.

CROP PROTECTION

Xyway™ LFR® Fungicide Studies

Xyway™ LFR® fungicide is applied in-furrow at planting. There has been an interest from farmers to use this product in areas where aerial fungicide application is not allowed, such as fields near towns or various industrial facilities. Thus, the impact of Xyway™ LFR® fungicide was evaluated on corn yield and plant disease. Xyway™ LFR® was applied in-furrow or as a band at planting at a rate of 15.2 oz/ac.

SITES

Eight studies were conducted in Buffalo, Hall, Seward, and York counties in 2021 (Figure 1). Site details are displayed in Table 1.

Table 1. Sites, location, planting date, irrigation, starter fertilizer used for the check treatment, and application method for eight sites evaluating Xyway™ LFR® fungicide. Only the starter fertilizer product added with the Xyway ™ LFR® is listed here. Additional products and timing applied to the field are listed in the individual reports.

ID	Report ID	County	Planting Date	Irrigation	Starter Fertilizer (check treatment)	Application Method
2021-1	1253019202101	Buffalo	5/1/2021	Pivot	15 gal/ac UAN 32%	Surface
2021-2	0908079202101	Hall	4/24/2021	Gravity	3.5 gal/ac 10-34-0	In-furrow
2021-3	0802159202103	Seward	4/26/2021	None	3.84 gal/ac 10-34-0	In-furrow
2021-4	0718185202102	York	4/29/2021	Pivot	3 gal/ac 10-34-0	In-furrow
2021-5	1258019202101	Buffalo	4/26/2021	Pivot	3 gal/ac Riser®	In-furrow
2021-6	0118185202101	York	4/26/2021	Pivot	4 gal/ac 10-34-0	In-furrow
2021-7	1121019202101	Buffalo	4/26/2021	Pivot	3 gal/ac 10-34-0	In-furrow
2021-8	1255019202101	Buffalo	5/8/2021	Pivot	4 gal/ac 10-34-0	In-furrow

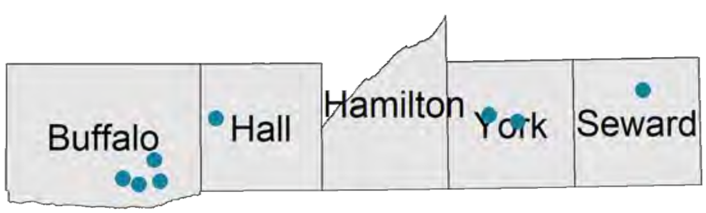


Figure 1. Xyway™ LFR® site locations in 2021.

RESULTS

Yield data from the studies were analyzed as a large group by comparing the check and Xyway™ LFR treatments. There was no interaction between the site and treatment; therefore, yield data for the treatments are examined for all sites.

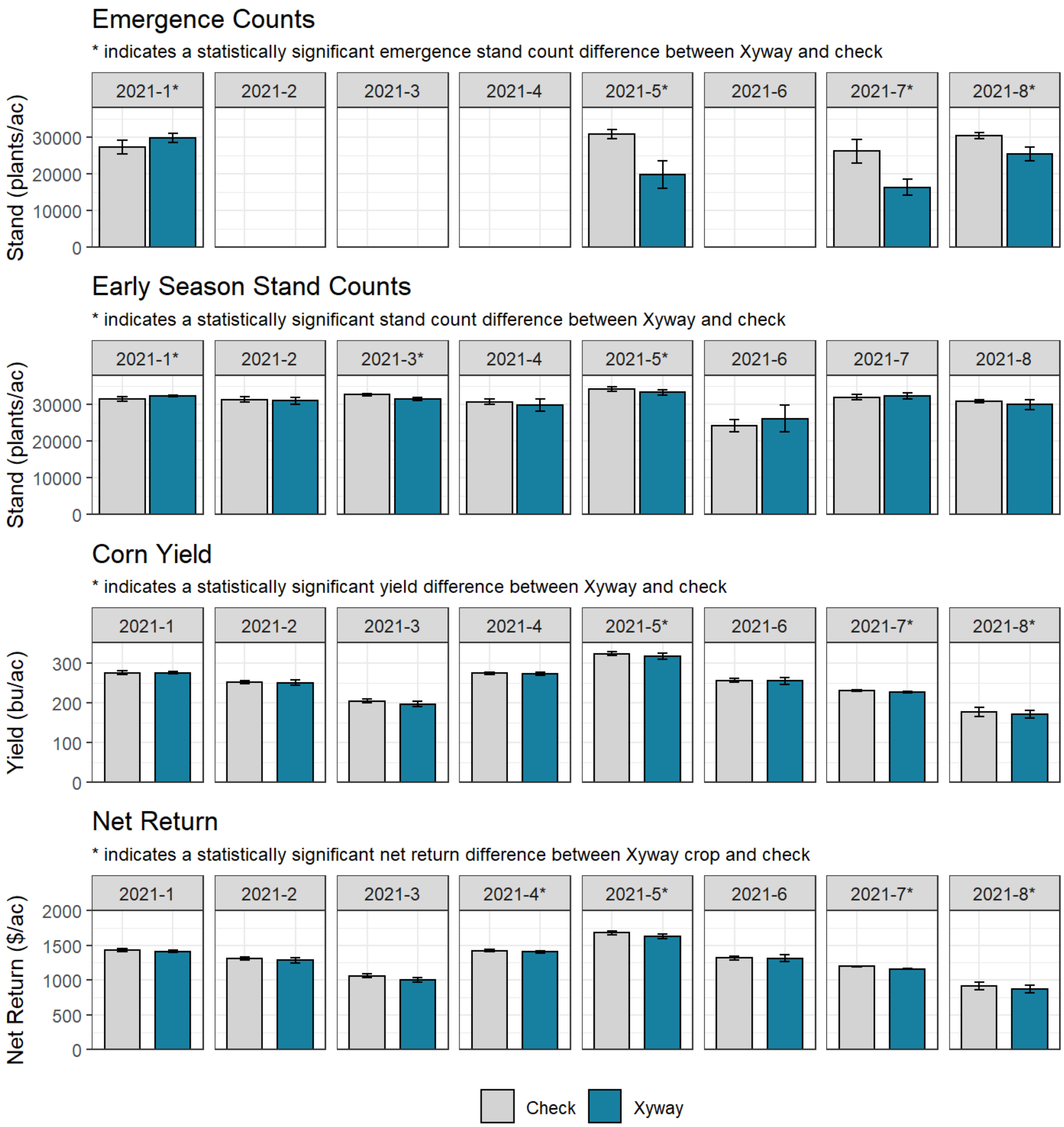


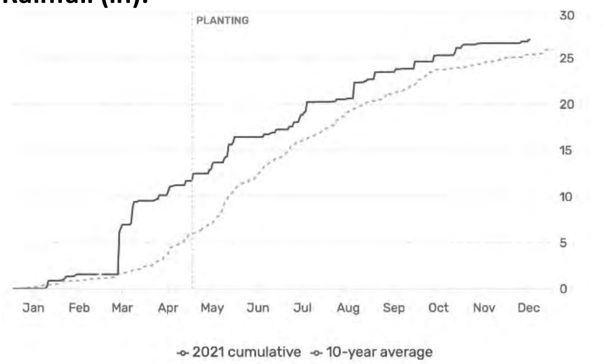
Figure 2. Mean emergence counts (panel 1), early season stand counts (panel 2), yield (panel 3), and net return (panel 4) for Xyway™ LFR® and check treatments. Emergence and early season stand counts were taken to determine any potential stand impacts of Xyway™ LFR®.

SUMMARY

Plant emergence was evaluated at four sites; at three of these sites, the Xyway™ LFR® treatment had slower emergence (Figure 2). Early season stand counts were collected for all sites; only two sites had significantly reduced early season stand counts for the Xyway™ LFR® treatment (2021-3 and 2021-5). Other data collected from University of Nebraska-Lincoln research farm experiments suggested there were not stand differences with the use of Xyway™ LFR® when applied with starter fertilizer products that do not contain micronutrients. Yield was statistically lower in three of the sites (2021-5, 2021-7, and 2021-8), which corresponded to sites with reduced emergence counts. While two of these sites (2021-7 and 2021-8) did not have stand count differences in the early season stand counts, yields were still reduced.

