Golden Harvest®

AGRONOMY IN ACTION

Photo: Research combine harvesting a plot in Seward, NE

RESEARCH REVIEW

ROOTED IN GENETICS AGRONOMY & SERVICE℠ •SINCE 1973•

WHATEVER IT TAKES, 365 DAYS A YEAR

Golden Harvest is driven to deliver the ultimate service experience on your farm, all year round. We'll be there to offer insights on your field conditions, listen to your needs and tailor recommendations to meet them exactly. Not just throughout the growing season, but long before planting and way beyond harvest.

Count on us to be relentless about adding value at every stage of your crop's development, from planting to monitoring performance to evaluating results and planning for the following year.

Golden Harvest®

SERVICE THAT NEVER QUITS.

OUR YEAR-ROUND COMMITMENT:

1. SEASON PREP

- Field planning
- Planting tips/watch-outs

2. ESTABLISHMENT

- Early-season field issues
- Replant decisions

3. PLANT GROWTH

- Plant heath/nutrients
- Disease-insects

4. YIELD POTENTIAL

- Disease-insects
- Start yield expectations

5. HARVEST PREP

- Harvest priority
- Harvest expectations and timing

6. HARVEST–POST-HARVEST

- Yield insights
- Understanding performance via year

GENETICS. AGRONOMY. SERVICE.

Unique Genetics – Golden Harvest is fully committed to bringing you unique genetics and trait options that give you the most choice of products that are bred, tested and proven locally. All genetics are backed by local agronomic expertise and the tireless service of your Golden Harvest Seed Advisor.

Agronomic Expertise – Our expert teams of Seed Advisors, Agronomists and Sales Representatives have a wealth of data and experience ready to precisely place products for maximum performance in your fields.

Tireless Service – Golden Harvest will never stop working to understand you and your fields, so that we can offer locally proven product recommendations to yield in your conditions. Count on us to be relentless about delivering the genetics, agronomy and service you need to optimize results.

INTRODUCTION

FOREWORD BY GOLDEN HARVEST AGRONOMY MANAGERS, DAVID SCHLAKE AND STEVE WILKENS

David Schlake
Golden Harvest West Agronomy Manager

The year 2020 was one none of us will soon forget, but not because of the agronomic or weather challenges that farmers in the Golden Harvest West Agronomy territory experienced. Instead, it is because of the added challenges of growing and producing a crop in the grips of a global pandemic. With schools closed, businesses impacted, and stay-at-home orders in place, we were able to kick off the 2020 planting season under normal weather and agronomic conditions. Almost all parts of the western Corn Belt planted at a normal pace. However, parts of South Dakota and North Dakota continued to see weather delays that resulted in another year of prevented plant acres.

Throughout the entire western region, we saw lower-than-normal temperatures in April and May lead to much higher-than-normal temperatures from June onward. Aside from weather challenges, we continued to see ever-increasing corn rootworm pressure. Corn rootworm numbers rose in fields not only with historic issues, but also in areas which have normally seen little to no pressure. We need to continue implementing comprehensive corn rootworm management plans, with larvae and beetle monitoring in all corn-on-corn fields.

In 2020, we experienced only slight pressure for corn and soybean disease. Golden Harvest saw the introduction of Saltro® seed treatment for protection against sudden death syndrome (SDS) with great results. Environmental challenges continued during pollination and grain fill, and the higher temperatures were coupled with lower-than-normal precipitation in some regions. The crops quickly matured, and few harvest delays were experienced.

Throughout a year filled with ups and downs, we were committed to helping navigate those challenges, whether it be through our E-Luminate® digital agronomy platform – where data helps drive decisions on every field – or through agronomic service and helping troubleshoot field issues.

Regardless of what the growing season brings, or the world challenges us with, the Golden Harvest agronomy team is willing to continue to do whatever it takes to stand by our commitment of genetics, agronomy and service.

Steve Wilkens, M.S.
Golden Harvest East Agronomy Manager

To describe the 2020 growing season as a challenge for corn and soybean production would be an understatement. While most of us were happy to leave 2019 in the past, 2020 certainly left a lasting imprint, too. What started with so much promise and high expectations soon gave way to a series of events that led to production problems and reduced crop yields.

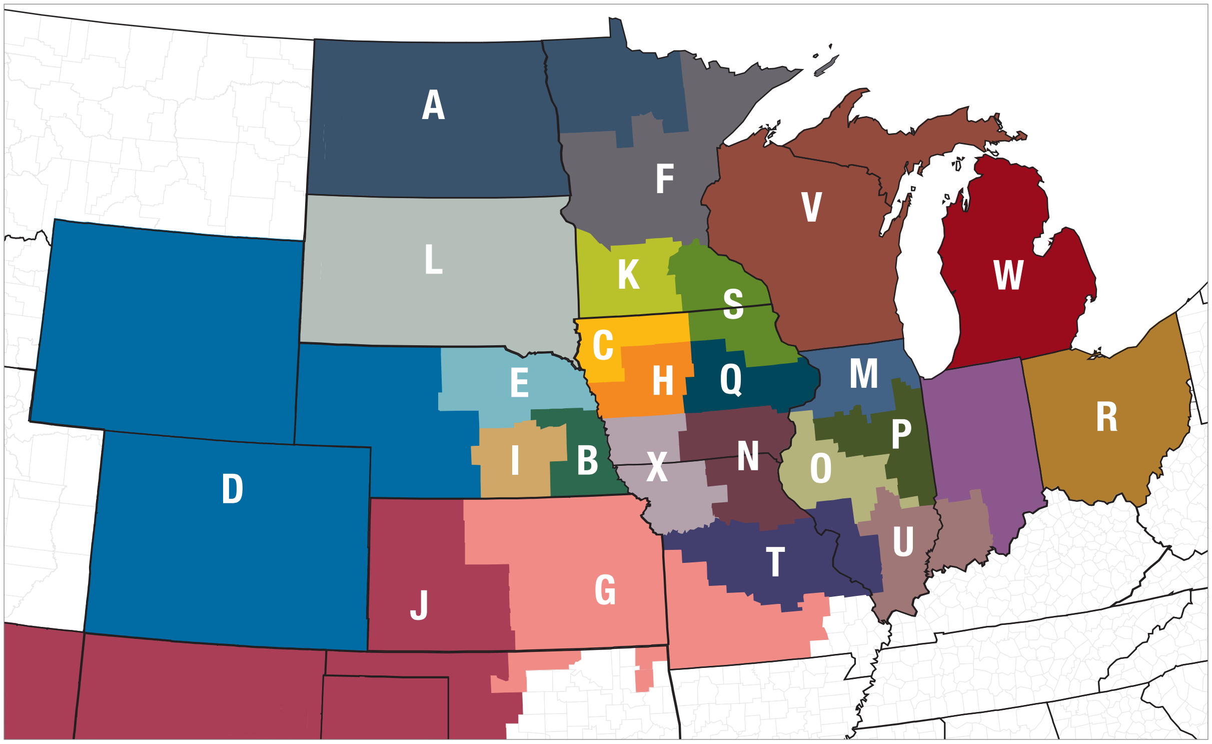
Spring 2020 was a welcome change for many growers. Planting occurred on time and at a near-record pace across much of the central and eastern Corn Belt. But then things shifted as farmers faced unprecedented challenges, including unfavorable environmental conditions, changing in-season soybean weed control options, and severe outbreaks of corn rootworm (CRW).

Few will forget the events of August 10, when a derecho that spanned more than 770 miles negatively affected an estimated 37.7 million acres across pockets of Iowa, Illinois and Indiana and caused severe crop damage. Outbreaks of southern rust, bacterial leaf streak, charcoal rot and pockets of sudden death syndrome (SDS) were also observed. Farmers that utilized SDS seed treatments on soybeans and foliar fungicides on corn received a strong return on their investment in 2020.

Late September brought an early frost, cutting short the growing season for many in the north and north-central Corn Belt. But things ended on a high note, as harvest season mimicked planting season's record pace with few delays.

Throughout all this year's challenges, Golden Harvest® products continued to perform at a very high level. Many growers reported outstanding weed control and top-end yields with our new Enlist E3® Soybeans, while many others continued to experience the dominating performance of Golden Harvest Roundup Ready 2 Xtend® Soybeans. The year also saw a new and exciting level of yield and agronomic performance from many of the recently launched Golden Harvest corn products. The highlight of my year was receiving a message from a grower whose G10D21 was making prolonged runs of more than 400 BPA in a corn-on-corn environment.

Now, as we set our sights on the 2021 growing season, many of us are faced with important decisions to help mitigate risk from the things learned from 2020 that may affect our farming operations. To help address some of these management decisions, we've compiled a comprehensive set of applied and practical agronomy research studies in this review. Know that the Golden Harvest agronomy team is ready, willing and able to serve you 365 days a year. After all, we are rooted in genetics, agronomy and service and we will do whatever it takes to ensure our products succeed on your operation. We look forward to partnering with you and helping you succeed in 2021.



GOLDEN HARVEST WEST AGRONOMY TEAM


Adam Aarestad
A

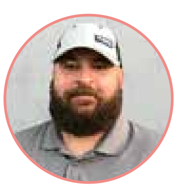

Brian Banks
B


Ron Beyer
C


John Flynn
D

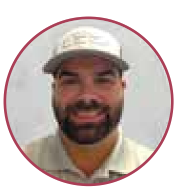

Steve Heinemann
E


Josh Lamecker
F


Spencer McIntosh
G


Mitch Montgomery
H


Blake Mumm
I

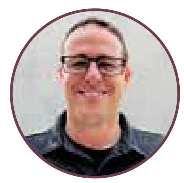

Billy Myatt
J

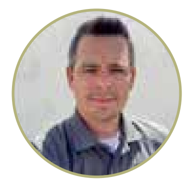

Roger Plooster
K


Tom Schmit
L

GOLDEN HARVEST EAST AGRONOMY TEAM


Lance Coers
M


Ryan Dunsbergen
N


Brad Koch, M.S.
O


Bob Lawless
P


Rich Lee
Q


Wayde Looker, M.S.
R


Adam Mayer
S


Adam Noellsch, M.S.
T


Nate Prater
U


Andrew Rupe, M.S.
V


Charles Scovill, M.S.
W


Greg Wallace
X

GOLDEN HARVEST TECHNICAL AGRONOMY TEAM

Bruce Battles, M.S.
Technical Agronomy Manager

Dori Harris, DPH
Agronomy Information Manager

Ranae Dietzel, Ph.D.
Agronomy Data Scientist

Brad Bernhard, Ph.D.
Eastern Agronomic Research Scientist

Andy Burkhardt, Ph.D.
Western Agronomic Research Scientist

Benjamin Jahnke
Central Agronomic Research Scientist

Nellie Spence
Agronomy Information Intern

GOLDEN HARVEST AGRONOMY LEAD

Andy Heggenstaller, Ph.D.
Seeds Agronomy Head

CONTRIBUTING AUTHORS

Brent Reschly, M.S.
Global Seeds Quality Technology Implementation Lead

Dale Ireland, Ph.D.
Technical Product Lead, Seedcare

Eric T. Winans, M.S. and Frederick E. Below, Ph.D.
Crop Physiology Laboratory, Department of Crop Sciences, University of Illinois at Urbana-Champaign

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EXPERIENCE E-LUMINATE, INSIGHTS ON THE GO

Golden Harvest® Seed Advisors provide the expertise to help you get consistent results from your investment, season by season. The E-Luminate® digital experience, available through your Golden Harvest Seed Advisor, makes that task more precise with corn and soybean planting guides tailored to your local region. While innovative technology can do a lot, our expert team of Seed Advisors make the difference in turning that data into yield potential. Your Seed Advisor compiles, analyzes and uploads data and insights onto E-Luminate for you, using a wealth of experience to delve deeper into and optimize your fields' potential.

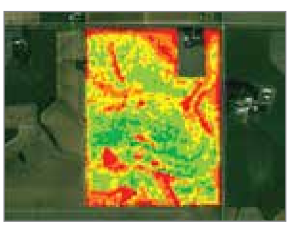
DATA INSIGHTS DRIVE INFORMED DECISION MAKING

Each E-Luminate digital agronomy platform feature is designed with intention, allowing greater visibility to see what you need, when you need to see it in your fields.

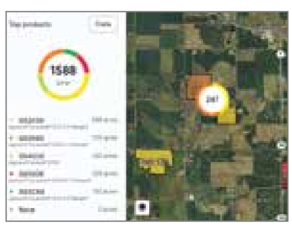
IT'S INCLUDED

We offer farmers access to E-Luminate Mobile at no additional cost with their seed purchase. Download the E-Luminate Mobile App available on the app store, and discover the convenience of having the ability to make data-driven decisions at your fingertips.

Contact your Golden Harvest Seed Advisor and visit GoldenHarvestSeeds.com to learn more about E-Luminate and our Service 365 commitment.



E-Luminate Mobile
- In-field scouting
- Quick grower reporting
- Growing season modeling backed by decision field analytics



Game Plan
- Advanced field placement algorithm
- Field x field proposal
- Field management properties
- Rate assignments
- Customized product information

Decision Hub
- Weather data
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E-luminate®

IMPORTANCE OF CORN STAND UNIFORMITY

INSIGHTS

- Planting skips has the largest negative impact on grain yield compared to doubles or delayed plants.
- Doubles can increase overall potential yield due to the higher plant population, however, the yield increase may not be enough to pay for the additional seed.
- There are four key components to keep in mind that are required for corn emergence: proper soil temperature, good seed-to-soil contact, no excess salt near the seed and an adequately oxygenated soil.
- To promote more uniform emergence, ensure that the soil is dry enough for planting, the planter is in optimal condition, the planting depth is correct and consistent and residue is properly managed.

Figure 1. The middle corn plant experienced delayed emergence by 4 days in a 2020 uniformity trial

Figure 2. (left to right) Ear size of plants that experienced a 4 day, 2 day and no delay in emergence

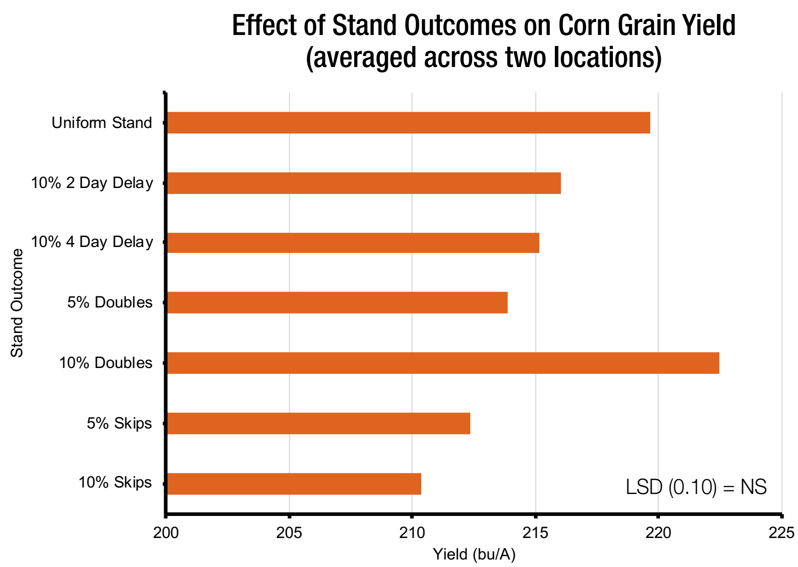
A uniform corn stand is where every plant is evenly spaced, and each corn plant emerges at roughly the same time. Common causes for uneven stands include skips, doubles or delayed emerging plants. Skips are caused by the failure of the planter to drop a seed at the intended place in the row, or by failure of a seed to emerge as a plant. Dropping two seeds in the same place that was intended for one seed is referred to as a double. Plants that emerge from the soil surface later than the rest of the plants are considered delayed plants. Uneven stands can have an effect on grain yield.

STAND ESTABLISHMENT TRIALS

The Golden Harvest® Agronomy In Action research team implemented trials to determine the impact on yield from various stand outcomes: skips, doubles and delays. Plots were planted at a targeted seeding rate of 35,000 plants/A in Seward, Neb. and Clinton, Ill.. Seeds were either removed or planted by hand in order to achieve 5 and 10% skips or doubles. Seeds were also removed and replanted by hand either 2 or 4 days later to simulate delayed emergence (Figure 1). Doubled and delayed plants along with the neighboring plants to the skip, doubled and delayed plants were harvested by hand and yield was calculated. Additional whole plots with the same imposed treatments were mechanically harvested to get a larger representative yield sample of each stand outcome in the field.

ESTABLISHMENT TRIAL RESULTS

Doubles: Planting a double resulted in each ear producing significantly less (-17%) grain per ear than plants spaced uniformly (Table 1). However, when the grain of the two plants in a double are added together, the double yielded 67% greater than a single plant spaced uniformly. Additionally, the neighboring plants to each side of the double produced 8% less grain due to competition from the double.



Graph 1. Yield achieved with different stand outcomes

Skips: When a skip occurred, the data showed no neighboring yield compensation for the missing plant. This differs from previous findings where the neighboring plants were able to compensate. Nafziger (1996) recorded the yield of plants next to a skip to be 15% above the control when planting 18,000 plants/A, but only 9% higher at 30,000 plants/A.[1] At 35,000 plants/A, the gap created by the skip may not be large enough to influence the neighboring plants in our trials.

Delays: An emerging plant that was delayed by 2 days produced 15% less grain than a plant that emerged the same time as the rest of the stand. The reduction in grain produced increased to 21% when the plant emergence was delayed by 4 days (Figure 2). The immediately adjacent plants to each side of the delay plants produced between 3-6% more grain as these plants were able to better compete for resources compared to the delayed plants. However, the

Stand Outcome	Individual Plant Grain Yield (%) and Spacing			Combined Grain Yield
				% of Yield at Uniform Stand
Outcome				100
% of yield	100	100	100	
Double				117*
% of yield	92	83 83	92	
Skip				67*
% of yield	100		100	
2 Day Delay				97
% of yield	103	85	103	
4 Day Delay				97
% of yield	106	79	106	

*significantly different than uniform stand at α=0.10

Table 1. Individual plant yield and subplot yield of different stand outcomes in relation to the yield of plants in a uniform stand

yield compensation from these neighboring plants were not enough to equal the yield achieved with a uniform stand.

Whole plots: Whole plots that were mechanically harvested included either 5 or 10% skips, doubles or delays. A stand with 10% of the plants delayed by 2 or 4 days resulted in a yield decrease of 4-5 bu/A (Graph 1). Having 10% doubles throughout a field tended to yield 3 bu/A greater than a uniform stand. However, in most cases the yield increase would not cover the additional 10% cost of seed for the double. Out of all stand treatments, skips had the largest negative effect on yield. A stand with 5 and 10% skips yielded 8 bu/A and 10 bu/A less than having a uniform stand, respectively. The yield decreases are the result of having a lower plant population.

It is important to note that the individual ear sampling results are only a yield estimate of the subplots or stand outcome. It is unlikely 100% of a field would have skips, doubles or delays. Realistically, many fields can suffer 5 to 10% stand uniformity issues. Therefore, the yield impact from the different stand outcomes are reduced in the whole plots with only 5 or 10% skips, doubles or delays compared to the individual ear samples from the subplots. This study, along with previous studies, have documented the importance of a strong uniform stand (Nafziger et al., 1991).[2]

FACTORS INFLUENCING UNIFORM STANDS

1. **Soil temperature:** Should be near 50°F to ensure good germination.
2. **Seed-to-soil contact:** Poor soil contact can cause emergence delays, which lead to inconsistent ear size on the later emerging plants.
3. **In-furrow fertilizer injury:** Excess salt near the seed can cause burning and weakened seedlings which are more susceptible to pathogens. Limit pop-up fertilizer to 5 gallons per acre or less. Adjusting placement to at least 2 inches to the side and 2 inches below the seed can allow fertilizer rates to be increased.
4. **Anaerobic soil conditions:** Germination and growth in corn requires an adequate supply of oxygen for proper development.

MANAGING FOR UNIFORM EMERGENCE

Maximizing the potential of a corn field requires establishing a uniform stand. In order to do so, it is critical to evaluate each field and management practices for them individually.

1. Is the soil dry enough? Tillage of wet soil results in cloddy seedbeds which can reduce seed-to-soil contact at the time of planting, resulting in inconsistent seed germination. Planting into wetter soils can cause sidewall compaction and emergence issues.
2. Is the planter ready? Worn planter parts can cause problems in achieving uniform corn stands.
3. Planting depth: Maintain a planting depth of 2 inches. While shallow-planted corn (planted less than 1.5 inches) may occasionally emerge faster, the long-term benefits of proper planting depth will outweigh the quick emergence associated with shallow planting.
4. Manage residue: Residue from a previous crop is one of the leading causes of poor uniformity. Residue in the seed furrow can drastically reduce seed-to-soil contact and consistency of germination.

MANAGING HIGHER CORN SEEDING RATES WITH NARROWER ROW SPACINGS

INSIGHTS

- Like seeding rate, row spacing responses are dependent on the environment.
- Positive yield responses to narrower row spacings are most consistent when seeding rates are above typical 30-inch row seeding rates for a given environment.
- Hybrids respond differently to changes in row spacing so selecting a hybrid that performs well in narrower rows is key.

Corn grain yield is the product of the number of plants per acre, kernels per plant and weight per kernel. Because kernels per plant and weight per kernel are primarily affected by environmental conditions after initial agronomic management factors are implemented in modern commercial field corn, the yield component factor most under manual control is seeding rate.

Currently, the average corn seeding rate in the U.S. is just under 32,000 seeds/A and has increased by an average of 400 seeds/A/year since the 1960s. As this trend continues, the average U.S. corn seeding rate will reach 38,000 seeds/A in 15 years and 44,000 seeds/A in 30 years. These higher seeding rates reduce the plant-to-plant spacing within the row and the intensifying crowding stress may become yield-limiting. Narrower row spacings can be used to increase plant-to-plant spacing within a row to reduce crowding and subsequently reduce competition among individual plants, allowing the crop to better utilize available light, water and nutrients.

Currently, the vast majority of corn is planted in 30-inch row spacings, with narrow rows generally defined as any row spacing or configuration less than 30-inches. Planting corn in a 15-inch row creates twice as much distance between plants within a row compared to 30-inch row spacings at a given seeding rate. For example, at a seeding rate of 38,000 seeds/A, there is 11 inches between plants when planting in 15-inch row spacings compared to only 5.5 inches between plants in 30-inch row spacings.

PREVIOUS FINDINGS

In 2019, The Golden Harvest® Agronomy In Action research team evaluated more than 46 hybrids in 30-inch and 20-inch row spacings

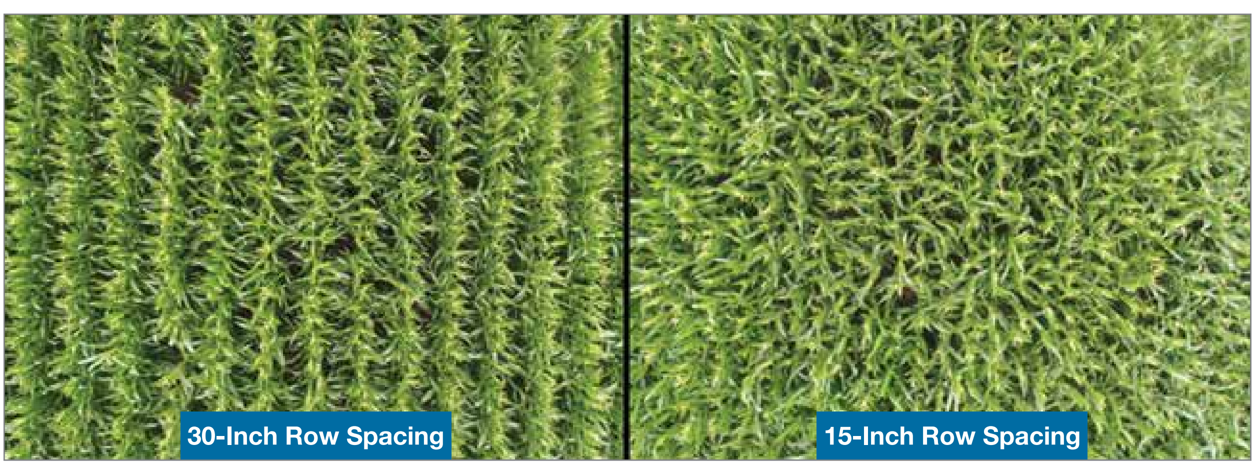


Figure 1. Aerial photo of corn planted in 30-inch and 15-inch row spacings within 2020 rows spacing trials

at various seeding rates across 5 locations. Three of the five locations had a positive yield response to 20-inch rows, one location had no response, and one location had a negative response. On average, across all locations, seeding rates and hybrids there was a 2 bu/A yield advantage to planting 20-inch rows compared to 30-inch rows.

In general, 20-inch rows tended to perform better at seeding rates greater than 35,000 seeds/A and less than 50,000 seeds/A. When populations were below 35,000 seeds/A, the 30-inch row spacing tended to yield greater. At 50,000 seeds/A or greater there was little yield difference between the row spacings.

Hybrid responses to 20-inch row spacings were variable across locations. Some hybrids tended to have a positive yield response to 20-inch rows while other hybrids had a negative yield response.

2020 NARROW ROW CORN TRIALS

In 2020, four seeding rates ranging from 35,000 to 50,000 seeds/A were evaluated in 30-inch and 15-inch rows across seven hybrids (Figure 1). These trials were established at Clay Center, Kansas, Clinton, Illinois, Fairfield, Iowa, Seward, Nebraska, and Slater, Iowa (Figure 2). Due to the late season derecho wind events, the Slater location was removed from any data analysis.

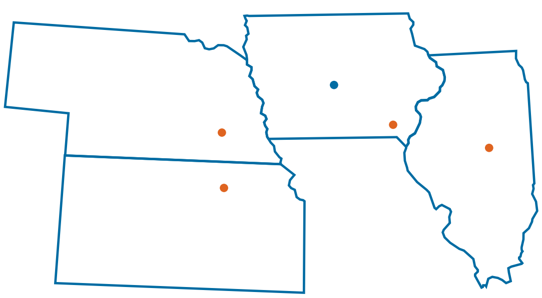
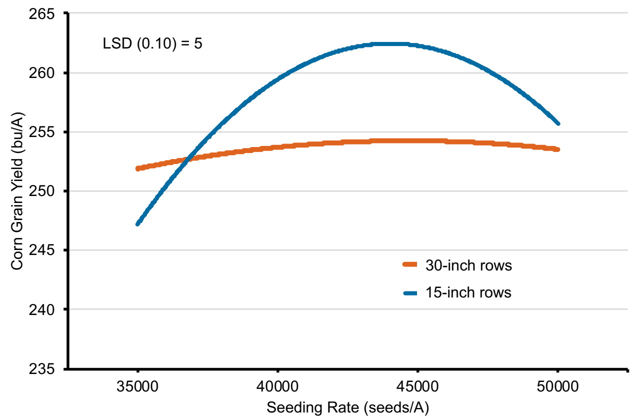


Figure 2. Row spacing evaluation trial locations in 2020, locations lost to the derecho are in blue



Graph 1. Effect of row spacing and seeding rate on grain yield averaged across seven hybrids and four locations in 2020

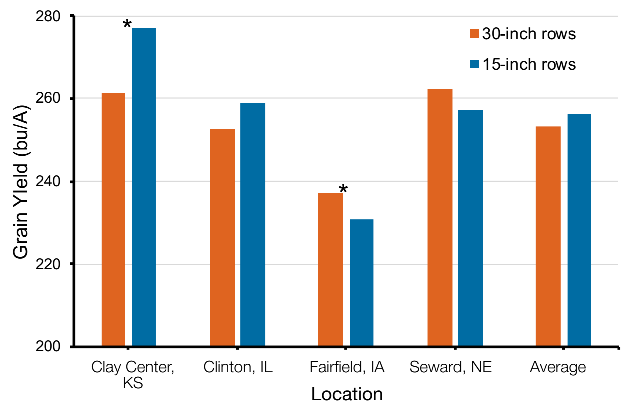
EFFECT OF SEEDING RATE AND ROW SPACING ON GRAIN YIELD

When averaged across all locations and hybrids, there was a significant interaction between row spacing and seeding rate. At the lowest seeding rate of 35,000 seeds/A, planting 30-inch rows yielded 5 bu/A greater than planting 15-inch rows (Graph 1). Lower seeding rates in narrower rows increased in-row plant spacing, likely resulting in a loss of narrow row efficiency for capturing solar radiation. However, 15-inch rows produced an 8 bu/A yield advantage at 40,000 seeds/A and a 5 bu/A yield advantage at 44,000 seeds/A compared to 30-inch row spacings (Graph 1). Interestingly, the yield potential of plants grown in a 15-inch row decreased dramatically at 50,000 seeds/A, whereas plants in a 30-inch row were not as negatively impacted, resulting in similar yields between row spacings at this seeding rate. Likely, plants experienced enough in-row competition that changes in the between-row environment were not meaningful.

A recent study found similar results where the greatest yield advantage of narrower row was in the seeding rate range between 44,000 and 50,000 seeds/A.[1] They observed that as seed rate increased, plants focused their energy and resources to producing above-ground biomass at the expense of below-ground biomass. For every additional 6,000 plants/A, the size of the root system decreased 15-18%. However, when switching from a 30-inch row to a 20-inch row, the better plant-to-plant spacing resulted in a 22% increase in root mass. They concluded that narrower row spacings helped mitigate crowding stress at greater seeding rates by promoting phenotypic changes that consequently led to greater yields.

There were differences in response to row spacing for each location. Yield response to 15-inch rows ranged from -5 bu/A to 16 bu/A at 4 locations (Graph 2). Two out of the four locations had a positive yield response to the narrower row spacing while the other two locations showed a negative yield response.

The significant interaction between location and row spacing is not surprising, given the typical interaction between location and seeding rate. Both row spacing and seeding rate change the spatial arrangement of plants in a field, which has a major impact on the ability of plants to capture sunlight and acquire nutrients and water. In addition, it effects the movement of air through the canopy which can influence disease development and canopy temperature.



*significant difference between row spacings at α=0.10

Graph 2. Effect of row spacing on grain yield at four locations averaged across four seeding rates and seven hybrids in 2020

The degree of impact on grain yield from these plant spatial arrangement effects depends on the environment.

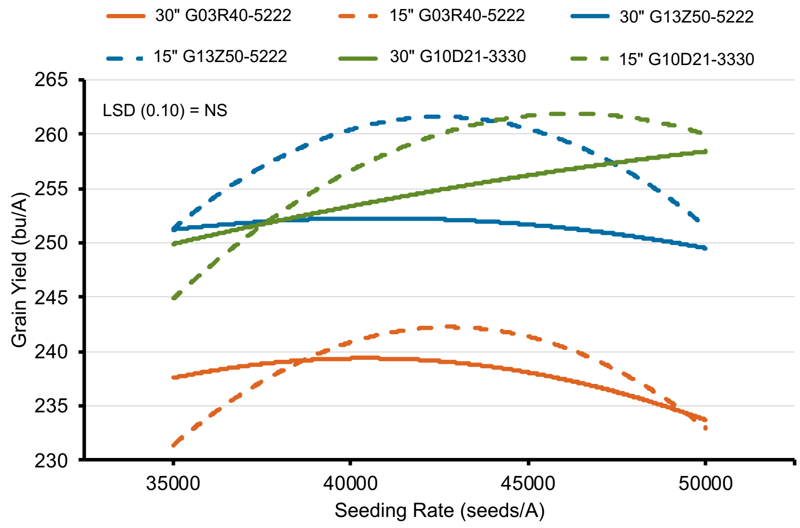
HYBRID RESPONSE TO NARROWER ROWS AND SEEDING RATE

Hybrids responded differently to row spacing and seeding rate. In a 30-inch row, hybrid G03R40-5222 had no yield response to seeding rate until rates exceeded 45,000 seeds/A when yield began to decrease. Alternatively, G03R40-5222 responded positively to increased seeding rates in a 15-inch row maximizing grain yield at rates between 40,000 – 45,000 seeds/A. There was little to no yield difference between planting G03R40-5222 in 15-inch rows compared

Figure 3. Ear size of hybrid G13Z50-5222 in response to seeding rate and row spacing

Figure 4. Ear size of hybrid G10D21-3330 in response to seeding rate and row spacing

to 30-inch rows across the different seeding rates. Hybrid G13Z50-5222 showed a similar response to seeding rate. However, the yield response to narrower rows was much greater (Figure 3 and Graph 3). When planted in a 15-inch row compared to a 30-inch row, G13Z50-5222 yielded 8 and 9 bu/A more at seeding rates of 40,000 and 45,000 seeds/A, respectively. Hybrid G10D21-3330 was much more responsive to higher seeding rates than the other hybrids in both a 30-inch and 15-inch row spacing (Figure 4 and Graph 3). G10D21-3330 was also responsive to narrower rows at seeding rates of 40,000 and 45,000 seeds/A yielding 5 bu/A greater on average.



Graph 3. Yield response of hybrids G03R40-5222, G13Z50-5222 and G10D21-3330 to seeding rate and row spacing

The difference in response between these hybrids demonstrates the importance of selecting the right hybrids to match the management system.

Researchers also found that hybrids respond differently to seeding rate and narrower row spacings, attributing the differences to the inherently distinct phenotypic traits of the hybrids.[2]

CONSIDERATIONS WHEN PLANTING IN NARROWER ROWS

When planting in narrower rows, it is important to select a hybrid that is responsive to higher seeding rates and narrower rows. A hybrid with excellent agronomic characteristics, such as good stalk strength, standability and a solid root system is beneficial in these more intensive cropping systems.

There tends to be a more consistent response to narrower rows at increased seeding rates for the given environment. For example, in these environments the average seeding rate is around 35,000 seeds/A in a 30-inch row. Switching to 15-inch rows while keeping the same seeding rate resulted in a yield decrease. However, by increasing the seeding rate to 40,000 seeds/A in a 15-inch row there was a yield increase of 8 bu/A compared to the standard practice of planting 35,000 seeds/A in a 30-inch row. Increased seeding rates when planting in narrower rows can be adjusted accordingly based on the typical seeding rates in 30-inch rows for the given environment and hybrid.

At greater seeding rates, crop management becomes even more important. Adequate fertility is critical to setting a higher potential and foliar protection is needed to maintain that yield potential throughout the growing season in these more intensive cropping systems.

ENHANCING CORN NUTRIENT UPTAKE WITH BIOLOGICALS

INSIGHTS

- Beneficial microorganisms can create symbiotic relationships with plant roots, promote nutrient mineralization, produce plant growth hormones, and provide biocontrol of plant pests.
- Many beneficial microorganisms are naturally present in soils but could be advantageous when re-introduced.
- If considering biologicals on your farm, leave check strips in each field to understand their value prior to broad adoption.

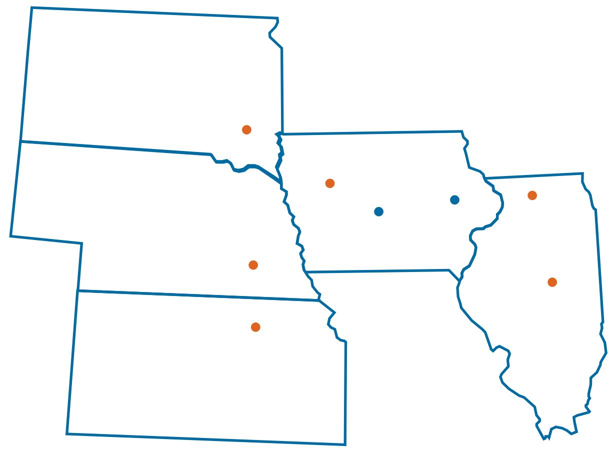


Figure 1. Trial locations in 2020, locations lost to derecho in blue

INTRODUCTION

Soil microorganisms are by far the principal form of life found in the soil, but due to their microscopic size they are often overlooked. In fact, there are more microbes in a teaspoon of soil than there are people on earth.[1] Soil microorganisms are made up of a combination of many types of bacteria and fungi that are commonly recognized for their role in breaking down organic matter. Beneficial soil microorganisms have also been documented for creating symbiotic relationships with plant roots, promoting nutrient mineralization and availability, producing plant growth hormones, and serving as biocontrol agents of plant pests, parasites or disease. In general, beneficial microorganisms are naturally present in soils, although in some cases there may be benefits to reintroducing them. Although the specific way soil microorganisms behave in the soil and interact with plants is often well understood, predicting when and where a grower may see an economic response can be more challenging. There will need to be continued work to better understand and place the correct biological in the specific fields or areas of fields where enhanced value may be seen.