Impact of Xyway™ LFR® Fungicide Applied as Surface Band at Planting

Study ID: 1253019202101
County: Buffalo
Soil Type: Hall silt loam 0-1% slope; Hord silt loam 0-1% slope
Planting Date: 5/1/21
Harvest Date: 10/22/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Hefty® H6524 STX
Reps: 5
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 1.5 qt/ac Degree Xtra®, 3 oz/ac mesotrione, 32 oz/ac Roundup PowerMAX® with 1% COC and Synurgize™ ***Post:*** 1.25 qt/ac Harness® MAX, 1 pt/ac atrazine, and 22 oz/ac Roundup PowerMAX® with 8.5 lb/ac AMS
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 14 gal/ac 10-34-0 and 1 gal/ac $ZnSO_4$ applied during strip-till; 15 gal/ac UAN 32% (53 lb N/ac) starter applied by surface dribble; 50 gal/ac UAN 32% (178 lb N/ac) side-dressed
Irrigation: Pivot
Rainfall (in):



Introduction: This study evaluates the impact of Xyway™ LFR® fungicide applied on corn at planting. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac. Xyway™ LFR® fungicide was applied by surface dribbling 2" from the row with 15 gal/ac of 32% UAN. The check treatment is 15 gal/ac of 32% UAN dribbled 2" from the row without Xyway™ LFR®. The treatments were arranged in a randomized complete block design and replicated five times. The overall foliar disease pressure was low at this site; therefore foliar disease observations were not recorded. Plant emergence stand counts were taken on May 21, 2021 and early season stand counts were taken on May 26, 2021.

Results:

	Emergence Count (plants/ac)	Stand Count (plants/ac)	Stalk Rot (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	27,250 B*	31,583 B	20.00 A	14.7 A	275 A	1,427 A
Xyway™ LFR®	29,750 A	32,333 A	22.60 A	14.9 A	275 A	1,411 A
P-Value	0.027	0.098	0.235	0.111	0.995	0.231

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $16.70/ac for Xyway™ LFR® fungicide.

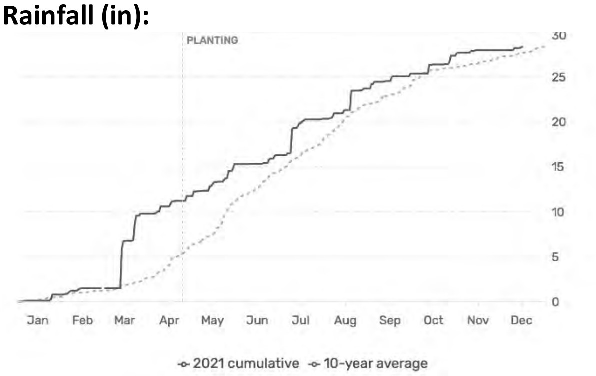
Summary:

- The Xyway™ LFR® treatment had significantly higher plant emergence stand counts (2,500 plants/ac greater) than the check. A few days later, when early season stand counts were collected, Xyway™ LFR® treated plots still had significantly higher stand counts, but the difference between the Xyway™ LFR® treated plots and check plots was not as great (only 750 plants/ac greater).
- There were no significant differences observed in the occurance of stalk rot between the Xyway™ LFR® and check plots. Foliar disease pressure was low in the field; therefore, no foliar disease data were collected.
- There was no significant yield or net return difference between the Xyway™ LFR® fungicide and check plots.

Impact of Xyway™ LFR® Fungicide In-Furrow

Study ID: 0908079202101
County: Hall
Soil Type: Detroit silt loam 0-1% slope
Planting Date: 4/24/21
Harvest Date: 10/4/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Seitec® Genetics S6144 VT2
Reps: 7
Previous Crop: Corn
Tillage: Ridge-till and Cultivate
Herbicides: ***Pre:*** 32 oz/ac glyphosate and 1.5 qt/ac Bicep ll Magnum® ***Post:*** 32 oz/ac glyphosate and 3 oz/ac Status®
Seed Treatment: Acceleron® 500
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 150 lb/ac 11-52-0 and 10 lb/ac 35.5% Zinc broadcasted during winter; 54 gal/ac 32% UAN (192 lb N/ac) split between pre-plant and sidedress applications; 3.5 gal/ac 10-34-0 starter applied at planting
Irrigation: Gravity, Total: 15"
Rainfall (in):



Introduction: This study evaluates the impact of Xyway™ LFR® fungicide applied in-furrow. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertilizer with no Xyway™ LFR®. The treatments were arranged in a randomized complete block design and replicated seven times. The plots were 1,240 ft long and 40 ft wide. Overall, plant disease pressure was low at this site, this year, thus disease evaluations were not made.

Results:

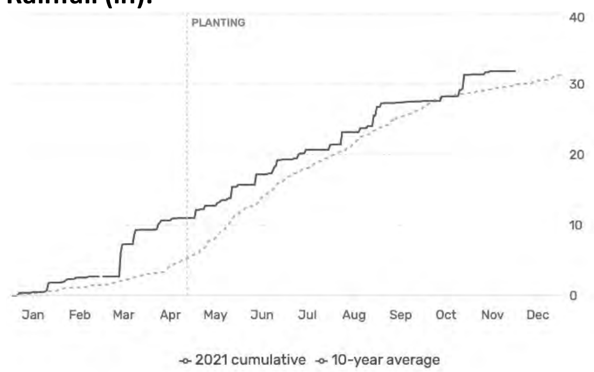
	Early Season Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	31,381 A*	16.7 A	252 A	1,309 A
Xyway™ LFR®	31,000 A	16.6 A	250 A	1,283 A
P-Value	0.457	0.111	0.514	0.188

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $13.72/ac for Xyway™ LFR®.

Summary: There were no differences in stand count, moisture, yield, or net return between the Xyway™ LFR® treatment and the check.

Impact of Xyway™ LFR® Fungicide In-Furrow

Study ID: 0802159202103
County: Seward
Soil Type: Fillmore silt loam frequently ponded; Crete silt loam 1-3% slope; Hastings silt loam 1-3% slope
Planting Date: 4/26/21
Harvest Date: 10/23/21
Seeding Rate: 32,400
Row Spacing (in): 30
Hybrid: Pioneer® P2042AML
Reps: 3
Previous Crop: Soybean
Tillage: No-till
Herbicides: ***Post:*** 2.5 qt/ac Resicore®, 1 pt/ac 2,4-D LV6, and 22 oz/ac Roundup PowerMAX® with 2.55 lb/ac AMS
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 3.84 gal/ac 10-34-0, 123 lb N/ac as anhydrous ammonia, 150 lb/ac 12-40-0 MicroEssentials® SZ®
Irrigation: None
Rainfall (in):



Introduction: This study evaluated the impact of Xyway™ LFR® fungicide applied in-furrow on corn yield. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertlizer with no Xyway™ LFR®. The treatments were arranged in a randomized complete block design and replicated three times. The plots were 2,499 ft long and 30 ft wide.

Results:

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	32,667 A*	32,667 A	17.50 A	0	13.9 A	204 A	1,060 A
Xyway™ LFR®	31,500 B	31,000 B	8.33 A	0	14.1 A	196 A	1,003 A
P-Value	0.073	0.063	0.380	-	0.635	0.307	0.201

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $15.58/ac for Xyway™ LFR®.

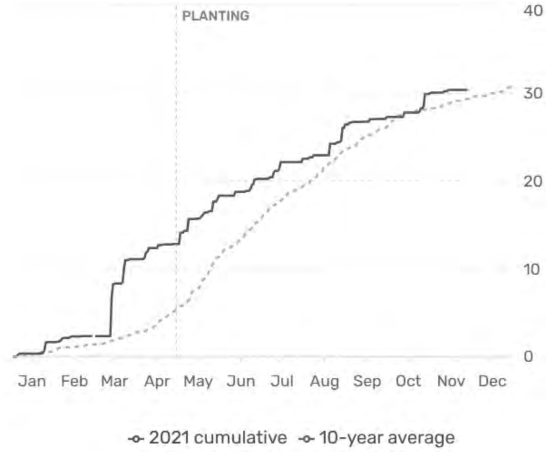
Summary:

- The number of plants in the early and late season stand counts were significantly different, with plant stands that were approximately 1,000 to 1,600 greater in the check compared to Xyway™ LFR® treated plots.
- There were no differences in stalk rot, yield, or net return.
- Foliar disease pressure was not estimated at this site.