BIOLOGICALS FOR NUTRIENT MANAGEMENT

Numerous products containing beneficial microbes are currently available for use as seed treatments or in-furrow applications. Each is unique to the specific type of bacteria or fungi utilized, as well as the approach used to enhance plants. The listed benefits by various biological crop product providers often promote improved nutrient availability in soil and increased root volume, resulting in increased water and nutrient uptake by plant roots, although they promote different microorganisms. The following biologicals and fertilizers were evaluated in the 2020 growing season to better understand plant response and consistency.

Location	Hybrid	Water Management	Rainfall (Apr-Aug)	PH	OM %	CEC	P1 ppm	K ppm
Bridgewater, SD	G03R40-5222	rainfed	14.3	6.4	3	26.2	19 M	231 H
Seward, NE	G13Z50-5222	irrigation	13.6	5.9	2.7	20	26 H	302 VH
Clay Center, KS	G13Z50-5222	irrigation	15.4	6.3	0.4	11.3	14 L	260 VH
Sac City, IA	G03R40-5222	rainfed	14.5	5.2	3.6	23	67 VH	360 VH
Clinton, IL	G13Z50-5222	rainfed	18.1	5.7	2.8	20.6	18 M	151 M
Oregon, IL	G03R40-5222	rainfed	17.7	6.3	2	13.1	26 H	233 VH

Table 1. Hybrid, management and soil nutrient levels of 2020 trial locations

1. **BioRise™ seed treatment:** Combination of *Penicillium bilaiae*, which releases bound soil phosphate, and lipochitooligosaccharide to enhance mycorrhizal fungi root colonization and promote nutrient availability and nutrient/water uptake.
2. **Biodyne Environoc 401 (in-furrow):** Bacteria and unicellular fungi with phosphate-solubilizing microbes and nitrogen-fixing microbes.
3. **Terrasym 450 seed treatment:** Beneficial microbes called methylobacterium (M-trophs) that form a symbiotic partnership with plants to improve plant development and nutrient uptake.
4. **Feed grade dextrose (in-furrow):** Reported to feed microorganisms in the soil to enhance nutrient mineralization (4 lbs/A).
5. **10-34-0 (in-furrow):** Traditional check used to provide early season phosphorous uptake (5 gal/A).

2020 BIOLOGICAL EVALUATIONS

Trials were established at eight locations in 2020 to better understand the potential value of biologicals for improving yield. Two of eight locations were lost to the late season derecho wind events. Results focus on the six remaining sites (Figure 1). Soil fertility for each location was managed according to normal practices of the local grower. Soil sampling was done prior to planting to understand nutrient availability that may influence trial results (Table 1). In general, phosphorous and potassium levels were at high to very high levels at most locations. The two unique locations were Clay Center, Kansas, having lower organic matter, CEC (cation exchange capacity) and phosphorous levels, along with lower phosphorous levels (<20ppm) at the Clinton, Illinois, site. Depending upon the specific treatment, biologicals were either applied on the seed as a seed treatment or via an in-furrow application. One treatment not receiving any biologicals was planted, in addition to the four biological treatments, and used as a comparison. A traditional in-furrow application of 10-34-0 at 5 gallons per acre served as the sixth treatment to better understand if phosphorous was a limiting factor at each location. All treatments were planted on the same day and replicated 4 times per location.

SUMMARY AND DISCUSSION

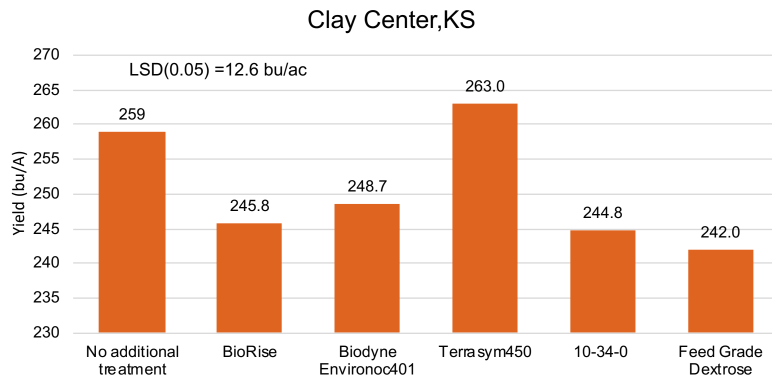
Yield environments were significantly different across the six trials conducted in the 2020 season, ranging from 178 bu/A at Sac City, Iowa, to 276 bu/A at the Seward, Nebraska, site. Of the six trials, significant yield differences among treatment were only observed at the Clay Center and Clinton sites. These were also the two locations most limited in soil phosphorous levels. At Clay Center, the Terrasym 450 seed treatment had only a small numerical yield advantage over the comparison plot without biologicals but yielded statistically more than all other treatments

(Graph 1). There was no response to 10-34-0 observed at this location. However, in the Clinton trial, the 10-34-0 treatment yielded 13.8 bushels per acre more than the check (Graph 2). BioRise did have a small numerical advantage of 4 bu/A over doing nothing.

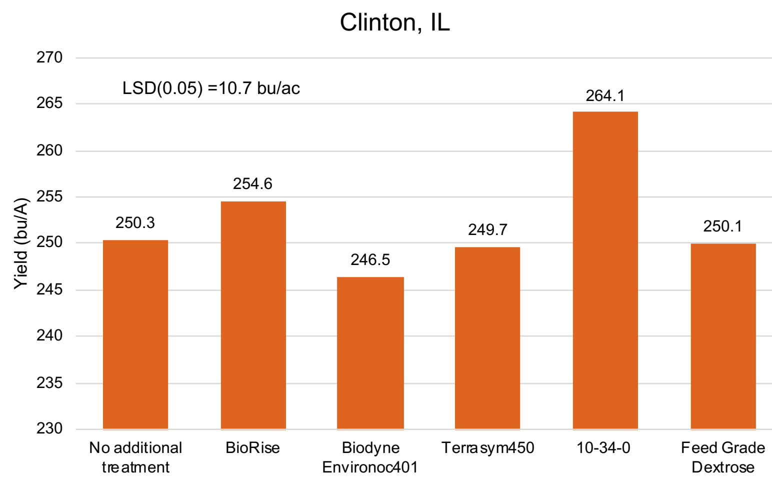
There were no consistent yield advantages observed at any of the other four locations (Graph 3). Although not statistically significant, the Biorise treatment did average 2 bu/A more than other treatments.

CONCLUSIONS

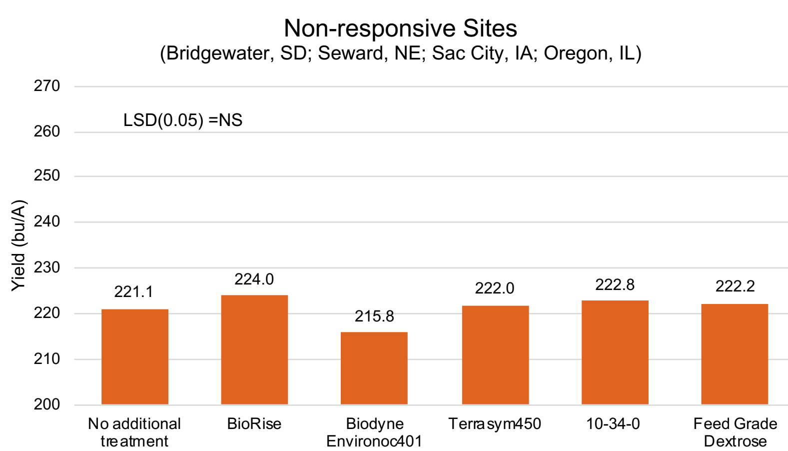
There was no consistent response observed across locations for any of the biologicals being evaluated. Small advantages from single locations were observed for the Terrasym 450 and BioRise seed treatment, but the only significant response was from the 10-34-0 starter fertilizer treatment at only one location. Potentially, absence of response was due to a lack of yield limiting factors, such as nutrient deficiency or unfavorable weather conditions. Testing in other environments may have resulted in a different outcome. However, test environments were indicative of a high percentage of Midwest corn growing acres. If considering using biologicals, it is suggested to leave check strips to help understand the value prior to broad adoption.



Graph 1. Clay Center, Kansas, 2020 yield results



Graph 2. Clinton, Illinois, 2020 yield results



Graph 3. Average of all locations not showing a significant treatment affect

POTENTIAL OF BIOLOGICALS FOR NITROGEN MANAGEMENT

INSIGHTS

- Microbial products that utilize bacteria to form mutualistic relationships with plants resulting in biological nitrogen fixation are now available.
- Field trials show promise for biologicals to increase yield potential, although yield response may not always be observed.
- Yield responses from microbials will be more likely if nitrogen application rates are less than plant requirements or environmental nitrogen loss occurs (leaching, denitrification, runoff etc.).

INTRODUCTION

Nitrogen management is one of the most complex issues farmers deal with on a year-to-year basis. The economical optimum nitrogen rate depends on yield potential, soil type, previous crop, form of nitrogen, timing of application and weather, among other things. Rainfall, for example, can influence both the application timing and extent of soil nitrogen loss after application. Traditionally, monitoring in-season soil nitrogen availability and adding supplemental nitrogen as needed have been key elements for managing through the complexity of the soil nitrogen cycle. Newly introduced biological in-furrow and seed treatment innovations are providing new options for managing risk of nitrogen loss as well as a potential method to reduce overall nitrogen rates.

BIOLOGICALS FOR NUTRIENT MANAGEMENT

Two companies recently introduced separate biological products that utilize bacteria to form a mutualistic relationship with the plant, resulting in biological nitrogen fixation. Azotic North America has introduced Envita™, a naturally occurring, food-grade bacteria *(Gluconacetobacter diazotrophicus)*. Pivot Bio also introduced a microbial product called Pivot Bio PROVEN®. Although both products refer to using biological nitrogen fixation to deliver nitrogen to the plant throughout the growing season, they utilize entirely different bacteria to do so. Pivot Bio PROVEN is a microbial product that is applied in-furrow at planting. Microbes attach to the outside of developing roots and colonize throughout the growing season on newly developing roots. The bacteria then take in nitrogen from the air and produce plant-available ammonia within the roots that is then relocated throughout the plant. Azotic explains that Envita works slightly differently. Their bacteria can be found colonizing both in the roots as well as above ground within individual chloroplast, helping to produce additional chlorophyll in plant leaves. Azotic claims growers can reduce total synthetic nitrogen applied in season due to Envita's ability to replace 27% of the total

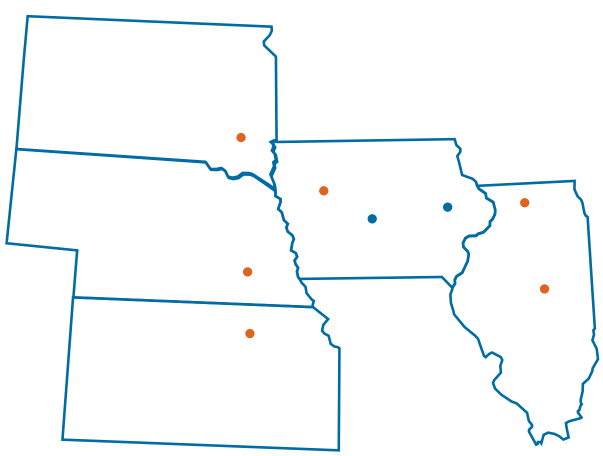


Figure 1. Trial locations in 2020, locations lost to the derecho in blue

Location	Hybrid	Water Management	PH	OM %	CEC	Rainfall (Apr-Aug)	July 1st Adapt-N Rx + = excess - = deficient	Nitrogen (spring applied) (lbs/A)
Bridgewater, SD	G03R40-5222	rainfed	6.4	3	26.2	14.3	+ 90 lbs/ac	150
Seward, NE	G13Z50-5222	irrigation	5.9	2.7	20	13.6	- 20 lbs/ac	150
Clay Center, KS	G13Z50-5222	irrigation	6.3	0.4	11.3	15.4	+ 35 lbs/ac	175
Sac City, IA	G03R40-5222	rainfed	5.2	3.6	23	14.5	+ 65 lbs/ac	220
Clinton, IL	G13Z50-5222	rainfed	5.7	2.8	20.6	18.1	- 45 lbs/ac	180
Oregon, IL	G03R40-5222	rainfed	6.3	2	13.1	17.7	+ 60 lbs/ac	231

Table 1. Trial location and management information

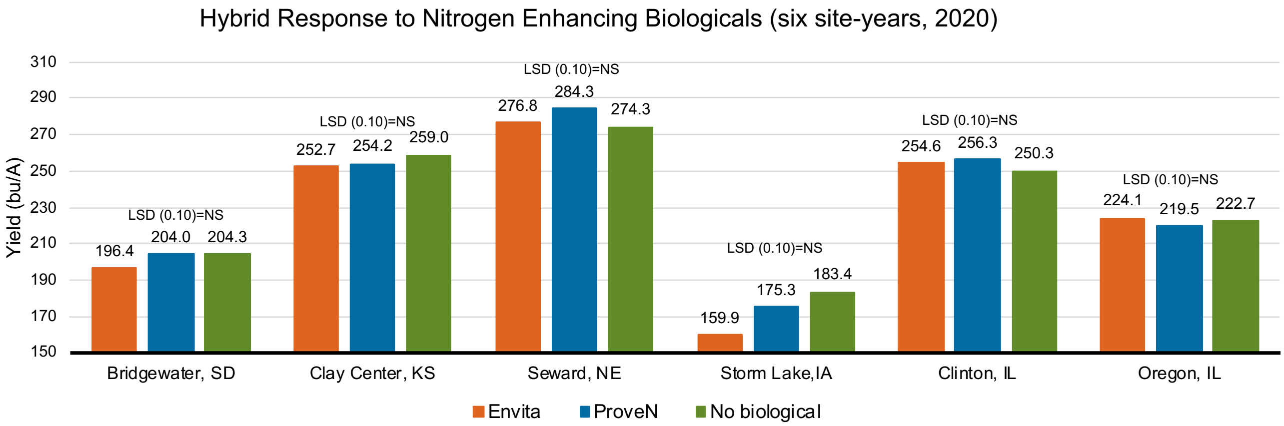
nitrogen needed by a corn plant on average. They also claim 5-13% corn yield increases can be observed when using Envita in addition to a normal recommended nitrogen fertility program. Pivot Bio states that Pivot Bio PROVEN delivers the equivalent of 25 pounds of synthetic nitrogen per acre. Some of their customers are reducing commercial fertilizer rates when using Pivot Bio PROVEN, although the company suggests maintaining normal nitrogen rates and adding Pivot Bio PROVEN to improve nutrient efficiency. The potential value of application simplicity, reduced risk of yield loss from nitrogen availability and improved environmental sustainability have created interest in the performance of both products.

2020 NITROGEN BIOLOGICAL EVALUATIONS

Golden Harvest® Agronomy In Action research trials were established at eight locations in 2020 to better understand potential value of the biologicals' ability to provide nitrogen. Two of eight locations were lost to the late season derecho wind events, so results focus on the six remaining sites (Figure 1). A uniform rate of nitrogen was determined for each location based on local grower application rates. Nitrogen was applied uniformly across each location prior to planting (Table 1). Pivot Bio PROVEN and Envita were separately applied as in-furrow treatments at the time of planting using a specialized research application system (Figures 2 and 3) to avoid plot-to-plot contamination. Comparison plots not receiving any biological additives or additional nitrogen were also planted simultaneously and replicated 4 times per location. Biological products remained sealed in their original container up until 48 hours of planting to ensure microbial activity was not impacted.

Figure 2. Side view of in-furrow delivery tube and placement just below seed tube

Figure 3. Individual product tanks of specialized in-furrow product delivery on research planter



Graph 1. Individual location yield response to nitrogen fixing microbial products applied in-furrow

SUMMARY AND DISCUSSION

Yield environments were significantly different across the six trials conducted in the 2020 crop season, ranging from 173 bu/A at Sac City, Iowa, to 278 bu/A at the Seward, Neb. site. Yields corresponded to differences in plant-available water (rainfall and irrigation) across sites. Overall, lower-than-normal rainfall across locations helped to minimize any potential loss of nitrogen at the majority of locations. The Sac City, Iowa, location, for example, received roughly 68% of the normal April-August 10-year precipitation average. Nitrogen recommendations estimated by Adapt-N on July 1 for each location showed that in general, most locations had sufficient nitrogen to meet crop demand. Only two locations, Seward, Neb., and Clinton, Ill., resulted in recommendations to apply additional nitrogen to meet current yield goals. Statistically no yield response was observed for either microbial product at any location, although Seward and Clinton did have a numerical increase (Graph 1). These are the same two locations that Adapt-N called for incremental nitrogen applications. There were 9.9 and 2.5 bu/A responses from Pivot Bio PROVEN and Envita respectively at Seward. There were 5.9 and 4.3 bu/A responses from Pivot Bio PROVEN and Envita respectively at the Clinton location. There was also a 1.5 bu/A response to Envita at the Oregon, Ill. location. Although not statistical, equivalent or reduced yields at the remainder of the locations resulted in a net loss for covering the cost of products applied. Retail price of Pivot Bio PROVEN ($20/A) and Envita ($9.95/A) and a corn price of $3.80/bu were used to look at the return on investment for locations with positive yield responses. Pivot Bio PROVEN netted a $2.57/A (Clinton) and $17.73/A (Seward) return. Yield response of Envita was only great enough at Clinton to provide a return on investment ($6.31/A).

CONCLUSION

The concept of utilizing microbial products to help plants reduce their need for synthetic nitrogen is very promising. It adds an additional tool to help manage nitrogen. However it also potentially adds an additional layer of complexity when trying to determine the right rate, placement and timing. There is an inherit risk of yield loss when using microbials to lower synthetic nitrogen application rates if the amount of nitrogen that the microbials provide is not known or consistently observed. There is an additional risk of financial loss if yield increase is not significant enough to offset the cost of applying microbials. We know from many trials that the yield response to nitrogen does eventually plateau when adequate nitrogen is available. Due to this, there is a point at which there should be no anticipated yield response from microbials until nitrogen rates are reduced or environmental nitrogen loss (leaching, denitrification, runoff, etc.) occurs.

SEEDING RATE MANAGEMENT TO OPTIMIZE CORN YIELDS

INSIGHTS

- Determining the proper seeding rate based on field potential and hybrid is an important first step to maximizing corn yield potential.
- Hybrid seeding rate response data can help fine tune seeding rate recommendations.

Yield potential of corn hybrids continue to increase yearly with introduction of new genetics. It is easy to credit these gains entirely to breeding efforts, however the change of management practices such as seeding rates have also played a critical role in yield gains. Average seeding rates have increased by over 24% in the last 30 years, although this would not have been possible without advances in stress tolerance through breeding. Due to this continued trend and the inherent differences in how hybrids respond to seeding rate, the Golden Harvest® Agronomy In Action research team has conducted trials since 1992 to provide hybrid specific guidance on seeding rates (Figure 1). Determining the best seeding rate for a field or zones within a field is not a simple process and requires understanding of multiple factors that drive final outcome.

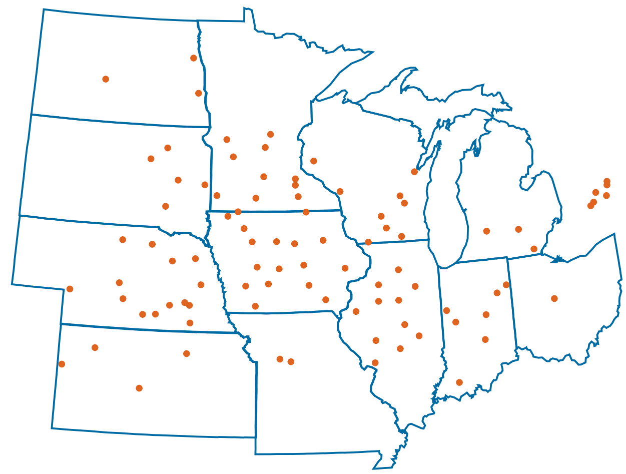


Figure 1. 2020 replicated corn seeding rate trial sites

POPULATION RESPONSE FACTORS

1. Yield environment

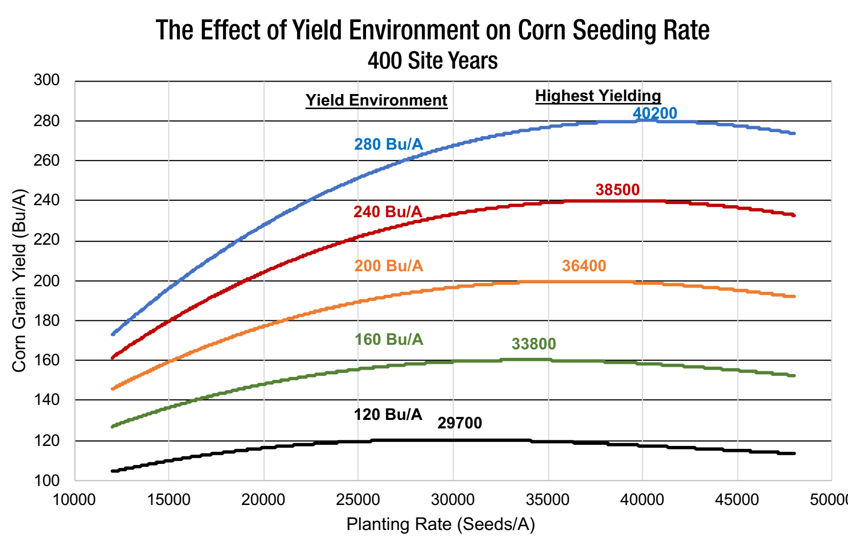
Optimum seeding rate increases as overall field yield potential increases. Penalty associated with incorrect seeding rate selection increases with yield environments (Graph 1).

2. Hybrid response

Yield response to increasing or decreasing seeding rates differs considerably among hybrids (Figure 2). Golden Harvest evaluates every hybrid's seeding response starting one year prior to commercialization to help fine-tune field recommendations by yield environments.

3. Economic factors

The optimum seeding rate for maximizing return will be slightly lower than the highest yielding seeding rate. The optimum economic seeding rate will also go up or down with commodity prices. Increases in seed cost will reduce the economic optimum, although cost



Graph 1. Yield environment influence on seeding rate

influences seeding rate much less than other factors. Table 1 compares several seeding rates and commodity prices in various yield environments.

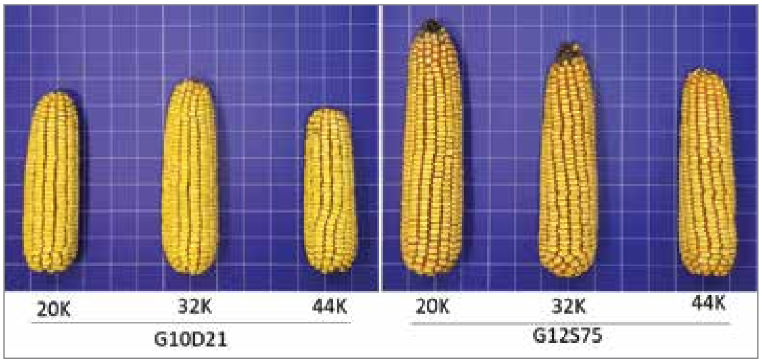


Figure 2. Hybrid differences in response to changing seeding rates

DETERMINING OPTIMUM SEEDING RATES

1. Use Table 1 to estimate the optimum seeding rate for anticipated yield potential and grain pricing. When estimating yield environment, consider the proven historical yield of the field across multiple years. *Example: A 200 bu/A yield environment and $4.00/bu grain price = 32,300 seeds/A optimum seeding rate.*
2. Work with a local Golden Harvest® Seed Advisor to adjust seeding rate up or down from optimum found in Table 1 for specific hybrids based on Golden Harvest multi-site and multi-year seeding rate trial results.
3. Consider individual hybrid root and stalk strength scores to determine if the hybrid will have suitable agronomic characteristics to support increased seeding rates.

CREATING VARIABLE RATE PRESCRIPTIONS

Most planters now offer a way to vary seeding rates to specific zones within a field. Many sources of data are available to help interpret zone productivity such as: fertility, drainage, topography, NDVI imagery, soil type and yield maps. Multiple years of individual field yield data will best predict high and low yield zones. Using more than one year of data helps to better account for outlier years caused by drought or flood prone areas. When yield data isn't available, soil productivity data can be useful in predicting areas of the field with different potential. Small increases and decreases in seeding rates with higher and lower yield zones will typically help maximize returns on investment potential, but always take individual hybrid characteristics into consideration.

TIPS FOR DEVELOPING A FIELD PRESCRIPTION

- ✔ More years of data for creating productivity zones is better.
- ✔ Highly variable fields will show greater responses to variable seeding rates.
- ✔ Creating validation areas with 3 or more seeding rates within the field can confirm prescription accuracy.

Talk to your Golden Harvest Seed Advisor about utilizing E-Luminate® (a digital tool running a proprietary product placement algorithm) to assist you in developing customized prescriptions for your fields.

YIELD ENVIRONMENT (BU/A)	HIGHEST YIELDING SEEDING RATE (SEEDS/A)	OPTIMAL SEEDING RATE (SEEDS/A) BY COMMODITY PRICE ($/BU) (SEED COST = $200/80K UNIT)		
		$3.00	**$3.50**	**$4.00**
280	**40200**	36600	37100	37500
240	**38500**	34100	34700	35100
200	**36400**	31000	31700	32300
160	**33800**	26900	27700	28400
120	**29700**	20900	21900	22700

Table 1. Influence of commodity price and yield environment on selecting seeding rates

SOIL COMPACTION AND ITS EFFECT ON CORN GROWTH

INSIGHTS

- Soil compaction reduces the size and amount of pore space, decreasing vertical water movement, soil aeration and oxygen movement.
- Compaction layers in the soil can alter plant rooting depth, causing issues later in the season.
- There are several types of soil compaction, including tillage pan/plow layer, planter side-wall compaction and deep compaction.
- The use of proactive measures to mitigate soil compaction are typically the most effective in reducing it long-term.

Figure 1. Compaction layer from tillage on wet soils

The temptation to begin field work or planting before soil conditions are ideal happens almost every year, but is even worse when cool, wet springs cause delays. Running across fields with planters or tillage implements when the soil is too wet can cause soil compaction issues that will impact growth and development of corn throughout the year.

EFFECT OF COMPACTION ON SOIL

Compaction increases bulk density of the soil, creating an impenetrable layer of soil that will break apart in flat pieces when digging as shown in Figure 1. Compaction reduces the size and amount of pore space in the soil, decreasing vertical water movement throughout the soil profile and increasing water runoff.[1] Less soil pore space also reduces soil aeration and oxygen movement, which is important for root respiration and nutrient uptake.

Soil compaction depletes the soil of oxygen, throwing off the balance of "healthy soil." Soil should be about 25% air.[2] Lower ratios of oxygen within soil reduce soil mineralization rates, resulting in reduced nitrogen, phosphorus and potassium availability to the crop through normal microbial processes.

Soil compaction can also alter and reduce rooting depth, which can cause trouble later in the growing season when water becomes scarce and plants are not able to mine the full soil profile for water and mobile soil nutrients.[3]

THREE COMMON TYPES OF COMPACTION

Tillage pan or plow layer – Tillage is mainly used to manage residue from prior crops and prepare an even surface for planting. As similar tillage practices are used across years, soil profiles will begin to form a hard, compacted layer across fields at the depth the tillage equipment was run. Disks or field cultivators will form a layer closer to soil surface due to their operating depth, where moldboard plowing creates similar layers at deeper depths. Tillage in wet soil conditions only worsens the effects of tillage pan or plow layers. The resulting layer will restrict water movement and root growth to needed depths for accessing nutrient and moisture.

Planter sidewall compaction – When the openers on a planter "smear" the sides of the seed trench, they create a layer of soil that restricts outward root growth. This "smearing" of the sidewalls of the seed furrow will restrict the root growth through the seed furrow, leading to the development of "mohawk" roots on the corn plant.

Figure 2. Sidewall compaction from wet planting conditions

Deep compaction – As the name implies, deep compaction forms at a deeper depth in the soil profile and is therefore much harder to eliminate with tillage. Deep compaction typically forms in areas with high traffic with implements loaded to maximum axle weights. The most common cause is grain cart or truck traffic lanes within fields or on end rows. This type of compaction is often the most visible, as the restricted rooting depth can dramatically reduce crop growth as shown in Figure 3.

EFFECT OF COMPACTION ON CORN PLANTS

Roots will grow and develop the best in a porous soil, free of compaction. A healthy root system that spreads out and penetrates into the soil profile will have large amounts of surface area. This large root surface area allows for efficient uptake of nutrients and water and helps anchor the plant into the soil, decreasing the risk of lodging throughout the growing season.

Compaction restricts root growth and affects nutrient and water uptake throughout the growing season, even if the proper rates of nutrients have been applied to the field and soil moisture is adequate. Roots cannot take up enough nutrients. This leads to plants cannibalizing stalks, d increasing the risk of late season lodging because the roots cannot fully develop enough to anchor the plant.

DETERMINING WHEN SOIL IS READY FOR FIELD WORK

Just because the soil surface is dry, doesn't mean that the field is ready for tillage. Purdue University recommends digging 1 inch below the depth of tillage, taking a handful of soil and rolling it into a "worm" shape. If the soil can be rolled into a "worm" that is longer than 5 inches and does not break apart, the soil is too wet for tillage.[4]

Growers may be tempted to use vertical tillage tools to work the top 2-3 inches of soil to "dry out" the soil to plant sooner. This is not recommended as it will create a tillage pan just below where the seeds will be placed and can

Figure 3. Deep compaction from grain cart traffic the prior fall

restrict water movement through the soil profile. That water will accumulate at the same depth as the seeds and can cause injury or death to the germinating and emerging seedlings.

MANAGING COMPACTED SOILS

Preventing soil compaction from happening is the best way to manage soils.[5] However, minimizing or controlling soil compaction are the next best options since farmers need to be in the field in less than ideal soil conditions. Consider controlled traffic in fields, managing axle loads and tire pressure, and selecting the right equipment for the job.[3] Before deciding on a compaction management tool, it is important to diagnose the existence and depth of compaction.[6]

During the early growing season, corn growing in compacted soils should be monitored for nutrient deficiency symptoms and corrected, if possible. For sidewall compaction, cultivation may be considered to help promote more root growth and help standability. For a tillage pan, a cultivator pass or sidedress N application can help break up the layer if it can be made deep enough.

For late season management, monitor the fields for any potential stalk or root lodging, and plan to harvest those fields early to help minimize losses. To help break up compaction in a field, a deep tillage pass at an angle to the normal cropping rows may be considered in the fall. This will help restore oxygen to the soil profile. In a no-till environment, consider planting an aggressively growing cover crop, such as tillage radish, to break compaction layers. The most important resource to growing a healthy and profitable crop is your soil, so consistent management of compaction is necessary.

SEED TREATMENT OPTIONS FOR *PYTHIUM* IN CORN

INSIGHTS

- *Pythium* species cause one of the most harmful diseases in corn and soybeans.
- Protection against seedling disease can lead to higher yields through plant retention.
- At locations where plant stand was impacted, Vayantis® seed treatments showed higher yield as a result of increased final plant stands.

INTRODUCTION

Stand establishment is one of the most important yield contributing factors. Many things can limit stand establishment, but seed and seedling diseases can reduce stand by reducing root development, impeding water and nutrient uptake, slowing seedling growth, and even cause seedlings to die in severe cases of infection. *Pythium* species cause one of the most damaging diseases in corn and soybeans.

Pythium fungi overwinter as oospores in the soil and plant material. *Pythium* fungi are known as "water molds" because they thrive in wet soils. These fungi are also active over a wide range of temperatures, including activity in cooler soils of early planted fields. Symptoms include stunted, chlorotic growth that may resemble nitrogen deficiency, drought-induced wilting, inconsistent plant size or leaf stage, and brown root tissue (Figure 1).[1]

Figure 1. Stunted, Pythium-affected plant (center) surrounded by unaffected plants

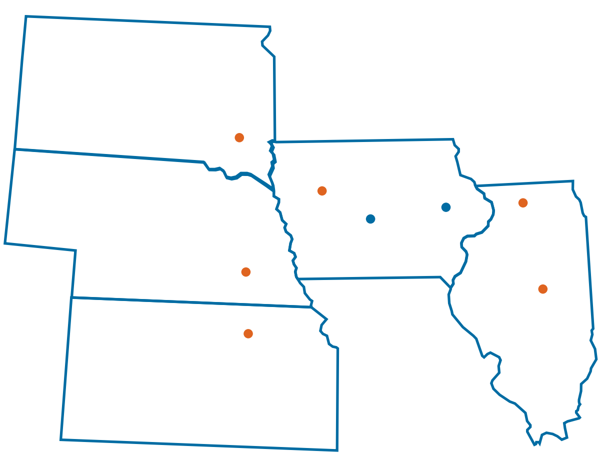


Figure 2. Trial locations in 2020 with locations lost to derecho in blue

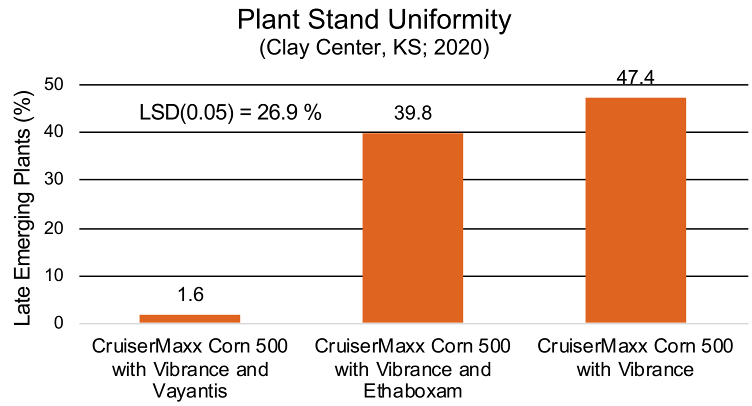
2020 SEED TREATMENT EVALUATIONS

Golden Harvest® Agronomy In Action research trials established at eight testing sites were designed to investigate the effectiveness of seed treatment in reducing *Pythium* damage. Specifically, a primary objective was to understand if adding either ethaboxam or picarabutrazox, a seed treatment undergoing registration which will be marketed as Vayantis seed treatment*, can provide additional levels of protection against *Pythium* greater than that already provided by CruiserMaxx® Corn 500. Two of the eight trials established were lost to a late season derecho in 2020 (Figure 2). All trial plots were inoculated with *Pythium* at the time of planting to improve chances of disease presence to see treatment differences. CruiserMaxx Corn 500 with Vibrance® seed treatment, a combination of 1 insecticide and 5 fungicides, was applied as a control as well as with either ethaboxam or Vayantis treatments to understand differences in performance. Trials were replicated four times in a randomized complete block design using the same hybrid across all treatments at each location. Plant vigor, emerged plants and plant uniformity data were collected at locations. Yield, moisture and test weight were recorded with a research combine at the time of harvest.