Impact of Xyway™ LFR® Fungicide In-Furrow

Study ID: 0718185202102
County: York
Soil Type: Hastings silt loam 0-1% slope; Hastings silty clay loam 7-11% slopes, eroded
Planting Date: 4/29/21
Harvest Date: 10/11/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Pioneer® P1185Q
Reps: 10
Previous Crop: Corn
Tillage: Spring tillage, Row cultivation
Herbicides: ***Pre:*** 2 qt/ac Medal® ll ATZ and 5 oz/ac Cavallo™ at planting on 4/29/21
Seed Treatment: 4 oz/ac Ethos® XB and 4 oz/ac Batallion™ on 4/29/21
Foliar Insecticides: 8 oz/ac Lorsban™ on 7/16/21
Foliar Fungicides: None

Fertilizer: 190 lb N/ac as anhydrous and 200 lb/ac MESZ® in the fall; 3 gal/ac 10-34-0 in-furrow at planting
Irrigation: Pivot, Total: 6"
Rainfall (in):



Soil Tests: (October 2020)

					Ammonium Acetate (ppm)				CEC	% Base Saturation				
pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	H	K	Ca	Mg	Na
6.5	6.8	3.4	12.3	34	415	2238	335	51	17.1	11	6	66	16	1
7.0		3.2	13.5	18	419	2490	365	50	16.8	0	6	74	18	1

Introduction: This study evaluates the impact of Xyway™ LFR® fungicide applied in-furrow on disease pressure and corn yield. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertlizer with no Xyway™ LFR®. The treatments were arranged in a paired comparison design. The plots were 2,445 ft long and 15 ft wide. Disease severity was collected on September 10 by walking 1/1,000 of an acre in each treatment and rep noting the percent of leaf area covered by lesions in the mid-canopy. Southern rust was the main disease present in this field and rated via percent disease severity. Gray leaf spot (GLS) ratings were recorded by noting how high on the plant GLS was present. The ear leaf is considered 0. Leaves above the ear leaf were positive and those below the ear leaf were negative. For example, -1 indicates that GLS was present at the leaf below the ear leaf while +1 indicates that GLS was present at the leaf above the ear leaf.

Results:

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Stalk Rot (%)	GLS Leaf Number	Disease Severity (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	30,714 A*	30,357 A	0.00 A	-0.6 A	3.0 A	16.8 A	274 A	1,424 A
Xyway™	29,857 A	29,786 A	0.36 A	-1.1 A	2.4 A	16.8 A	273 A	1,403 B
P-Value	0.248	0.364	0.356	0.321	0.464	0.967	0.162	0.001

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $13.75/ac for Xyway™.

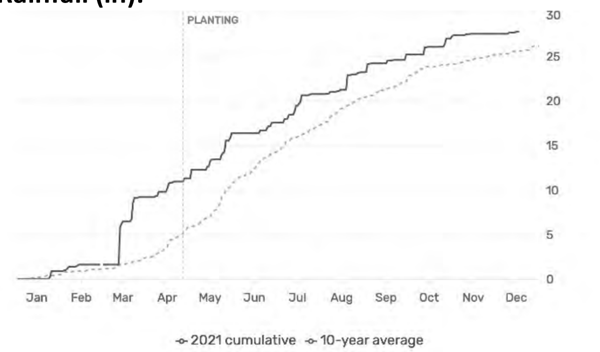
Summary:

- There were no statistical differences in stand count, stalk quality, or disease ratings. Overall, disease was fairly low and was predominantly southern rust. On average GLS was approximately 1 leaf below the ear for both treatments.
- There was no yield advantage for using Xyway™ LFR® fungicide. Due to the increased cost of the product, this resulted in a statistically lower partial profit for the Xyway™ LFR® treatment compared to the untreated check.

Impact of Xyway™ LFR® Fungicide In-Furrow

Study ID: 1258019202101
County: Buffalo
Soil Type: Hall silt loam 0-1% slope
Planting Date: 4/26/21
Harvest Date: 9/27/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: DEKALB® 63-91 VT2P RIB
Reps: 7
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 1.5 qt/ac Degree Xtra®, 3 oz mesotrione , 32 oz/ac Roundup PowerMAX® with 1% COC and 8.5 lb/ac AMS ***Post:*** 1.5 qt/ac Resicore®, 1 pt/ac atrazine, and 32 oz/ac Roundup PowerMAX® with 8.5 lb/ac AMS

Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 3 gal/ac Riser® in-furrow, 42-50-0 dribble starter, and 48 gal/ac UAN 32% (170 lb N/ac) through fertigation
Irrigation: Pivot, Total: 12"
Rainfall (in):



Introduction: This study evaluates the impact of Xyway™ LFR® fungicide applied in-furrow. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertilizer with no Xyway™ LFR®. The treatments were arranged in a randomized complete block design with seven replications. Plant emergence stand counts were taken on May 11, 2021 and early season stand counts were taken on May 26, 2021.

Results:

	Emergence Count (plants/ac)	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	30,714 A*	34,238 A	21.1 B	323 A	1,680 A
Xyway™ LFR®	19,714 B	33,333 B	22.4 A	316 B	1,627 B
P-Value	0.0003	0.015	0.078	0.011	0.002

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $16.70/ac for Xyway™ LFR®.

Summary:

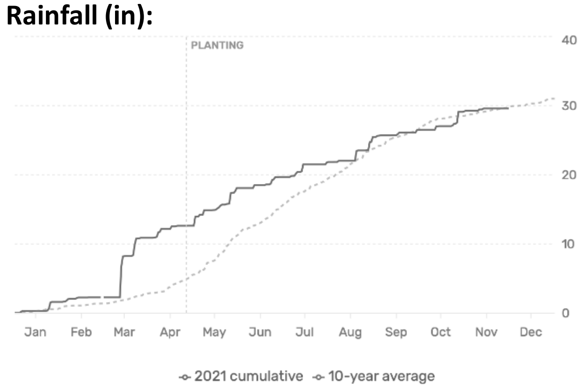
- The Xyway™ LFR® treatment had slower emergence than the check (at the time of emergence stand counts Xyway™ LFR® had approximately 11,000 fewer plants/ac than the check). The number of plants in later stand counts were closer between the treatments, but the Xyway™ LFR treated plots still had a significantly lower stand count with approximately 900 fewer plants/ac than the check.
- The Xyway™ LFR® treatment had a 7 bu/ac lower yield compared to the check. This may be attributed to the delayed and uneven emergence.
- A significant difference was found in the marginal net return with a $53/ac decrease for the Xyway™ LFR® treatment due to the lower yields and additional treatment cost.

Impact of Xyway™ LFR® Fungicide In-Furrow

This study was completed as part of the Innovative Youth Corn Challenge by the team CSI-York

Study ID: 0118185202101
County: York
Soil Type: Hastings silt loam 0-1% slope; Hastings silt loam 1-3% slope
Planting Date: 4/26/21
Harvest Date: 10/16/21
Seeding Rate: Irrigated: 32,500, Non-Irrigated: 25,000
Row Spacing (in): 30
Hybrid: DEKALB® DKC60-80
Reps: 6
Previous Crop: Soybean
Tillage: Ridge-till
Herbicides: ***Pre:*** 3 qt/ac Lexar® EZ on 4/30/21
Foliar Insecticides: None
Foliar Fungicides: None

Fertilizer: 150 lb N/ac applied via anhydrous ammonium on 11/10/21, 4 gal/ac 10-34-0 starter on 4/26/21, 30 lb N/ac as urea dry spread then hilled on 6/14/21
Irrigation: Pivot, Total: 6.5"
Rainfall (in):



Introduction: This study evaluated the impact of Xyway™ LFR® fungicide applied in-furrow on disease pressure and corn yield. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertlizer with no Xyway™ LFR®. The treatments were arranged in a paired comparison design and replicated six times. The plots were approximately 1,200 to 1,900 ft long and 40 ft wide. Disease severity was collected on September 10 by walking 1/1,000 of an acre in each treatment and rep and noting the percent of leaf area covered by lesions in the mid-canopy. Southern rust was the main disease present in this field and rated via percent disease severity. Gray leaf spot (GLS) ratings were recorded by noting how high on the plant GLS was present. The ear leaf is considered 0. Leaves above the ear leaf were positive and those below the ear leaf were negative. For example, -1 indicates that GLS was present at the leaf below the ear leaf while +1 indicates that GLS was present at the leaf above the ear leaf. Stand counts were taken on May 18, 2021 and October 1, 2021.