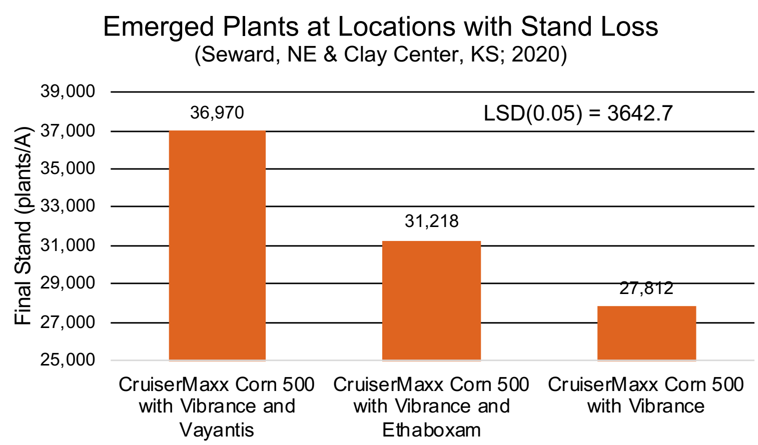
RESULTS

Measurement of early season uniformity, percent of plants at least one growth stage behind the majority of plants, was similar across all locations except Clay Center, Kansas. Roughly 47% and 39% of the CruiserMaxx Corn 500 with Vibrance alone and with ethaboxam were at least 1 leaf stage behind other plants, respectively. Uniformity was greatly improved when Vayantis was included in the treatment, with only 1.6% weak plants observed (Graph 1).

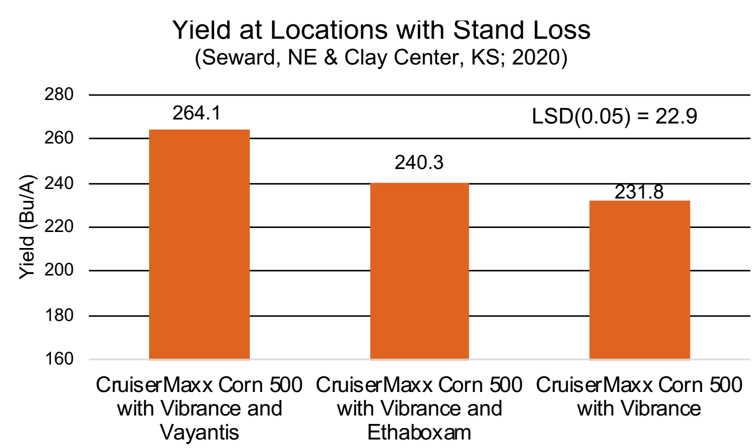
Bridgewater, South Dakota, Sac City, Iowa, Clinton and Oregon, Illinois, had no differences in final plant stand or yield. Both



Graph 1. Percent of plants at least one growth stage behind normal

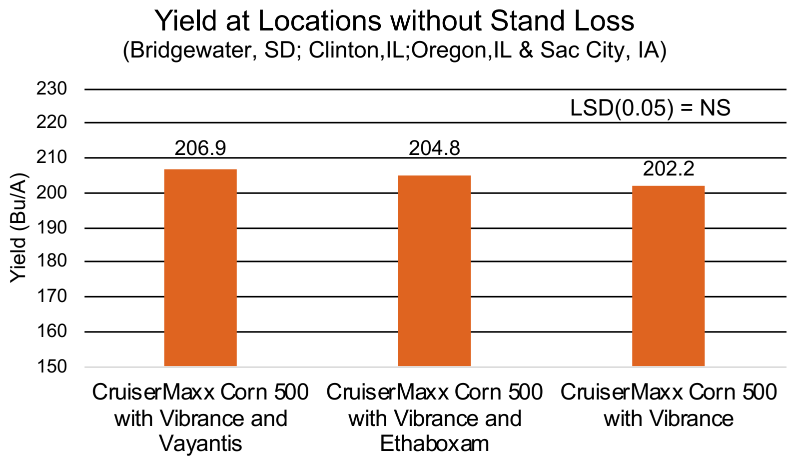


Graph 2. Emerged plants at locations where reduced stands were observed



Graph 3. Yield response to seed treatments at locations experiencing reduced stands

Seward, Nebraska, and Clay Center experienced significant stand reductions from *Pythium*. At these locations, on average, adding ethaboxam increased plant stands by 3,400 plants/A whereas adding Vayantis increased plant stands by more than 9,000 plants/A (Graph 2). The combined stand reduction and lack of plant uniformity at Clay Center and Seward also resulted in yield differences among treatments. Although not statistical, ethaboxam increased yield by 8.3 bu/A, whereas adding Vayantis statistically increased yields by 32 bu/A (Graph 3). At the locations not observing plant emergence or uniformity differences, there was still a small numerical yield advantage of 4.7 and 2.6 bu/A when adding Vayantis and ethaboxam, respectively (Graph 4).



Graph 4. Yield response to seed treatments at locations not experiencing stand establishment problems

SUMMARY & DISCUSSION

Results from these locations suggest that adding a second mode of action for *Pythium* control can help preserve plant stand and uniformity in cases where *Pythium* disease risk is high. Improved yield potential is also likely by improving plant stands and uniformity in growth.

For disease to be present and impactful, a susceptible host, favorable environment and a pathogen capable of causing disease, must all be present. These three key elements make up the disease triangle. Typically, the impact of *Pythium* on corn plant stand has been minimal due to the effectiveness of active ingredients in current seed treatment packages that address this specific disease. However, as we continue to see shifts in *Pythium* species and their sensitivity to current seed applied fungicides, it will be even more important to add a second mode of action, such as Vayantis, to current seed treatment packages. Management practices such as installing drainage in wetter areas to reduce water-logged soils can create less favorable environments for *Pythium* development. Another management example would be to avoid planting immediately before any extended cool and wet weather forecast. Planting when soil conditions are warm and favorable for seed germination and growth is one of the best ways to protect corn seedlings from *Pythium* damage, although this may not always be possible. Utilizing premium seed treatments such as Vayantis can help ensure your achieve your target stands.

**A seed treatment coming soon from Syngenta; please check with your local extension service to ensure registration status; Vayantis is currently not registered for sale or use in the U.S.*

UNDERSTANDING HYBRID RESPONSE TO NITROGEN TRIALS

INSIGHTS

- Historical university, industry and presented studies predominantly found hybrids respond similarly to nitrogen (N) availability.
- Trial results suggest high RTN (response to nitrogen) ratings identify hybrids that are more sensitive to N limited conditions. However, high RTN ratings are not a good indicator of response to intensive crop and N management practices, such as split applications or increased rates.
- Later relative maturity (RM) hybrids that undergo a longer grain fill period are shown to be more sensitive to N shortages and are indicated with increasing RTN scores.
- RTN ratings lack the ability to predict economic optimum N rates making it difficult to predict how hybrids would perform at different levels of N availability, which render it challenging to create an actionable N management plan.
- Analytical approaches to N management that adjust for environmental factors, such as in-season soil and plant tissue testing or predictive N modeling tools, can provide more accurate, timely in-season decisions for a more profitable N management program.

Identifying differences among corn hybrids in nitrogen use efficiency has long been investigated for improving management. Numerous studies have been conducted with the goal of understanding hybrid by nitrogen (N) response. The following article is a brief summary of RTN trials and how to best interpret and utilize ratings when considering best management practices.

EVALUATING HYBRIDS FOR RESPONSE TO NITROGEN

Trials were conducted at 21 locations in 2018 to compare 13 Golden Harvest hybrids' response to nitrogen (RTN) for better understanding of RTN ratings as a management tool. RTN is used by some seed providers to quantify the yield loss of a hybrid under N limited environments in comparison to the yield at a non-limiting N rate. Based on trial results, a value of 0-1 is assigned to individual hybrids and used as a metric to compare to the N response of other hybrids. The RTN value signifies the % yield a hybrid lost due to limited nitrogen availability (Figure 1).

$$\textbf{RTN} = \frac{\textbf{High N Yield - Low N Yield}}{\textbf{High N Yield}}$$

Figure 1

The same 13 hybrids, ranging from 103 to 114-day RM, were planted at all locations to provide consistency in hybrid ratings across growing environments. The distribution of trials

LOCATION	RTN
1	0.00
2	0.09
3	0.16
4	0.17
5	0.18
6	0.21
7	0.23
8	0.24
9	0.29
10	0.32
11	0.33
12	0.36
13	0.37
14	0.40
15	0.48
16	0.48
17	0.50
18	0.53
19	0.57
20	0.57
21	0.69
Mean	**0.34**

Table 1

HYBRID	RTN
G03C84-3120	0.28
G04519-3010	0.32
06EXP-3010	0.26
G06Q68-3220	0.28
G07F23-3111	0.33
G08M20-3010	0.30
G09Y24-3220A	0.34
G11A33-3111	0.32
G12W66-3122	0.32
G13T41-3010	0.36
14EXP-3120	0.33
G15L32-3110	0.35
G15Q98-3000GT	0.30
Max	**0.36**
Min	**0.26**
Mean	**0.32**

Table 2

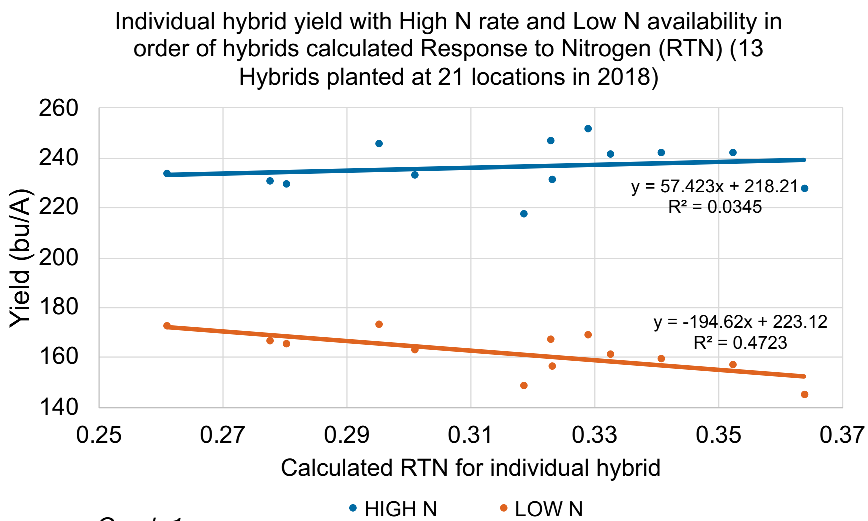
and the average yield penalty per location are outlined in Table 1. The significant effect of environment and soil type on nitrogen availability can be observed across trials. Individual locations ranged from as little as 0% to 69% yield loss at the most stressed locations. On average, limited nitrogen availability resulted in a 34% yield loss across locations.

HYBRID RESPONSE TO USING RTN

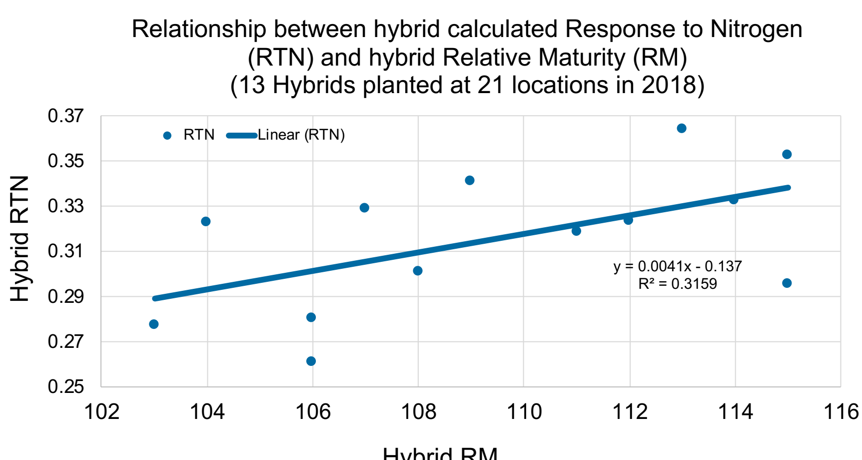
For identification of hybrids that most consistently have high/low RTN ratings, all 21 trials were combined and summarized for response trends. RTN ratings averaged 0.32 across 13 hybrids and ranged from 0.26 to 0.36 (Table 2). Yield loss in limited N environments ranged from 61-85 bu/ac across all hybrids with a 24 bu/ac variance (Graph 1). Previous interpretations of how to best manage hybrids with higher RTN ratings have implied they will be responsive to incremental nitrogen rates and split application timings, while maintaining above average yield potential in low N environments. These data (Graph 1) suggest a lack of relationship between yield and RTN score when high nitrogen rates were applied, indicating RTN scores likely have little to do with hybrid response to incremental N rates. In the low N treatments, a trend for decreased yield as RTN scores increased suggests that hybrids with higher RTN ratings are a better indicator of hybrids more sensitive to N loss.

HYBRID RM IN RELATION TO NITROGEN MANAGEMENT

Relative Maturity (RM) is a common indicator of how long a corn hybrid requires to complete its grain filling period, otherwise known as reaching physiological maturity. Due to fuller season hybrids having a longer and later grain fill period, it is reasonable to anticipate they may respond differently to nitrogen. A mobile nutrient, such as nitrogen, will decrease in availability as the season progresses due to plant uptake and soil N losses, lending to fuller season hybrids being further disadvantaged. Observations from 2018 trials indicate a linear relationship between hybrid RTN score and RM (Graph 2). As hybrid RM increased, RTN ratings also increased. This relationship



Graph 1



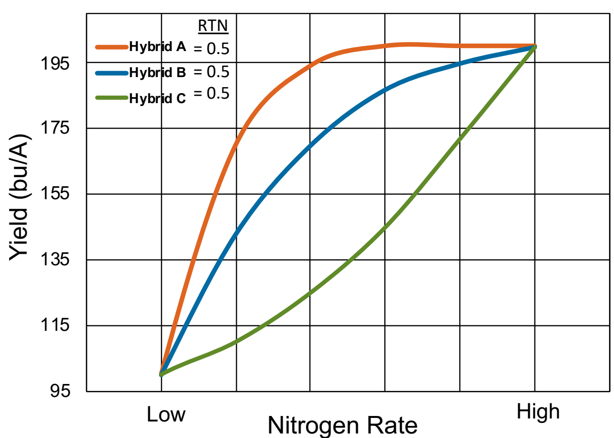
Graph 2

SEASON PREP

supports the concept that fuller season hybrids are more sensitive to yield loss and illustrates the importance of higher intensity N management for fuller season hybrids.

PREDICTING HYBRID RESPONSE AT DIFFERENT LEVELS OF N AVAILABILITY

It is important to note, due to the trial design, it is not possible to extrapolate what may have happened in situations with less severe N loss. The following theoretical example illustrates potential yield response curves of hybrids receiving different nitrogen rates. This demonstrates how the critical amount of nitrogen needed to achieve the economic optimum rate could vary significantly among hybrids with the same RTN score (Graph 3).



Graph 3

SUMMARY

Trial results did not illustrate high RTN ratings as being a good indicator of hybrids that are responsive to more intensive N management practices, such as split applications or increased rates. However, lower RTN ratings did identify hybrids that yield better under extreme N limiting conditions. Differences among hybrid RTN ratings do not appear to be large enough and consistent enough to justify hybrid specific management. The magnitude of RTN differences among hybrids would likely be less pronounced in low N stress situations representative of normal corn production scenarios. The results of RTN studies do support the observation that hybrids with a longer grain fill period are most susceptible to yield loss in low nitrogen environments and highlight the importance of intensive nitrogen management for these hybrids. RTN ratings are not able to predict economic optimum nitrogen rates or how hybrids would perform when managed to those levels, and therefore, have limited utility in creating hybrid specific N management plans. Conclusions from this work suggest RTN ratings are of limited use in differential hybrid N management due to two factors. First, the experimental design limits the ability to predict hybrid differences at rates in between the high and low rates utilized in testing. Second, the strong influence of environmental variability on hybrid nitrogen use efficiency requires an extensive multi-year and location evaluation of hybrids to gain confidence in differences between hybrids. Because of the relatively short life span of hybrids, characterization may not be completed until late into a hybrid lifecycle. Due to lack of actionable N management options associated with characterizing hybrids, analytical approaches that adjust for environmental factors, such as in-season soil and plant tissue testing or predictive nitrogen modeling tools, likely provide more opportunity for in-season management to correct for potential yield loss.

FACTORS INFLUENCING SOYBEAN PLANTING DATE RESPONSE

INSIGHTS

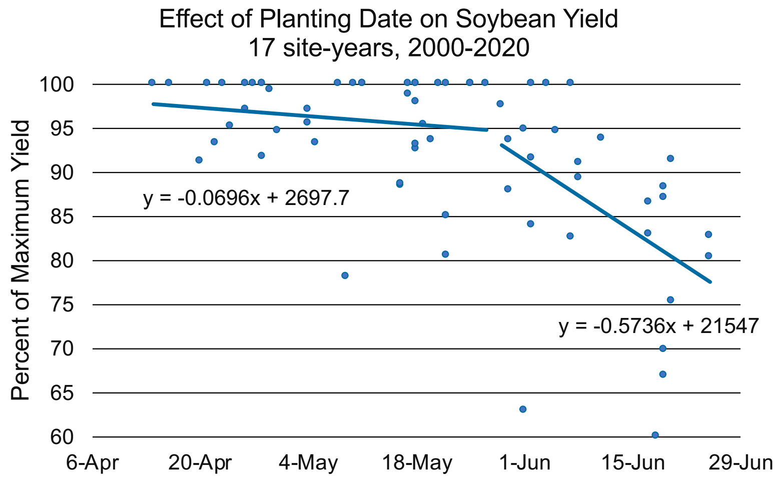
- May or earlier planting dates for soybeans will usually maximize yield potential.
- Yield reductions of half a percentage point per day may occur each day planting is delayed after mid-May.
- Planting the fullest relative maturity (RM) possible for a geography will enhance yield potential.
- Seeding rates resulting in final stands greater than 100,000 will maximize yield potential and/or economic return potential.