Results:

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	GLS Leaf Number	Disease Severity (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	24,200 A*	24,200 A	8.00 A	0 A	-0.5 A	15.6 A	16.0 A	255 A	1,327 A
Xyway™	26,200 A	26,000 A	11.00 A	1 A	-2.6 B	17.8 A	15.9 A	254 A	1,302 A
P-Value	0.154	0.208	0.426	0.374	0.011	0.178	0.681	0.776	0.273

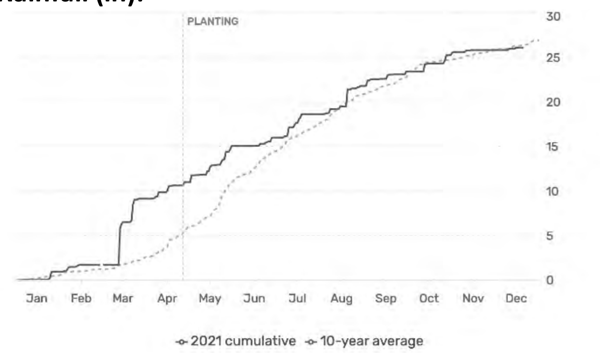
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $18.50/ac for Xyway™ LFR® fungicide.

Summary:

- There were no statistical differences in stand count, stalk rot, grain moisture, yield, or profit.
- Disease incidence ranged from 5 to 40% in this field and was predominantly southern rust.
- GLS was significantly worse for the check treatment, with GLS being found on average between the ear leaf and the leaf below the ear leaf. In contrast, for the Xyway™ LFR® treatment, GLS was found further down the plant, at 2 to 3 leaves below the ear leaf.

Impact of Xyway™ LFR Fungicide In-Furrow

Study ID: 1121019202101
County: Buffalo
Soil Type: Hord silt loam 0-1% slope
Planting Date: 4/26/21
Harvest Date: 10/22/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Hefty® H6714 STX
Reps: 7
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** 1.5 qt/ac Degree Xtra®, 3 oz/ac mesotrione, 32 oz/ac Roundup PowerMAX® with 1% COC and 8.5 lb AMS/100 gal water ***Post:*** 1.25 qt/ac Harness® MAX, 1 pt/ac atrazine, and 22 oz/ac Roundup PowerMAX® with 8.5 lb AMS/100 gal water
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 8 gal/ac 10-34-0 and 12 gal/ac UAN 28% (35 lb N/ac) applied during fall strip-till; 3 gal/ac 10-34-0 applied in-furrow and 12 gal/ac UAN 32% (43 lb N/ac) applied by surface dribble at planting; 40 gal/ac UAN 32% (142 lb N/ac)
Irrigation: Pivot
Rainfall (in):



Introduction: This study evaluates the impact of Xyway™ LFR fungicide applied in-furrow on corn yield. Xyway™ LFR contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertlizer with no Xyway™ LFR. The treatments were arranged in a randomized complete block design and replicated seven times. Early season plant emergence counts were taken on May 14, 2021. Stand counts were completed again on May 26, 2021.

Results:

	Emergence Count (plants/ac)	Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	26,143 A*	31,952 A	19.4 B	230 A	1,196 A
Xyway™ LFR®	16,286 B	32,381 A	19.8 A	226 B	1,159 B
P-Value	0.001	0.417	0.0004	0.0001	<0.0001

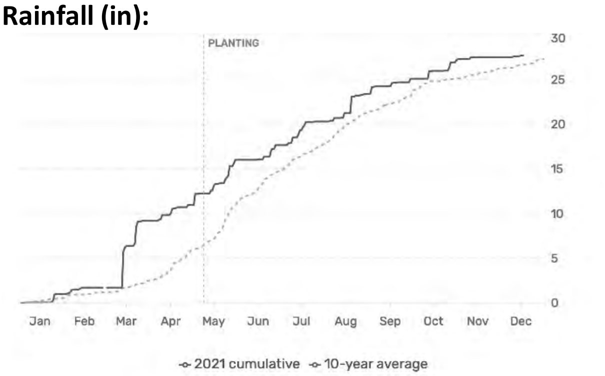
*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $16.70/ac for Xyway™ LFR.

Summary:

- The Xyway™ LFR treatment had slower emergence than the check (Xyway™ LFR had only 16,286 plants/ac compared to 26,143 plants/ac for the check). Early Season stand counts still had significant differences, but were more similar (Xyway™ had approximately 430 more plants/ac than check)
- The Xyway™ LFR treatment had a 3.9 bu/ac lower yield compared to the check. This may be attributed to the delayed and uneven emergence.
- Marginal net return showed a $37/ac decrease in yield for the Xyway™ LFR treatment due to the lower yields and additional treatment cost.

Impact of Xyway™ LFR® Fungicide In-Furrow

Study ID: 1255019202101
County: Buffalo
Soil Type: Hord silt loam 0-1% slope
Planting Date: 5/8/21
Harvest Date: 10/8/21
Seeding Rate: 32,000
Row Spacing (in): 30
Hybrid: Golden Harvest® Enogen E113Z5
Reps: 7
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Post:*** 3.75 pt/ac Acuron® GT, 8 oz/ac Detonate®, and 15 oz/ac Roundup PowerMAX®
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 4 gal/ac 10-34-0 applied in-furrow at planting; 15 gal/ac UAN 32% (53 lb N/ac) surface dribble starter; 40 gal/ac UAN 32% (142 lb N/ac) sidedress
Note: The field experienced heavy disease pressure and pre-mature death in both treatments
Irrigation: Pivot
Rainfall (in):



Introduction: This study evaluates the impact of Xyway™ LFR® fungicide applied in-furrow on corn yield. Xyway™ LFR® contains the active ingredient flutriafol and was applied at a rate of 15.2 oz/ac in-furrow with starter fertilizer. The check treatment is starter fertlizer with no Xyway™ LFR®. The treatments were arranged in a randomized complete block design and replicated seven times. The plots were 2,550 ft long and 30 ft wide. Plant emergence counts were taken on May 21, 2021 and early season stand counts were taken on June 3, 2021. The field experienced heavy disease pressure in both treatments.

Results:

	Emergence Count (plants/ac)	Stand Count (plants/ac)	Stalk Rot (%)	Test Weight (lb/bu)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	30,357 A*	30,857 A	66 A	57 A	12.4 A	176 A	917 A
Xyway™ LFR®	25,429 B	30,048 A	63 A	57 A	12.2 A	170 B	869 B
P-Value	0.0003	0.173	0.583	0.986	0.481	0.051	0.009

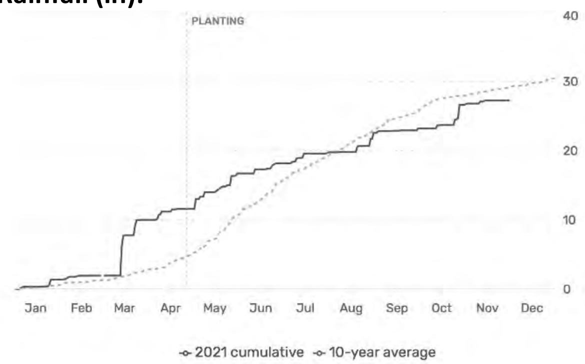
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $16.70/ac for Xyway™ LFR®.

Summary:

- The Xyway™ LFR® treatment had slower emergence than the check (at the time plant emergence stand counts were taken, Xyway™ LFR® had approximately 5,000 fewer plants/ac than the check). Early season stand counts still had significant differences, but were more similar (Xyway™ had approximetely 800 fewer plants/ac than check).
- There was not a significant difference in the percentage of stalk rot.
- The Xyway™ LFR® treatment had a 6 bu/ac lower yield compared to the check. This may be attributed to the delayed and uneven emergence.
- Marginal net return was $48/ac less in the Xyway™ LFR® treatment due to the lower yields and additional treatment cost.