BACKGROUND

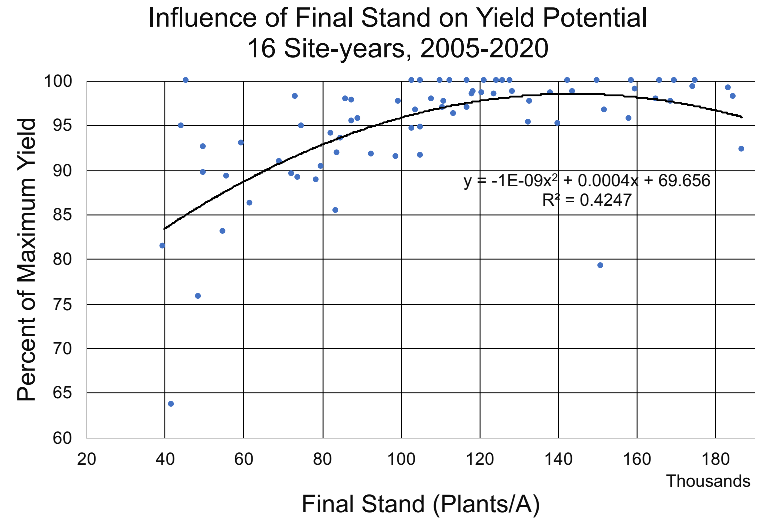
Earlier planting can help maximize photoperiod which impacts soybean development and helps avoid excessive heat and moisture stress during critical flowering stages.[1] Though planting too early may result in poor stands or delayed emergence from cool, wet soils, significant delays in planting often results in reduced yields.[2] Balancing the time spent accumulating nodes during vegetative growth and the length of time in reproductive stages to fill pods is crucial to ensuring high yield potential.[3] Planting fuller-season varieties adapted for the region is typically one of the best ways to maximize yields and return potential.[4] Golden Harvest® Agronomy In Action research trials were conducted in 2020 to demonstrate how planting date, RM and seeding rate interact with each other.

MULTI-YEAR PLANTING DATE AND SEEDING RATE RESULTS

Results from historic Agronomy In Action planting date research conducted across Nebraska, Iowa and Illinois show that yield potential is generally maximized if planted by mid to late May (Graph 1). If planting is delayed after this cutoff, yield losses average 0.5% per day. Planting by mid-May will usually maximize light capture for full-season



Graph 1. Multi-year planting date influence on soybean yield



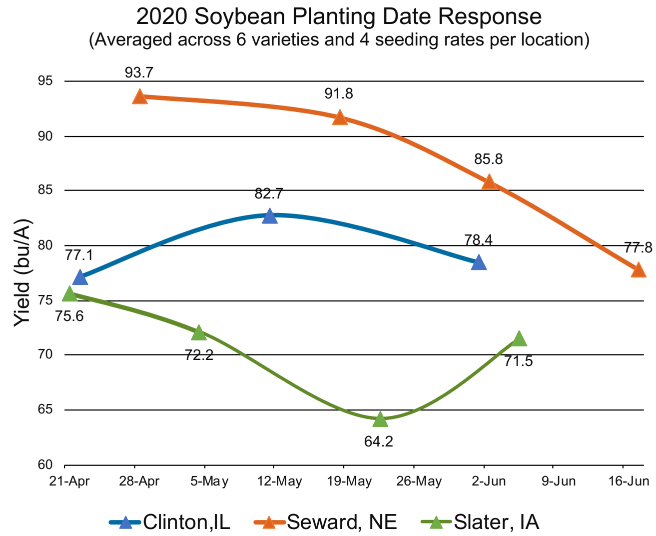
Graph 2. Influence of final stand on yield using 16 site-years of data

soybeans, whereas delaying will put full-season soybeans at risk of frost damage.

Final plant stands are usually lower than actual seeding rates, and in many cases can be significantly less. Final stand establishment is more important than actual seeding rates in determining yield potential. Multi-year seeding rate trials have shown that achieving final stands greater than 100,000 plants per acre yielded similarly. Increasing seeding rates to achieve higher stands resulted in small inconsistent yield gains (Graph 2). When final stands were less than 100,000 plants/A, there was a 2% loss of maximum yield potential for every 10,000 fewer plants established.

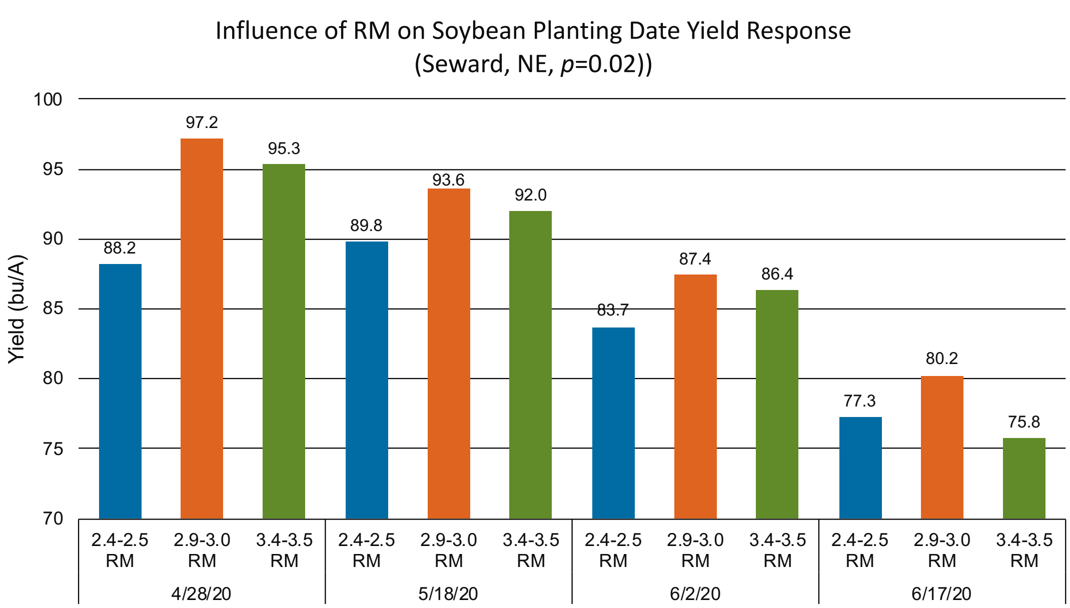
2020 PLANTING DATE TRIALS

Studies were conducted at Seward, Nebraska, Slater, Iowa, and Clinton, Illinois, in 2020. Two varieties of similar RM were selected per grouping of early, mid- or full-season RM for each trial location. Early and mid-RM varieties were respectively 1.0 and 0.5 earlier than the fullest season variety normally planted in that location. Each of the 6 varieties were planted at 100,000, 140,000, 180,000 and 220,000 seeds per acre.



Graph 3. Individual location 2020 soybean planting date response averaged across varieties and seeding rates

Planting date responses behaved differently across the three locations in 2020, but overall followed general trends observed in multi-year planting date trials (Graph 3). Unlike Seward and Slater, Clinton did not see any advantages to planting in April. However, the most rapid yield loss resulting from late May to early June planting dates was consistent with multi-year trends. The lack of response to the April 22 planting date at Clinton in 2020 was a result of only achieving 68% stand establishment, likely due to a period of cool, wet weather from April 23 through April 29 that slowed



Graph 4. Yield comparison of planting date for three relative maturity groups at Seward, Nebraska

plant establishment. The spike in June planting date yield at Slater is a good example of how planting date interaction with seasonal weather can result in variable yield response in some years. Stands were roughly 37% below targeted seeding rates for the Slater May 22 planting date, resulting in a more severe yield penalty than expected. Additionally, after a relatively dry August at Slater, the June 5 planting date was likely able to take advantage of early September precipitation, whereas earlier planting dates were already nearing maturation.

RM ADJUSTMENTS WITH DELAYED PLANTING CONSIDERATIONS

Switching to an earlier RM is a common practice in years where planting is delayed, often done in efforts to avoid early fall frost or to enable an earlier harvest. However, shortening RM too much can result in lost yield potential. In the 2020 Seward trial, yields declined with each subsequent planting date regardless of RM (Graph 4). Generally, mid- and full-RM varieties outperformed early varieties at all planting dates, except for the final June planting date, where it was beneficial to switch from full-season to a mid-season RM. However, it was never beneficial at any planting date to transition to any RM earlier than 2.9. Aerial views of all planting dates on September 17th illustrate how relative maturity of 3.0 or less were rapidly maturing when planted in mid June, confirming there was little advantage of moving to earlier RM's to avoid frost risk (Figure 2).

SEEDING RATE ADJUSTMENT CONSIDERATIONS

In general, increasing seeding rates to achieve final plant stands greater than 100,000 plants per acre has shown minimal value at normal planting dates. However, prior work has shown an advantage to increasing seeding rates when planting is delayed into late June or July. Late-planted soybeans are less able to maximize the number of nodes developed prior to flowering as compared to normal planting dates, capping the plants' overall capacity to generate normal pod and seed numbers per-plant. Due to plants being less elastic in their ability to increase per plant yield potential at late planting dates, increasing seeding rates may be beneficial. Although this has been observed in the past, there was not enough of an increase in yield in 2020 to justify increasing seeding rates (data not shown). Dry soil conditions with June or July planting dates can dramatically reduce emergence and should be taken into consideration to guarantee a minimum final stand of 100,000 or more plants per acre to maximize yield potential.

IMPACT OF RM ON SEEDING RATE

In 2020 trials, there was no basis to adjust seeding rates if adjusting RM to an earlier or later variety. The relative performance of the three RM treatments was consistently the same across all four seeding rates.

SUMMARY

This study shows the importance of planting date and seeding rate on soybean management. Data from this season and previous years suggest beginning soybean planting in the latter half of April and finishing by mid-May to avoid yield penalties in most Midwest geographies. Both April and mid-May planting dates have the ability to maximize crop canopy closure early in the season which helps improve photosynthesis efficiency as seen on July 27 at Seward (Figure 2). Soil

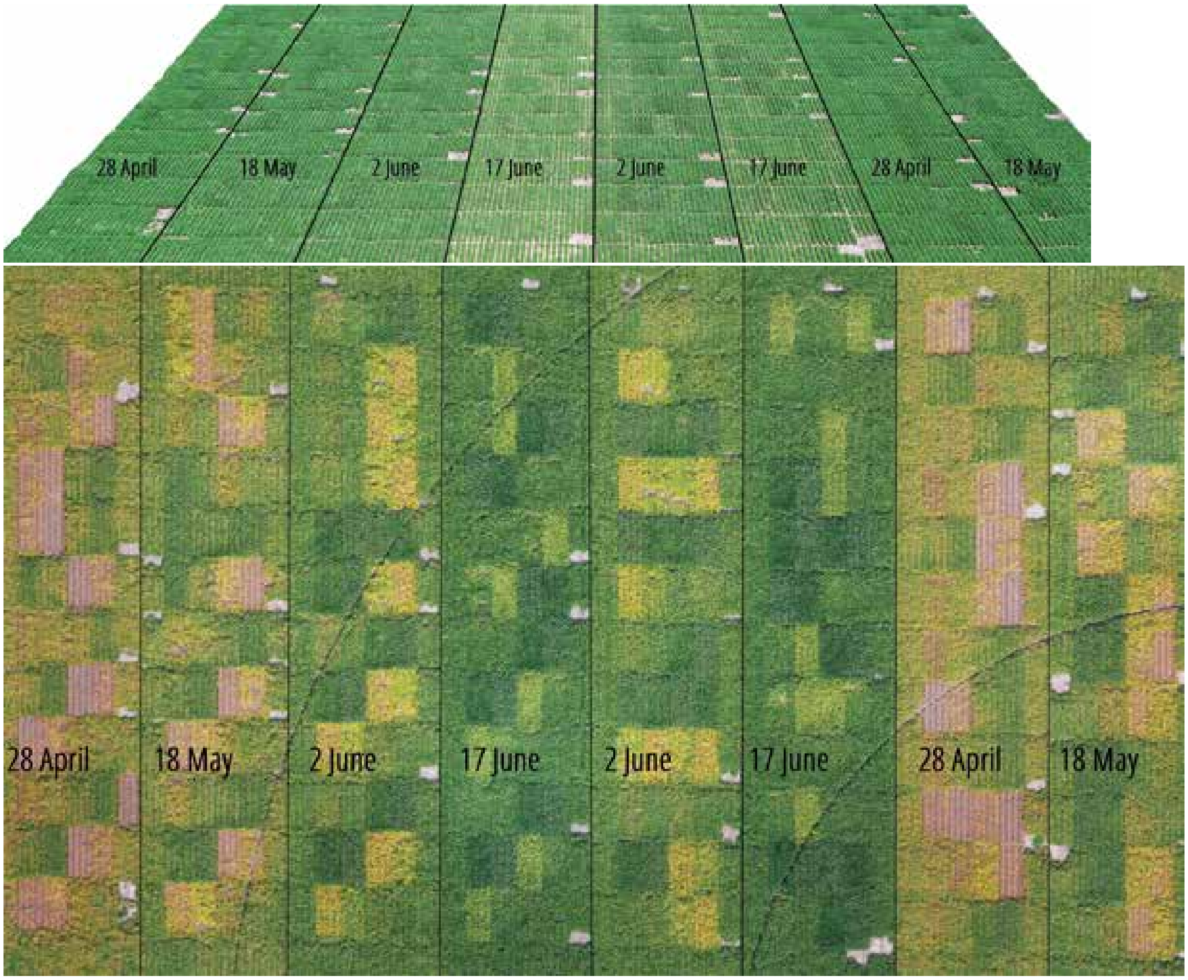


Figure 2. Planting dates of the trial at Seward, NE; images taken on 27 July 2020 (top panel) and 17 September 2020 (bottom panel).

temperature and weather forecast should be monitored closely when planting in April, as yield benefits from early planting are dependent upon date of emergence rather than actual planting date. Soil temperatures below 50°F and saturated soil conditions after planting can result in delayed emergence and uneven stands that negate the value of planting early.

In years where planting is delayed, balancing between maximizing yield with a full season RM and reaching maturity prior to frost with an earlier RM is important. These trials reinforced that when this happens, only small adjustments of 0.5-0.75RM earlier than normal are necessary to reach maturity faster and still maximize yield potential (Figure 2).

Seeding rates from 2020 and prior years suggest that planting 140,000 seeds/A will typically result in final stands greater than 100,000 plants/A and maximize yield potential. There are years that increasing seeding rates higher than 140,000 have given slight yield benefits but most often didn't provide an economic return due to additional seed and seed treatment cost. If reducing seeding rates less than 140,000 seeds/A, it will be increasingly difficult to achieve the minimum final stand of 100,000 plants per acre. Although yield penalties may not always be seen with reduced seeding rates, it will be more likely to occur as germination and stand establishment rates decrease.

COMPARING SOYBEAN HERBICIDE TRAIT FIT

INSIGHTS

- Introductions of new soybean herbicide traits have increased weed management options and complexity.
- June 30th dicamba over-the-top application label restrictions for soybeans could result in short postemergence application windows with delayed planting compared to the application restriction with 2,4-D herbicide on Enlist E3® soybean systems.
- Roundup Ready 2 Xtend® and Enlist® soybean systems both have stewardship requirements, although Enlist systems are less restrictive.

Effectiveness of individual herbicides utilized with various soybean herbicide trait platforms

Weed Species	Dicamba herbicides approved for Roundup Ready 2 Xtend® / XtendFlex®	Enlist One® (2,4-D)	Roundup® (glyphosate)	Liberty® (glufosinate)
Crabgrass	P	P	E	E
Fall Panicum	P	P	G-E	G
Foxtail	P	P	E	G-E
Woolly Cupgrass	P	P	E	E
Shattercane	P	P	E	E
Waterhemp	G-E	G-E	G-E[1]	G
Black Nightshade	G	G	F-G	E
Cocklebur	E	E	E	E
Common Ragweed	G-E	E	E[1]	E
Giant Ragweed	E	E	G-E[1]	G
Lambsquarter	G	E	G	G
Smartweed	E	F-G	G	E
Sunflower	G	G-E	E	E
Velvetleaf	F-G	G-E	G	E

Table 1

Ratings recreated from Iowa State University "2020 Herbicide Guide for Iowa Corn and Soybean Production" and are based on full label rates

E=Excellent; G= Good; F=Fair; P=Poor

[1] Frequently occurring weed species with glyphosate resistance which will result in performance less than rating

INTRODUCTION

Weed management in soybeans has become more challenging over the last decade as the broad-spectrum control of glyphosate has become less consistent due to weed resistance. This has increased complexity when developing weed management plans. Recent introductions of soybean herbicide traits have provided new management options but also increased the knowledge base required to determine the appropriate one. In many cases, effective control of glyphosate-resistant weeds may still be accomplished without depending solely on new herbicide traits that allow the use of Group 4 (synthetic auxin) herbicides on soybeans. Enlist E3® soybeans, Roundup Ready 2 Xtend®, Xtendflex® and LibertyLink® GT27® traits provide additional advantages for managing biotypes of weeds resistant to Groups 2,5,6,7,9,14 and 27 herbicides. Marestail, ragweed, waterhemp and Palmer amaranth are widely known to be resistant to many of the same herbicide groups in various combinations. Even with new trait options, fundamental weed management practices are still critical to achieving good weed control.

1. ***Start Clean –*** Tillage or burndown herbicides are essential to control emerged weeds prior to crop emergence.
2. ***Residual control importance –*** Preemergence herbicides with residual activity help minimize seedbank emergence early in the season, allowing crop canopy to establish quickly and reduce later weed emergence.

	Roundup Ready 2 Xtend® and Xtendflex® Soybeans	Enlist E3® Soybeans	LibertyLink® GT27® Soybeans
Burndown Flexibility	Enables approved dicamba herbicides as burndown without planting interval ↑	Enables 2,4-D burndown with no planting interval ↑	Must allow 7+ day planting interval for 2,4-D and must allow 14-28+ day plant interval for dicamba ↓
Post Auxin + Liberty tank mix flexibility	Roundup Ready 2 Xtend does not have Liberty tolerance. Xtendflex does offer tolerance, but no approved dicamba + Liberty tank mixes exist ↓	Approved 2,4-D and glufosinate may be tank mixed for improved control of glyphosate tolerant weeds ↑	No auxin tolerance; unable to tank mix auxin herbicides ↓
Multiple MOAs for broadleaf post control of glyphosate tolerant weeds	1) Dicamba based herbicides 2) Liberty[1] ↑	1) 2,4-D based herbicides 2) Liberty ↑	1) Liberty ↓
Window of application	No over-the-top applications after June 30th regardless of growth stage ↓	Apply glyphosate/Enlist herbicides through R2 (full flower) or Liberty through R1 ↑ →	Liberty through R1 (begin flower) →
Application stewardship requirements	Most Restrictive ↓	Minimal Restrictions →	Least Restrictive ↑

Table 2

[1] Roundup Ready 2 Xtend® soybeans do not offer tolerance to Liberty® herbicide. Liberty can be applied to Xtendflex® Soybeans.

3. ***Post spraying within labeled weed heights –*** Residual herbicides help delay weed emergence and minimize weed height at the time of postemergence spray applications. Postemergence control is greatly improved when herbicides are applied to smaller weeds.

CONSIDERATIONS FOR SELECTING A SOYBEAN TRAIT OPTION

1. ***Complimentary herbicide combinations based on individual weed species effectiveness –*** Each individual field has different combinations of problematic weeds to control. Understanding weed seed banks can help determine the best soybean herbicide trait platform to enable herbicide options that provide the greatest overall weed control. The weed control efficacy chart (Table 1) illustrates the strengths of herbicides labeled for use within specific herbicide trait systems. Depending upon the weed species, an individual or a combination of herbicides may have unique advantages. The ability to apply an approved synthetic auxin (2,4-D and dicamba) or Liberty® herbicides provides unique control advantages with waterhemp, Palmer amaranth and giant ragweed resistant to glyphosate and other herbicides. (Chart reflects glyphosate efficacy on non-resistant weed species.) Postemergence herbicide plans should take the frequency of glyphosate resistance into consideration and use specific herbicides that have effective sites of action.
2. ***Burndown options –*** Managing emerged weeds prior to crop emergence in no-till systems is important. Herbicides such as glyphosate, 2,4-D ester, dicamba, Liberty or paraquat can provide great options for managing winter annuals and

perennial weeds prior to planting. Planting intervals restrict how soon planting can occur after burndown applications when using 2,4-D or dicamba herbicides. Roundup Ready 2 Xtend, XtendFlex® and Enlist E3 soybeans trait systems provide additional options to use approved dicamba and 2,4-D herbicides respectively (not interchangeable) when burndown and planting dates need to occur closer together. The extended planting interval restrictions for dicamba herbicides likely limit the usage for burndown unless planting Roundup Ready 2 Xtend or XtendFlex soybeans and using approved formulations.

Figure 1. Broadleaf weed control of a synthetic auxin herbicide applied to appropriate soybean herbicide trait system

3. ***Post tank mix flexibility –*** Simultaneously controlling emerged grass and broadleaf weeds in a single application is highly advantageous. Glyphosate provides excellent grass control, but due to the number of broadleaves weed species that have become resistant to glyphosate, it is increasingly important to include a second mode of action for effective broad-spectrum control. Repeated use of approved dicamba or 2,4-D herbicides as a single effective mode of action on glyphosate-resistant weeds will only further increase weed resistance selection pressure. One advantage of Enlist E3 soybean systems is the ability to spray Liberty (or glufosinate) and approved Enlist herbicides in combination, giving two effective modes of action against glyphosate-resistant weeds. XtendFlex soybeans also provide tolerance to dicamba and Liberty, however currently there are no approved dicamba + Liberty tank mix combinations (as of 10/30/20). Spray volume and nozzle requirements needed for Liberty are not generally well suited for dicamba-based herbicide tank mixes. Current dicamba label restrictions limit over-the-top application before June 30th, restricting the opportunity to apply tank mix combinations of any sort during late vegetative and early reproductive stages.

4. ***Application and stewardship requirements –*** Enlist Duo® applied to Enlist E3 soybeans offers the least restrictive application window (through R2) of all three systems. Adding Liberty further limits applications to R1. Over-the-top applications of dicamba-based herbicide to Roundup Ready 2 Xtend or XtendFlex varieties must be applied by June 30th regardless of growth stages. In some cases where planting of Roundup Ready 2 Xtend or XtendFlex soybeans are delayed, there may not be any opportunity to apply dicamba post or the window for application will be very short, depending on emergence date.

Roundup Ready 2 Xtend, XtendFlex and Enlist E3 soybean systems all have stewardship requirements, although Enlist systems are less restrictive.

- A key difference between the two systems is the 240 and 310-foot downwind sensitive area buffer requirements of Xtend soybean systems in comparison to the 30-foot downwind requirement for Enlist.
- In addition to distance, it is acceptable to spray Enlist herbicides when wind is blowing toward soybeans without the Enlist trait, although it is not acceptable to spray Xtend herbicides if wind is blowing in the direction of soybeans without the Xtend trait.

Stewardship requirements may be complex and unique to each field and herbicide system being used. To ensure correct application, refer to the product use guides of each trait system and herbicide labels for specific requirements.

OVERALL PROGRAM EFFECTIVENESS SUMMARY

Each herbicide trait system offers advantages over glyphosate-only systems. However, a holistic comparison of all three systems favors Enlist E3 soybeans over the other two systems for the following reasons:

1. The cumulative "excellent" efficacy ratings across key weed species when applying Enlist One® + Liberty outnumber dicamba + glyphosate herbicides "excellent" ratings.
2. The flexibility to tank mix post applications of Enlist One herbicide with Liberty or glyphosate (premix of Enlist Duo).
3. Enlist One + Liberty provides more effective modes of action for glyphosate-resistant weeds in a single application than if using approved dicamba herbicides or Liberty separately.
4. Enlist Duo provides a wider window of application than other systems.
5. There is less risk of off-site movement with Enlist One than approved dicamba herbicides.
6. Enlist herbicides are not restricted use and do not require special applicator certifications whereas approved dicamba herbicides do.
7. There are less restrictive stewardship requirements than with Xtend soybean systems.
8. There is no planting interval restriction after application of 2,4-D herbicides with Enlist E3 soybeans, whereas LibertyLink GT27 has restrictions.

WHY USE A SOYBEAN SEED TREATMENT?

INSIGHTS

- The color of a soybean seed treatment doesn't mean much. Instead it is important to know the active ingredients and that it was applied properly.
- It can be compelling to cut seed treatment investments to help with overall spending, even though value may have been seen in previous years. It is critical to consider the needs of the field for insect, disease and nematode control.

Many growers have witnessed the value and return on investment of a seed treatment on soybeans, especially when protecting seed when planting earlier to try and optimize yield. Research has shown that seed treatment can help reduce seeding rates and reduce seed costs. The problem today is that the color of the seed doesn't mean it's fully protected. With tight operating margins, farmers have to understand what they're purchasing and if it was applied properly. This requires knowing what active ingredients, additives and rates were used. Otherwise farmers may just be purchasing a flashy color.

INSECTICIDE

Many seed treatment packages[1] consist of insecticides that are labeled to protect against insects such as aphids, bean leaf beetles, seedcorn maggot, and other early season pests. It's important to understand the rate used as there can be significant differences in performance. Value of a seed-applied insecticide can change from year to year depending on the level of insect pressure. However, as planting dates move earlier to help maximize yield, potential for insects increases. First-planted soybean fields often have more yield potential but are also most likely to encounter bean leaf beetles. Planning ahead with a robust offering like Golden Harvest® Preferred Seed Treatment can help take advantage of early planting. But even in the absence of insect pressure, seed-applied insecticides have shown a positive vigor effect, increase in speed to canopy and potential yield increase.

FUNGICIDE

Multiple fungicide components are needed in a seed treatment in order to protect against soil pathogens *Pythium* sp., *Phytophthora*, Rhizoctonia and Fusarium sp. Golden Harvest Preferred Seed Treatment offers a combination of active ingredients to provide broad-spectrum protection across the most common soilborne pathogens. Some of these active ingredients also give flexibility to manage seedborne disease, such as Phomopsis sp, that might not even be present in the field but could be introduced from the prior year's seed production fields. Golden Harvest Agronomy in Action research continues to look at potential new fungicide active ingredients for continued improvement.

NEMATICIDE

Soybean cyst nematode (SCN) pressure can be unevenly distributed throughout a field, with no obvious injury visible. Heavy reliance on a single source of plant genetic resistance, PI 88788, has reduced its overall effectiveness for managing SCN. Due to this, SCN populations can grow, increasing the need to consider using seed-applied nematicides for early season SCN management. Reduced feeding can also indirectly reduce the number of pathways of soilborne pathogens to enter roots, reducing the risk of diseases such as Fusarium virguliforme, commonly known as sudden death syndrome (SDS). Saltro® seed treatment is a newly registered fungicide that also provides protection against nematodes. Saltro provides direct activity on fusarium and SCN, which also helps indirectly lessen fusarium infection by reducing SCN root injury. Many biological nematicides are now available. However many do not have direct activity on SCN, but instead create protective zones around roots. Performance can vary greatly among biological nematicides.

BIOLOGICALS AND INOCULANTS

Biologicals are often produced from natural microbes (bacteria or fungi). They can have a variety of claims to improve insect, disease and SCN control or for enhancing nutrient uptake to promote growth and yield. Some biologicals promote minor to significant yield increases. Consistency of many of these products can sometimes be challenging to understand the return on investment.

Inoculants are another form of a natural solution that has evolved over many years. Most inoculants contain soil bacteria called Rhizobia which is needed as part of a symbiotic relationship with soybeans to help roots fix nitrogen. In some instances, research has shown 1 to 2 bushel-per-acre yield responses when new inoculants are used within a corn – soybean rotation. On-farm research, such as replicated, side-by-side strip trials over multiple years, is suggested prior to adding inoculants into a farming operation.

PREMIX FORMULATIONS VS. CUSTOM BLENDS

In efforts to provide a low-cost treatment, downstream treaters sometimes use custom blends of individual seed treatment products to provide broad-spectrum control. Custom blends are separately registered products that are mixed together just in time for delivery and use. Since custom blends are not precisely formulated to be intermixed in all combinations, the overall use rate can often be higher than a similar premix product that was carefully designed and formulated together to deliver at lower use rates. Seed treatment recipes exceeding 7 fl. oz. per 100 lb. of seed can be more difficult to dry and will sometimes result in poor seed flow and plantability issues. Depending on the recipe and number of products, it may be challenging to add products, such as inoculants, to the overall treatment recipe.

RETURN ON INVESTMENT

With tight margins, it can be compelling to cut seed treatment investments to help with overall spending even though value may have

PROBABILITY OF SEED TREATMENT POTENTIAL RETURN ON INVESTMENT

Treatment ROI @ $12/bu	Field Yield bu/A		
	40	60	80
Fungicide	84%	92%	94%
Fungicide + Insecticide	88%	98%	98%

Source: University of Wisconsin 2008-2010 data. S. Conley been seen in previous years. Multi-year analysis at the University of Wisconsin has shown that in 40-80 bushel yield environments, fungicide and insecticide seed treatments offered return on investments 88-98% of the time based on field trials.[2]

SUMMARY

Remember that all seed treatments are not created equal. Just because soybeans are colored and shiny doesn't mean they have a high-quality seed treatment. Some seed treatments may only contain a single fungicide or a reduced rate of multiple active ingredients. If you're not sure what's on the beans, consult the seed supplier. When planting early or late, foregoing a seed treatment increases risk. Whether it be for insect protection or fungal protection, high-quality seed treatments are a must – especially with reduced seeding rates.

Ultimately, the goal for using high-quality treated seed includes:

- Improved emergence
- Increased vigor
- Earlier canopy closure
- Broad-spectrum insect protection
- More yield potential

USING BIOLOGICALS AS A COMPONENT OF FERTILITY MANAGEMENT IN SOYBEANS

INSIGHTS

- Scientific advancements in biological development will continue to push the possibility of yield increases.
- When yield limiting resources such as sunlight nutrients, and water are sufficient, there will be less opportunity for benefits from biologicals.

POTENTIAL BENEFIT OF BIOLOGICALS IN SOYBEAN PRODUCTION

Using biologicals (plant protection products derived from living organisms) in crop production has been a focus of attention in recent years. Soil microorganisms provide many important agronomic benefits to crops such as fixing atmospheric nitrogen and converting soil nutrients into plant-available forms.

Soybeans have a high demand for nitrogen and must accumulate 4.8 lbs of N per bushel. It has been documented that biological nitrogen fixation from *Bradyrhizobium* can supply roughly 60% of the nitrogen requirement for soybeans.[4] The other 40% must come from the soil through mineralization or synthetic nitrogen fertilizers. As yield levels increase, the soil may not mineralize enough nitrogen to meet the demand of soybeans beyond that supplied by biological nitrogen fixation.

The presence of plant-available nitrogen (nitrate or ammonium) has been shown to reduce nodule formation, growth and activity in soybeans.[1,2,3] The reduction is directly proportional to the quantity of nitrogen available within the soil. This is largely why soybeans are non-responsive to synthetic

LOCATION	VARIETY	RAINFALL (APRIL-AUG)	SOIL TYPE	PH	ORGANIC MATTER	CEC	P‡	K‡‡
		inches			%	meq/100g	ppm	ppm
Bridgewater, SD	GH2041X	14.3	Loam	6.3	2.5	22.2	14	176
Cedar Rapids, IA	GH3088X	17.7	Silty Clay Loam	6.6	4.0	20.0	39	174
Clay Center, KS	GH3582E3	15.4	Silt Loam	6.7	1.9	16.9	18	328
Clinton, IL	GH3546X	18.1	Silt Loam	6.4	4.0	18.8	45	266
Malta, IL	GH2552X	16.0	Silty Clay Loam	6.6	3.8	19.2	21	323
Seward, NE	GH3088X	13.6	Silt Loam	5.8	2.2	18.1	18	293
Slater, IA	GH3088X	14.8	Loam	5.4	3.0	18.6	28	151
Storm Lake, IA	GH2041X	14.5	Loam	6.4	2.2	19.6	50	223

‡ Weak bray test (20-30 ppm considered adequate)
‡‡ Ammonium acetate test (175-250 ppm considered adequate)

Table 1. Variety, precipitation and soil test values for 8 locations across the Midwest

nitrogen fertilizer applications. A slow release form of nitrogen through biological fixation from other bacteria could be a promising concept to meet this need. Biologicals that can stimulate root growth, improve nutrient uptake and reduce plant stress may also help overcome nutrient deficiencies often seen in soybean production.

SOYBEAN BIOLOGICAL EVALUATION TRIALS

In 2020 Golden Harvest® Agronomy In Action research trials, two biological products were evaluated at 8 locations across the Midwest (Figure 1).

Envita®, a naturally occurring bacteria *(Gluconacetobacter diazotrophicus)*, introduced by Azotic North America, forms a beneficial relationship with the plant and fixes atmospheric nitrogen within every plant cell.

Terrasym® 401, a seed treatment for soybeans that includes beneficial microbes called methylobacterium (M-trophs), was developed by NewLeaf Symbiotics. NewLeaf Symbiotics claims that the bacteria form a symbiotic relationship with the plant that improves plant development, nutrient uptake and tolerance to abiotic stresses.

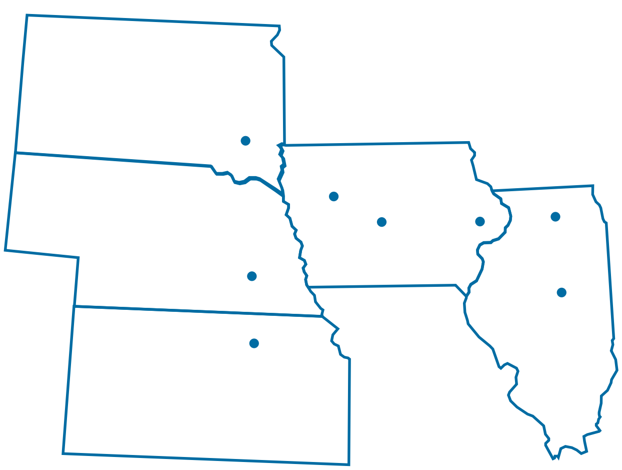


Figure 1. Soybean trial locations in 2020

Field research locations were managed according to the normal practices for the local grower. Envita was applied in-furrow at planting while Terrasym 401 was applied as a seed treatment.

The Golden Harvest soybean variety, precipitation amount and soil test values for each location are outlined in Table 1. All soil test levels for phosphorus (P) were adequate or above adequate for all locations except Bridgewater, South Dakota, Clay Center, Kansas, and Seward, Nebraska. Soils at Bridgewater and Cedar Rapids, Iowa, had borderline adequate potassium (K) levels and Slater, Iowa, was below adequate. The lowest organic matter soils were at Clay Center, Seward and Storm Lake, Iowa.

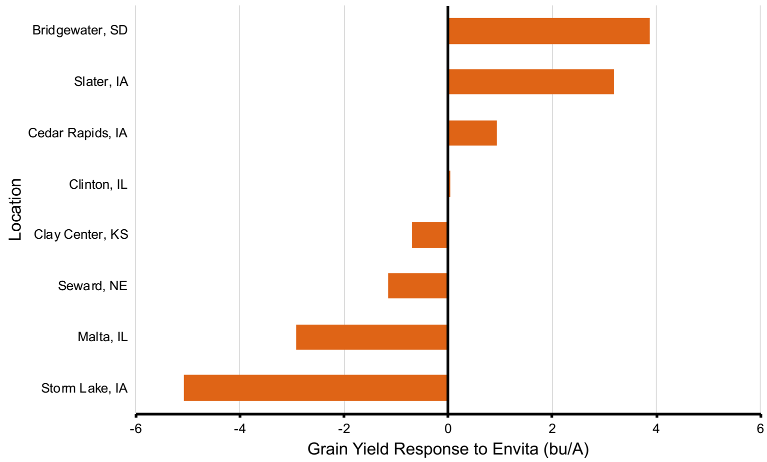
TRIAL RESULTS

Yield environments were significantly different across locations with averages ranging from 53 bu/A at Bridgewater to 104 bu/A at Seward. When averaged across all locations, there was no yield difference between the check and the application of either biological product. At individual locations, grain yield responses to biological treatments were inconsistent. Soybeans grown at Bridgewater and Slater experienced the highest positive yield response when Envita was applied in-furrow, yielding 3.9 and 3.2 bu/A greater than the check, respectively (Graph 1). The only location where applying Terrasym 401 as a seed treatment tended to increase yield over the check was at Slater, yielding 6.5 bu/A greater (Graph 2).