Evaluating ILeVO® Seed Treatment for Sudden Death Syndrome in Soybeans

Study ID: 0811185202101
County: York
Soil Type: Hastings silty clay loam 3-7% slopes, eroded
Planting Date: 4/26/21
Harvest Date: 9/26/21
Seeding Rate: 140,000
Row Spacing (in): 30
Hybrid: Pioneer® 27A30X
Reps: 4
Previous Crop: Corn
Tillage: No-Till
Herbicides: ***Pre:*** 8 oz/ac dicamba, 32 oz/ac glyphosate, and 8 oz/ac Authority® Supreme ***Post:*** 44 oz/ac Roundup PowerMAX®, 2 oz/ac Anthem® MAXX, and 10 oz/ac generic Select®
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: None
Irrigation: Pivot, Total: 8"
Rainfall (in):



Introduction: Sudden death syndrome (SDS) is caused by the soil-borne fungus *Fusarium virguliforme*. In fields where SDS is present and soybean cyst nematode is also present, the disease can be more severe. There are not clear guidelines to determine at what point treatment is justified; therefore, on-farm research projects like this one are needed. Additionally, as new seed treatment products become available, evaluations such as this one are needed to help producers evaluate the impact of various treatments. Historically, the field in this study has had SDS present.

This study evaluated:

A: Base seed treatment of 0.284 oz Lumisena™, 0.50 oz EverGol® Energy, 0.8 oz Gaucho®, and 1 oz rhizobia per 45,000 seeds.

B: Base seed treatment plus ILeVO® (fluopyram) at a rate of 1.0 oz/140,000 seeds.

The treatments were arranged in a randomized complete block design and replicated four times. Because of the relationship between soybean cyst nematode (SCN) and SDS, soil samples were collected on May 13 and September 8 from each treatment and three replications to estimate initial and mid-season population densities, respectively. SCN eggs were extracted and used to calculate the SCN Reproduction factor (Rf) for each treatment. Sudden death syndrome severity and incidence was visually estimated on September 8 and used to calculate the SDS disease severity index. Early and late-season stand counts were also collected on June 4, 2021 and September 21, 2021, respectively. Yield, grain moisture, and net return were evaluated.

Results:

	SCN Initial Population (P_i) May 13, 2021	SCN Mid-Season Population (P_m) Sept. 8, 2021	SCN Reproduction Factor (Rf) [y]
Base Treatment	0 A*	0 A	1.0 A
Base Treatment + ILeVO®	107 A	80 A	80.7 A
P-Value	0.423	0.423	0.425

[y] $Rf=(P_m+1)/(P_i+1)$. Rf greater than "1" indicates SCN reproduction since the initial sampling date and Rf less than "1" indicates a decline in SCN population densities since the initial sampling date.

	SDS Incidence % Sept. 8, 2021	SDS Severity Sept. 8, 2021	SDS Disease Severity Index Sept. 8, 2021 [z]
Base Treatment	2.3 A	2.3 A	0.7 A
Base Treatment + ILeVO®	0.7 A	0.7 A	0.2 A
P-Value	0.423	0.199	0.423

[z] Calculated with the following equation: Index=[(Incidence % X Severity Value)/9]; the severity value was found with the Southern Illinois University Carbondale method for SDS scoring. Plant Dis. 99:347—354.
https://apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-06-14-0577-RE

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Base Treatment	127,750 A	107,000 A	8.0 A	93 A	1,085 A
Base Treatment + ILeVO®	123,250 A	108,000 A	7.9 A	95 A	1,096 A
P-Value	0.334	0.415	0.529	0.326	0.598

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybeans, $13.75/ac for the base seed treatment, and $25/ac for the base seed treatment + ILeVO®.

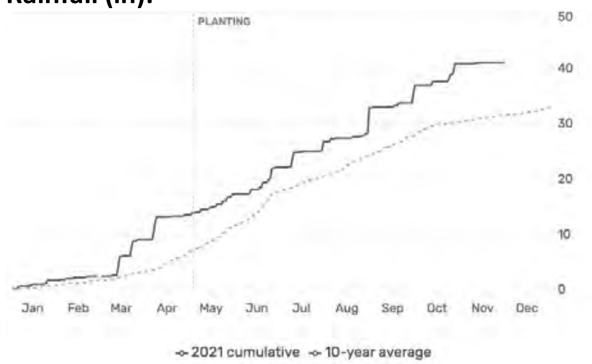
Summary:

- There were no significant stand count differences between the seed treatments. It is not known why harvest stand counts were lower than the early season stand counts.
- The use of the ILeVO® seed treatment did not significantly increase yield or profit in this study.
- SCN was detected in only one treatment and replication in the intial SCN samples, and detected in only one treatment and replication in the mid-season SCN samples. SCN reproduction was not significantly affected by the seed treatments in this trial.
- The SDS disease severity index was very low in this field in 2021. The ILeVO® seed treatment did not significantly reduce SDS disease severity index compared to the base treatment.
- Results from a previous study in this county in 2020 had higher SDS disease severity index (6.4 for the base treatment). In this case, ILeVO® was found to decrease disease severity and increase yields by 3 bu/ac.

Impact of Fungicide and Insecticide Application on Soybeans

Study ID: 0926039202102
County: Cuming
Soil Type: Kennebec silt loam occasionally flooded; Kennebec silt loam 0-3% slope
Planting Date: 5/3/21
Harvest Date: 10/8/21
Seeding Rate: 145,000
Row Spacing (in): 30
Hybrid: Midland® 2990
Reps: 4
Previous Crop: Corn
Tillage: Disk
Herbicides: ***Pre:*** Treflan® ***Post:*** Enlist® and glyphosate

Foliar Insecticides: 9 oz/ac Tundra® Supreme on 7/28/21
Foliar Fungicides: 10 oz/ac Affiance® on 7/28/21
Irrigation: None
Rainfall (in):



Soil Tests (July 2021)

pH	BpH	CEC	1:1 S Salts	OM	Nitrate-N	K	S	Zn	Fe	Mn	Cu	Ca	Mg	Na	H	K	Ca	Mg	Na	Mehlich P-III
		meq/100g	mmho/cm	%	ppm	----------------------------ppm------------------------									-----------%----------					---ppm--
6.4	6.7	18.1	0.24	3.9	7.1	612	6.9	2.3	76.1	18.7	1.5	2208	337	24	14	9	61	15	1	100

Introduction: This study builds on soybean benchmarking studies the grower has participated in during the 2019, 2020, and 2021 growing seasons. These studies examined an "improved" soybean practice of lower soybean seeding rate, earlier planting date, and using foliar fungicide and insecticide applications. The producer's improved practice resulted in a 7.5 bu/ac yield increase in 2019, a 4.2 bu/ac yield increase in 2020, and a 5.3 bu/ac yield increase in 2021. Because the study tested these factors in combination, it was not possible to determine how much of the yield difference was due to seeding rate, planting date, or fungicide and insecticide use. Therefore, this study evaluated the yield of a soybean crop with and without fungicide and insecticide applications at the same seeding rate and planting date. The earlier planting date (May 3, 2021) and lower seeding rate (145,000 seeds/ac) from the producer's 2021 benchmarking study was used for all treatments in this study. The study compared no fungicide and insecticide application (check) to 10 oz/ac Affiance® fungicide and 9 oz/ac Tundra® Supreme insecticide application on July 28. This is the second year of this study evaluating just the fungicide and insecticide application. The treatments were arranged in a randomized complete block design and replicated four times. The plots were 263 ft long and 12.5 ft wide.

Results:

	Test Weight (lb/bu)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return ($/ac)‡
Check	57 A*	12.0 B	53 B	620 A
Fungicide & Insecticide	57 A	12.1 A	56 A	626 A
P-Value	0.412	0.080	0.014	0.486

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $11.80/bu soybean and $36/ac for fungicide, insecticide, and application.

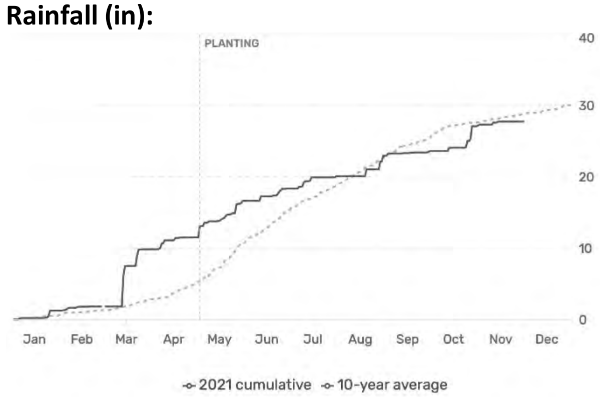
Summary:

- In 2020, there were no yield differences between the fungicide and insecticide and the untreated check, indicating the 4.2 bu/ac yield increase for the 2020 benchmarking study was attributed to planting date and seeding rate.
- In 2021, there was a 3.6 bu/ac yield increase in the plots where fungicide and insecticide were applied. This suggests that in the 2021 soybean benchmarking study, the 5.3 bu/ac yield increase came primarily from the fungicide and insecticide use (3.6 bu/ac increase) and secondarily from the planting date and seeding rate (1.7 bu/ac increase).

EQUIPMENT

Precision Planting® DeltaForce® Hydraulic Active Downforce vs Manual Downforce

Study ID: 0902185202101
County: York
Soil Type: Hastings silt loam 0-1% slope; Hastings silt loam 1-3% slope
Planting Date: 5/2/21
Harvest Date: 10/26/21
Seeding Rate: 34,500
Row Spacing (in): 30
Hybrid: Channel® 213-19
Reps: 7
Previous Crop: Corn
Tillage: Ridge-till, Root sliced twice in April 2021
Herbicides: ***Pre:*** 2.5 qt/ac Resicore® on 5/7/21 ***Post:*** 1 qt/ac atrazine, and 1 qt/ac Durango®
Seed Treatment: Acceleron® 250 with Poncho® VOTiVO®
Soil Applied Insecticides: 6.4 oz/ac bifenthrin on 5/2/21
Foliar Insecticides: 6.4 oz/ac Fanfare® and 3.5 oz/ac RAVAGE® 7/26/21
Foliar Fungicides: 14 oz/ac Propaz and 1 qt/ac fulvic acid on 7/26/21
Fertilizer: 150 lb/ac 11-52-0, and 3 lb/ac zinc applied in winter; 20 gal/ac 32% UAN (71 lb N/ac) applied with herbicide on 5/7/21; 61 lb N/ac as urea and 50 lb/ac AMS on 6/15/21; 20 gal/ac 32% UAN (71 lb N/ac) applied when hilling on 6/22/21 (229 lb N/ac total for season)
Note: Field was hailed on 6/22/21 & 7/9/21 adjusted 10% total loss
Irrigation: Gravity, Total: 5"
Rainfall (in):



Soil Tests: (December 2020)

pH	BpH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K ppm	Na ppm
5.6	6.7	2.8	12.1	21	217	36

Introduction: An uneven distribution of downforce across a planter can lead to uneven planting depth and emergence. Hydraulic active down pressure systems are of interest to reduce sidewall compaction and achieve consistent planting depth across various soil types and conditions. This study evaluated the Precision Planting® DeltaForce® system. Each treatment strip was 20' long by 1,638' long. The two treatments were:

1) no down pressure (manual setting), which resulted in 36 lb force (check)

2) active down pressure resulted in a net of 129 lb of downforce at the gauge wheel.

The planting depth was 1.75”. Emergence counts were taken for each replication on a near-daily basis as the crop emerged to determine if the active down pressure resulted in a more uniform emergence (Figure 1). Early season stand counts were recorded on May 26 and harvest stand counts and stalk quality were recorded on October 11. Grain moisture, yield, and net return were also evaluated.

Results:

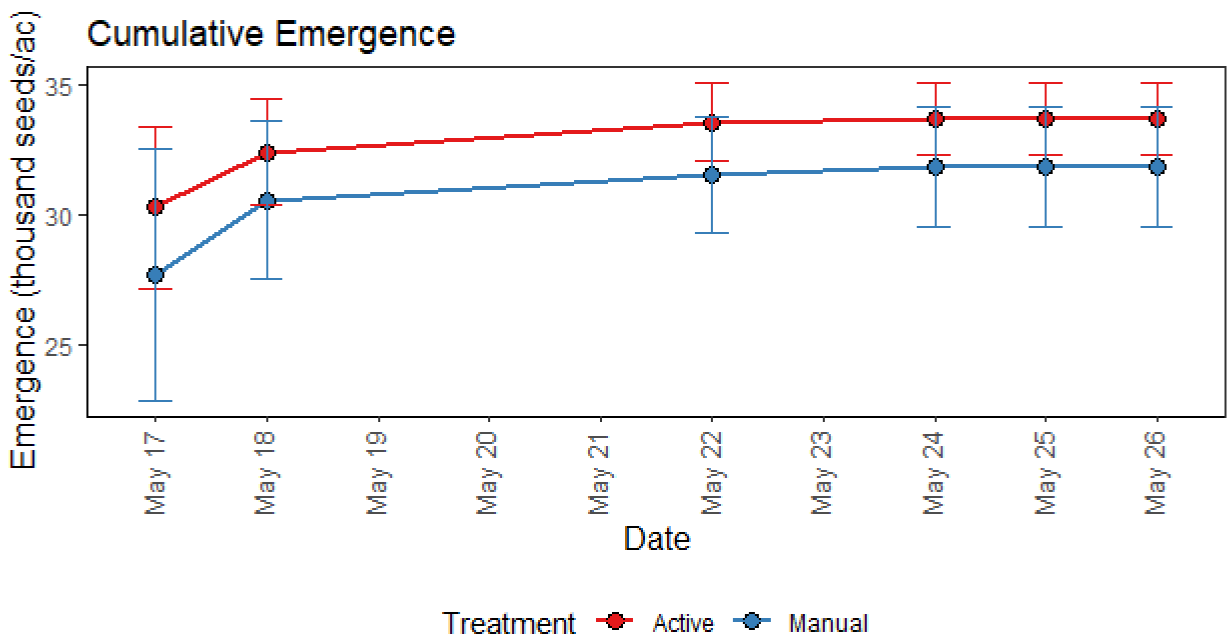


Figure 1. Cumulative emergence by date for manual downforce and active hydraulic downforce with the Precision Planting® DeltaForce® system.

	Early Season Stand Count (plants/ac)	Harvest Stand Count (plants/ac)	Stalk Rot (%)	Green Snap (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Manual Downforce	31,857 A*	30,857 A	5.00 A	1 A	15.6 B	260 A	1,354 A
Delta Downforce	33,714 A	32,571 A	5.71 A	5 A	15.7 A	263 A	1,362 A
P-Value	0.186	0.193	0.356	0.111	0.047	0.209	0.318

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $2.64/ac for active downforce ($24,000 cost for active downforce system spread over 1300 acres and prorated over 7 years).

Summary:

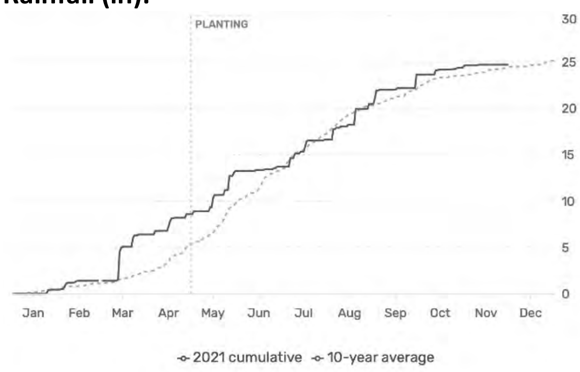
- Daily emergence counts showed a trend of higher stand counts for the active downforce system. This is likely due to improved seed-to-soil contact resulting from the higher load.
- There was no statistically significant differences in stand counts, stalk quality, yield, or net return between the manual and active downforce systems.

Ag Leader® SureForce™ Systems at Different Pressures (Manual vs Medium vs Heavy)

Study ID: 0709047202102
County: Dawson
Soil Type: Hord silt loam 0-1% slope; Cozad silt loam 0-1% slope
Planting Date: 4/30/21
Harvest Date: 11/9/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Channel® 214-22STX
Reps: 6
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** Burndown: 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer® 5 Extra, and 1 qt/ac atrazine 4L on 5/4/21 ***Post:*** 24 oz/ac Buccaneer® 5 Extra, 3 pt/ac Fearless Xtra®, 3 oz/ac Status®, 3 oz/ac mesotrione on 6/9/21.
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac Bifenthrin 2EC and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21

Fertilizer: 15 gal/ac 32-0-0 (53 lb N/ac), 5 gal/ac 10-34-0, 5 gal/ac 12-0-0-26s, 2 gal/ac Altura™ applied during strip-till on 4/12/21; 1 gal/ac Altura™, 1 gal/ac ReaX™ K, 0.25 gal/ac ReaX™ Zinc, with in-furrow starter on 4/30/21; 10 gal/ac 32% UAN (36 lb N/ac) on 5/4/21; 8 gal/ac 32% UAN (28 lb N/ac) and 2 gal/ac 12-0-0-26s applied by chemigations on 6/13/21, 6/29/21, 7/5/21, and 8/5/21

Irrigation: SDI, Total: 5.2"
Rainfall (in):



Soil Tests: (December 2020)

				Ammonium Acetate (ppm)				CEC	% DPTA			
pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	K	Ca	Mg	Na	me/100g	Zn	Fe	Mn	Cu
6.3	2.6	9	22	474	2118	233	25	14	1.1	14.6	13.6	0.6
6.4	2.7	9	31	500	2642	292	17	17	1.2	10.3	11.2	0.6

Introduction:

An uneven distribution of downforce across a planter can lead to uneven planting depth and emergence. Hydraulic active down pressure systems are of interest to reduce sidewall compaction and achieve consistant planting depth across various soil types and conditions. This study evaluated the Ag Leader® SureForce™ system. The three treatments were:

1) manual pressure set at a fixed down pressure of 100 lb force (check)

2) active down pressure set at medium, resulting in a net of 100 lb of downforce at the gauge wheel

3) active down pressure set at heavy, resulting in a net of 150 lb of downforce at the gauge wheel.

Planting depth was 2". Emergence counts were taken for each replication on a near-daily basis as the crop emerged to determine if the active down pressure resulted in a more uniform emergence (Figure 1). Early season (V4-V6) stand counts and the number of plants that were delayed by one growth stage were recorded on June 2. Harvest stand counts, moisture, yield, and net return were also evaluated.

Results:

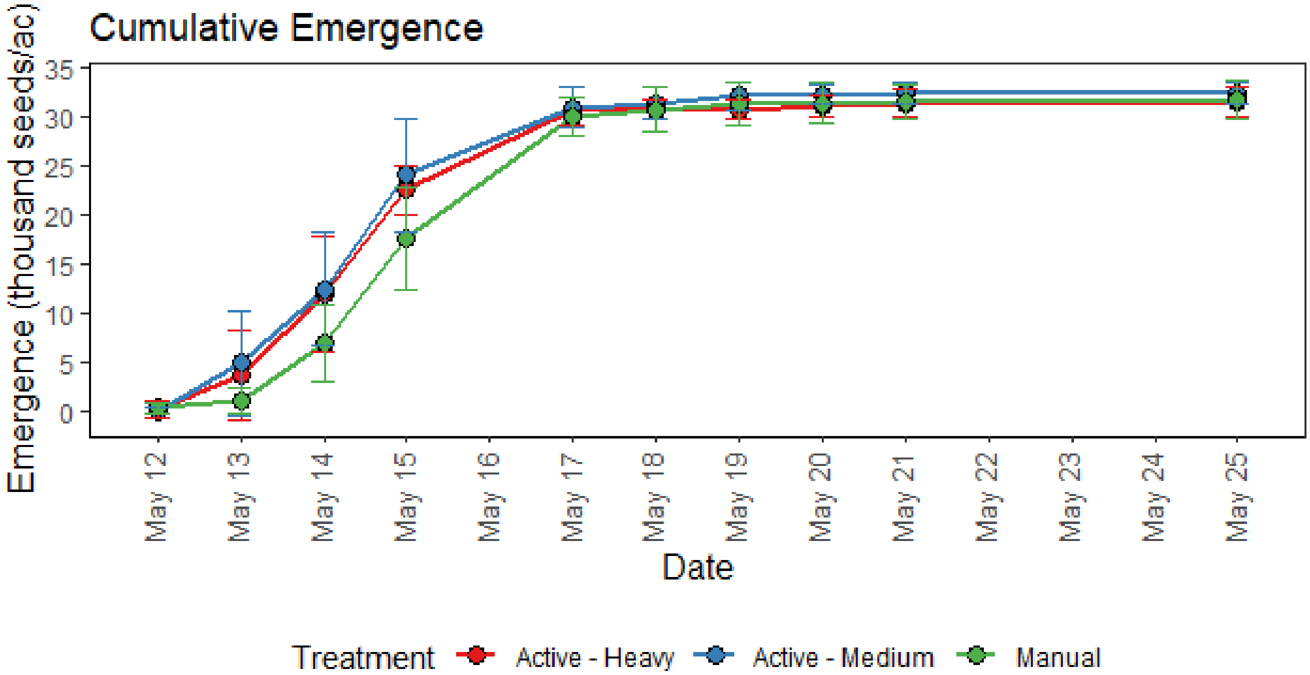


Figure 1. Cumulative emergence by date for manual downforce, active downforce at medium pressure, and active downforce at heavy pressure.

	Early Season Stand Count (plants/ac)	Number of Plants with Delayed Growth Stage	Harvest Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Manual Downforce (100 lb added)	32,333 A*	1 A	30,389 A	16.5 A	247 AB	1,282 AB
Medium Downforce (Net 100 lb at gauge wheel)	32,389 A	1 A	31,222 A	16.5 A	242 B	1,257 B
Heavy Downforce (Net 150 lb at gauge wheel)	32,167 A	2 A	30,389 A	16.6 A	250 A	1,296 A
P-Value	0.918	0.507	0.461	0.506	0.025	0.024

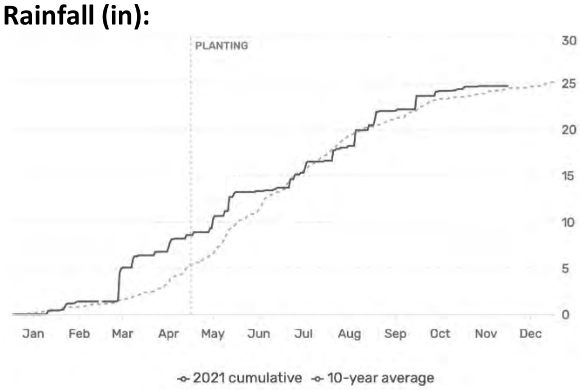
*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $1.90/ac for active downforce ($20,000 cost for active downforce system spread over 1,500 acres and prorated over 7 years).

Summary:

- The active downforce had quicker emergence early on (approximately May 13-15). By May 17 all treatments had approximately the same emergence.
- There were no differences in stand counts or grain moisture between the three treatments.
- Yield and profit were greater for the heavy active downforce compared to the medium active downforce.
- The manual downforce did not have a different yield or profit compared to either active downforce pressure.
- This is the second year of the study; in year one, there were no differences in yield or profit.

Corn Planting Speed with Ag Leader SureDrive™ and SureForce™

Study ID: 0709047202105
County: Dawson
Soil Type: Hord silt loam 0-1% slope; Cozad silt loam
Planting Date: 5/1/21
Harvest Date: 11/9/21
Seeding Rate: 34,000
Row Spacing (in): 30
Hybrid: Channel® 214-22STX
Reps: 5
Previous Crop: Corn
Tillage: Strip-till
Herbicides: ***Pre:*** Burndown: 6.4 oz/ac Verdict®, 24 oz/ac Buccaneer® 5 Extra, and 1 qt/ac atrazine 4L on 5/4/21 ***Post:*** 24 oz/ac Buccaneer® 5 Extra, 3 pt/ac Fearless Xtra®, 3 oz/ac Status®, 3 oz/ac mesotrione on 6/9/21
Seed Treatment: None
Foliar Insecticides: 6.4 oz/ac Bifenthrin 2EC and 2 oz/ac Lambda-Cyhalothrin 1 EC on 7/19/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/19/21
Fertilizer: 15 gal/ac 32-0-0 (53 lb N/ac), 5 gal/ac 10-34-0, 5 gal/ac 12-0-0-26s, 2 gal/ac Altura™ applied during strip-till on 4/12/21; 1 gal/ac Altura™, 1 gal/ac ReaX™ K, 0.25 gal/ac ReaX™ Zinc, with in-furrow starter on 4/30/21; 10 gal/ac 32% UAN (36 lb N/ac) on 5/4/21; 8 gal/ac 32% UAN (28 lb N/ac) and 2 gal/ac 12-0-0-26s applied by chemigations on 6/13/21, 6/29/21, 7/5/21, and 8/5/21
Irrigation: SDI, Total: 5.2"
Rainfall (in):



Soil Tests: (December 2020)

pH	OM LOI %	Nitrate – N ppm N	Mehlich P-III ppm P	Ammonium Acetate (ppm) K	Ca	Mg	Na	CEC me/100g	% DPTA Zn	Fe	Mn	Cu
6.3	2.6	9	22	474	2118	233	25	14	1.1	14.6	13.6	0.6
6.7	2.7	9	31	500	2642	292	17	17	1.2	10.3	11.2	0.6

Introduction: Too high planting speeds coupled with uneven distribution of downforce across a planter can lead to uneven planting depth and emergence. Electric drive systems coupled with hydraulic active down pressure systems are of interest to reduce sidewall compaction, achieve consistant planting depth, and achieve consistent spacing across various soil types and conditions. This is the second year of this study, which evaluates the Ag Leader® SureForce™ system to study if faster planting speeds are possible when using an active down pressure system. The standard planting speed of 5 mph was compared with speeds of 7 mph and 9 mph. The $1.90/ac treatment cost for the active downforce system was included in net return calculations for the 7 mph and 9 mph planting speeds. The planting depth was set at 2”.

Emergence counts were taken for each replication on a near-daily basis as the crop emerged to determine if the active down pressure resulted in a more uniform emergence (Figure 1). Early season (V4-V6) and harvest stand counts, moisture, yield, and net return were also evaluated.

Results:

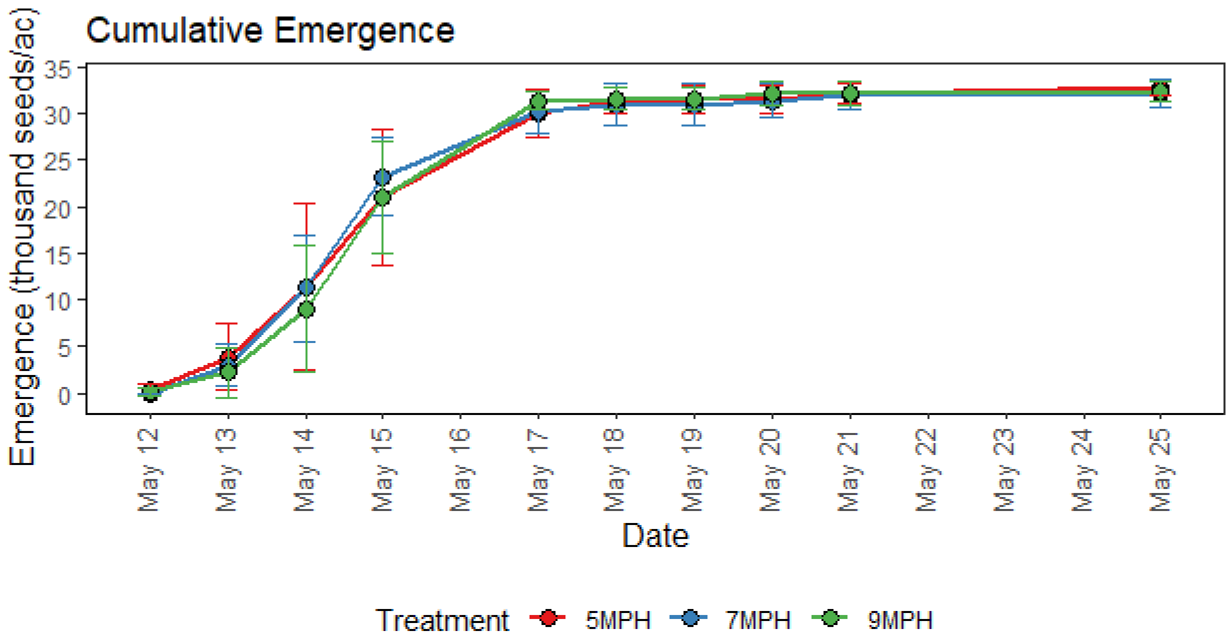


Figure 1. Cumulative emergence by date for 5 mph, 7 mph, and 9 mph planting speeds.

	Early Season Stand Count (plants/ac)	Number of Plants with Delayed Growth Stage	Harvest Stand Count (plants/ac)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
5 mph	32,867 A*	2 A	29,933 A	16.5 A	246 A	1,278 A
7 mph	32,133 A	2 A	30,400 A	16.6 A	245 A	1,273 A
9 mph	32,000 A	2 A	30,733 A	16.6 A	245 A	1,270 A
P-Value	0.507	0.940	0.733	0.208	0.769	0.641

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn and $1.90/ac for the active downforce for the 7 mph and 9 mph treatments ($20,000 cost for active downforce system spread over 1,500 acres and prorated over 7 years).

Summary:

- In the first year of the study, planting speeds of 5, 7, and 10 mph were evaluated; slower emergence for the 7 and 10 mph planting speeds were observed. This was not the case this year, as emergence for the three planting speeds were very similar (Figure 1).
- There were no differences in stand counts, yield, moisture, or net return between the three planting speeds, indicating in this system with strip-till the 9 mph planting speed can be used to improve planting efficiency without resulting in reduced yield or plant stands.

NEBRASKA ON-FARM RESEARCH NETWORK

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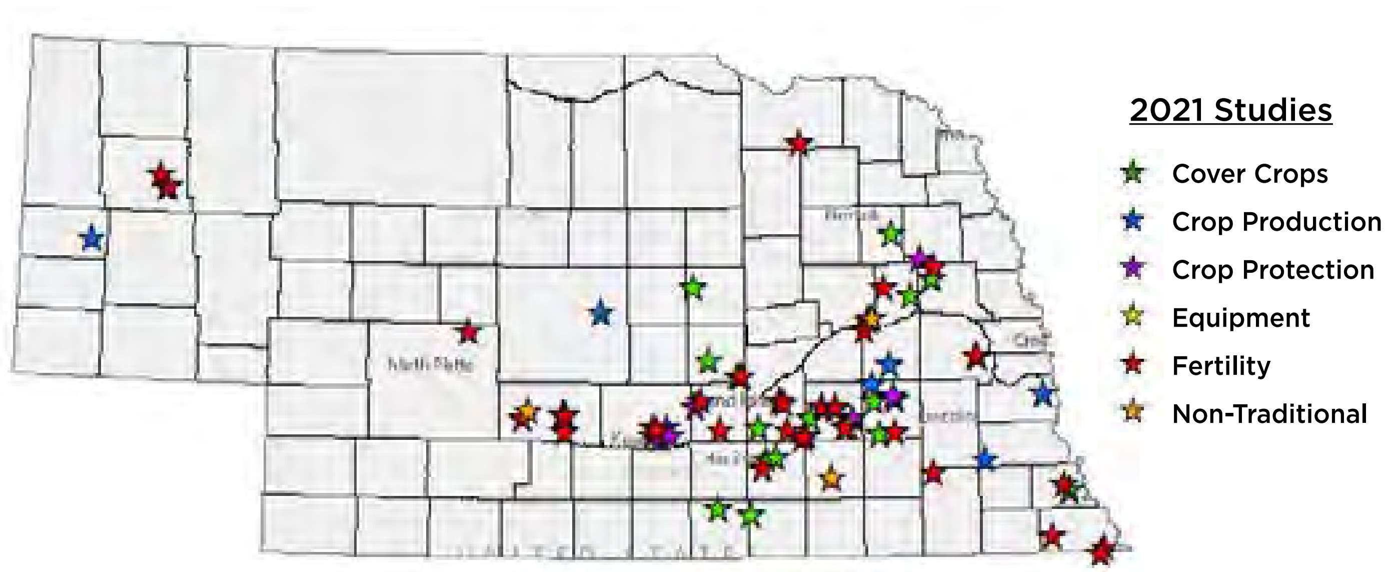
2021 STUDY LOCATIONS



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