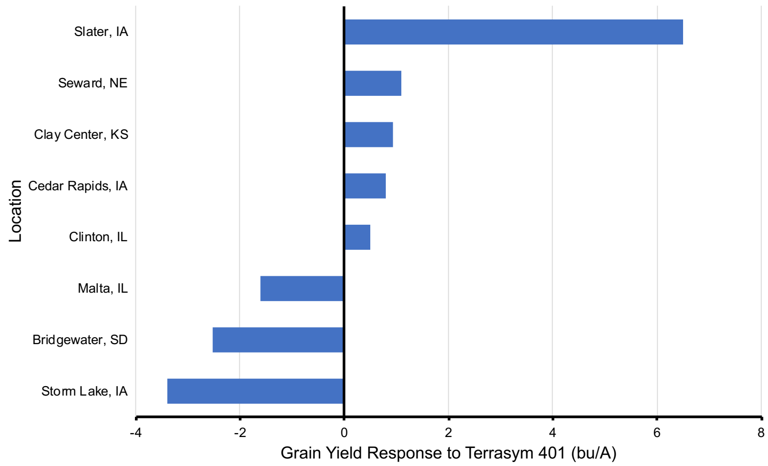
CONCLUSION

It is understood that yield is a complex trait and yield responses to biological treatments may be year and environment dependent.

There are many moving parts that need to fall into place to see a yield increase from biological products. These products are live bacteria and must stay alive through the application process and live in the soil. They also need to colonize the plant in order to form a symbiotic relationship and provide benefits to the plant. Finally, the yield potential of the plant must be limited without the benefits provided by the bacteria. For example, if a soybean plant is not nitrogen deficient, then applying a biological product that provides nitrogen to the plant will likely not increase yield. More research efforts to understand these environmental interactions with biological products are needed.



Graph 1. Yield difference when applying Envita in-furrow compared to the check at 8 locations across the Midwest



Graph 2. Yield difference when applying Terrasym 401 as a seed treatment compared to the check at 8 locations across the Midwest

WEED RESISTANCE MANAGEMENT

INSIGHTS

- Two herbicides can share the same mode of action, but still have a different site of action, making site of action the most important consideration for resistance management.
- Full rates of herbicides at the proper timing need to be applied to help avoid weed escapes, increase residual soil herbicide activity and keep resistance at a minimum.

The list of weeds with documented resistance to herbicide modes of action and cross resistance grows each year. Managing weed resistance successfully combines cultural and rotational actions taken by farmers along with herbicide programs that include multiple "effective" sites of action (SOA) at labeled use rates and timing. Key facts:

- Mode of Action (MOA) refers to the plant processes affected by the herbicide. Example: Cell membrane disruptor
- Sites of Action (SOA) can be defined as the biochemical site inside a plant that the herbicide blocks or inhibits. Example: PPO inhibitor
- Two herbicides can share the same MOA, but still have different SOA. MOA is "how" and SOA is "where" (the specific protein the herbicide binds to and inhibits function), making SOA the most important to consider for resistance management.
- Premixes offering multiple active ingredients may or may not offer multiple SOA. A nice reference that lists premixed herbicides by their trade name can be found here: https://iwilltakeaction.com/uploads/files/55620-1-ta-hrm-classificationposter-fnl.pdf.

WHY SHOULD YOU USE EFFECTIVE WEED RESISTANCE MANAGEMENT STRATEGIES?

- Make a profit or increase profit potential
- Investment in land value
- Control weeds that are no longer controlled with postemergence applications
- Resistance management

1. ***Start Clean –*** Start with tillage or an application of a burndown plus preemergence residual herbicide. If you choose tillage, make sure your tillage equipment is set correctly to fully uproot and kill emerged weeds. Weeds surviving tillage will be very difficult to control with postemergence herbicides later in the season. If you choose a burndown plus preemergence residual herbicide, your preemergence residual herbicide should contain three, or at least two, SOA that have activity against the problem weeds historically present in your field.
2. ***Two-Pass at Full Rates –*** A pre-followed by a well-timed postemergence herbicide application can provide longer target weed control. Full rates of herbicides need to be applied to help avoid weed escapes, increase residual soil herbicide activity and keep resistance at a minimum. Always apply herbicides at the proper timing. Applying herbicides to large weeds is similar to applying below label rates, the rate of the herbicide is not high enough to kill large weeds.

Herbicide applied to waterhemp at 2", 4", and 8" tall

3. ***Multiple Effective SOA With Overlapping Residuals –*** Target weed control is nearly impossible without good residual herbicide activity. Overlapping residual activity is the best way to manage resistant weeds. This means applying a second residual herbicide before the residual activity of the first herbicide dissipates to the point where weed emergence occurs.

Herbicides that deliver multiple effective SOA provide better weed control, help guard against development of weed resistance and improve management of herbicide resistant weeds. "Know Your Number" by counting the number of effective SOA you are planning to apply to each of your target weeds. Overlapping residuals, even of the same SOA, increase your Know Your Number value because the applications are at different times and on different weeds. In areas of heavy waterhemp or Palmer amaranth, "4 May Not Be Enough Anymore," to control the weeds all season long.

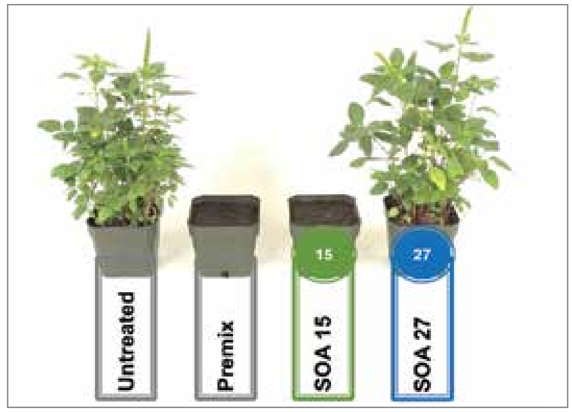
FIELDS ARE 83 TIMES LESS LIKELY TO DEVELOP WEED RESISTANCE WHEN 2.5 OR MORE EFFECTIVE SOA ARE APPLIED PER APPLICATION THAN 1.5 EFFECTIVE SOA[1]

FIELDS ARE 51 TIMES LESS LIKELY TO DEVELOP WEED RESISTANCE WHEN 3 EFFECTIVE SOA ARE APPLIED PER APPLICATION THAN 2 EFFECTIVE SOA[1]

The activity of the premix shown below and of its two individual active ingredient components in controlling Palmer amaranth, underscores the importance of knowing if an "active ingredient" will be effective. In this case, the SOA 2 active ingredients brought no agronomic value.

4. ***Diversified Management Programs –*** Use diversified management programs such as cover crops, mechanical weed control and crop rotation. Cover crops can suppress weeds through competition. It is important to research how a cover crop interacts with your planned weed control program and what type of cover crop can best suppress weeds in your field. Make sure you kill your cover crop quickly to avoid any allelopathy with the crop.

5. ***NO Weeds to Seed –*** Do not allow weeds to go to seed and add to the soil seed bank. Research has shown that weed species vary greatly in the amount of time that seeds remain viable in the soil. Pigweed and giant ragweed seed have a soil viability of approximately 2 to 4 years. In contrast, common lambsquarters has been shown to have soil viability of up to 70 years.



Effect of a premix herbicide and it's two SOA components on ALS-resistant Palmer amaranth

6. ***Good Agronomic Practices –*** Narrow rows, increased plant populations and other practices promote faster canopy closure and enable the crop to outcompete later emerging weeds. For example, in soybeans, 15-inch rows close canopy 25 days quicker compared to 30-inch rows[2]. Overlapping residual control is therefore all the more important in 30-inch production systems. Waterhemp and Palmer amaranth are sun-loving and long germination period weed species that can be managed with quick canopy closure.

PROTECT YOUR INVESTMENT

- The cost of preventing weed resistance is far less than weed resistance management.
- Weed and Resistance Management requires:
  - Multiple effective SOA
  - Overlapping residual activity
  - Proper timing and rate
- Premixes that deliver multiple effective SOA on driver weeds or hard-to-control weeds.
- Knowing resistance can be managed and is in your control.

NITROGEN AND SULFUR SIDEDRESS APPLICATIONS RESPONSE IN CORN

INSIGHTS

- Sulfur (S) deficiency is becoming more common in many areas of fields with lower organic matter.
- Sulfur deficiency symptoms often disappear as soils warm and S mineralization increases.
- Corn response to sulfur will be less likely in high organic matter soils.

INTRODUCTION

Applying nitrogen (N) in the fall or spring before planting is a good option for working towards a sufficient supply of N for plant growth, but much of this applied N can be lost before corn needs it most. On the other hand, applying excess N is an inefficient use of time and money and has negative environmental effects. Monitoring soil nitrogen availability and adding supplemental in-season nitrogen, when needed, can help minimize lost yield potential and prevent unintended consequences from over-application. Soil sampling-based recommendations and nitrogen application decision support tools are two options for predicting and addressing in-season nitrogen needs.

Sulfur (S) is another soil nutrient that can be in short supply as atmospheric S deposition has decreased. Sulfur is naturally present in organic matter, but like organic N it must be mineralized before becoming available to plants. Ammonium thiosulfate (ATS) is a form of S that is easily incorporated into either starter or sidedress N fertilizers.

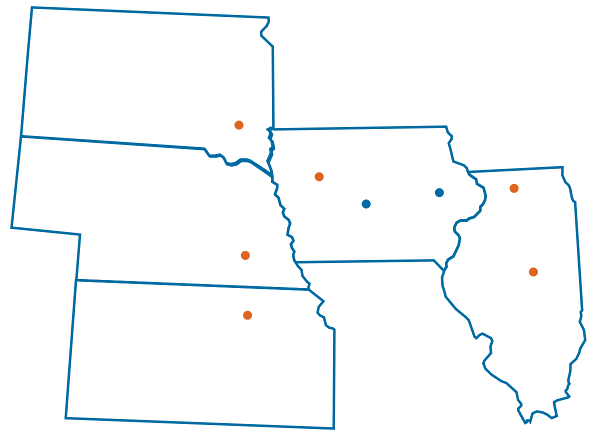


Figure 1. 2020 experimental sites, blue sites were lost to storm damage

SITE	PRE-SEASON N APPLIED (LB N)	LATE-SPRING NITRATE LEVEL (PPM)
Bridgewater, SD	150	43
Seward, NE	160	35
Clay Center, KS	175	34
Sac City, IA	217	52
Oregon, IL	225	65
Clinton, IL	200	26

Table 1. Nitrogen rates applied to entire trial before planting and soil nitrate levels prior to in-season applications

2020 ASSESSMENT OF IN-SEASON FERTILIZER APPLICATION

Golden Harvest® Agronomy In Action Research conducted trials at eight locations in 2020 to test response to sidedress N applications and any possible advantages of including sulfur in the form of ATS. Two Iowa locations were lost to storm damage, leaving Bridgewater, South Dakota, Seward, Nebraska, Clay Center, Kansas, Sac City, Iowa, Oregon, Illinois, and Clinton, Illinois.

The following five combinations of nitrogen and sulfur rates side dressed between the

V5-V6 growth stages were evaluated at all sites.

1) No in-season N application;

2) 50 lb N;

3) 50 lb N + 20 lb S (ATS and urea ammonium nitrate (UAN));

4) 75 lb N;

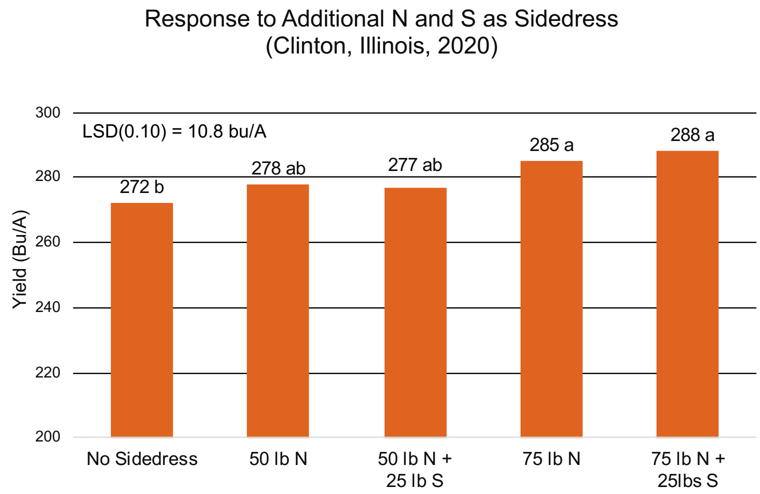
5) 75 lb N + 20 lb S (ATS and UAN). All sidedress applications were in addition to nitrogen applied to the entire trial by the location grower prior to planting (Table 1).

2020 NITROGEN RESPONSE

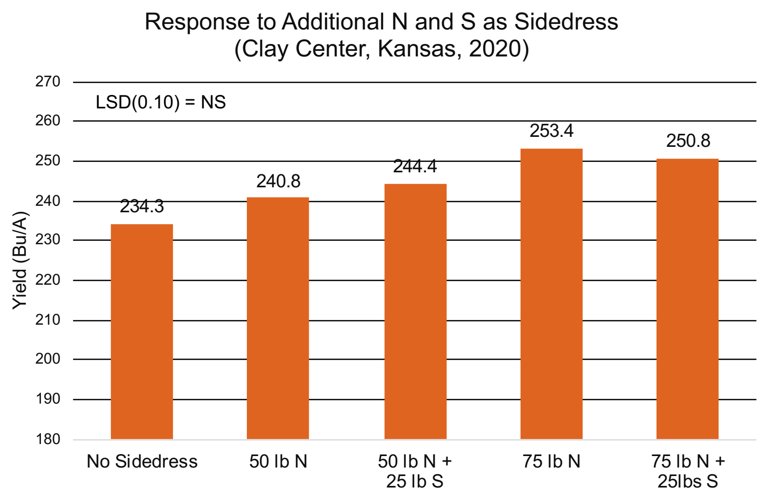
Hybrid response to 50 or 75 lbs/A of nitrogen was inconsistent across the 6 trial locations harvested in 2020. Extreme variability within many locations left much of the data unusable. Hybrids receiving an additional 75 lbs of nitrogen at Clinton significantly increased yield by 13-16 bu/A (Graph 1). Smaller increases of 7-8 bu/A were seen with the 50 lbs N rate. Numerical increase of 6.5-10.1 and 16.5-19.1 bu/A were also seen with sidedress applications of 50 and 75 lbs/A N respectively at Clay Center (Graph 2). No other locations consistently responded to in-season N.

2020 SULFUR RESPONSE

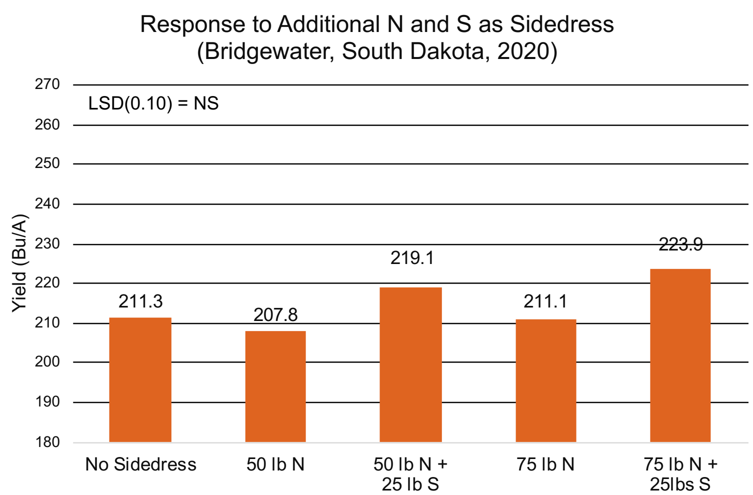
Bridgewater was the only site with any type of response to adding sulfur when sidedressing nitrogen. Although responses were not statistical at Bridgewater, similar increases of 7.8 and 12.6 bu/A were observed when S was applied with either the 50 or 75 lb



Graph 1. Response to nitrogen at Clinton, Illinois



Graph 2. Response to nitrogen at Clay Center, Kansas



Graph 3. Response to sulfur at Bridgewater, South Dakota

N rate respectively (Graph 3). The additional nitrogen did not appear to have any effect on yield at this location. Approximately 95% of the total sulfur in soils comes from organic matter. Due to this, responses to S are observed less frequently in soils with organic matter levels greater than 4%.[1] There are still instances where small responses can be observed in higher organic matter soils. Sulfur must mineralize from its elemental form into sulfate before plants are able to take it up from soil. The process of mineralization is known to slow in cooler soil temperatures and thus, signs of deficiency, such as yellow striping, may be seen with young plants but not visible with later growth as soils warm and S mineralization rates increase. Due to relatively high soil organic matter levels at the 2020 test sites, it is likely there were sufficient S levels already available to the plant. Sulfur will also be less readily available in soils with low or high pH levels and like nitrate, once mineralized to the sulfate form, S can easily leach. Although there is no established definition of the optimum soil test sulfur level, none of the trial sites tested below 7 ppm.[2] Other studies across the Midwest on lower organic matter soils known to be S-deficient have found sidedressing additional S may benefit corn yield.[3] With roughly 34 lbs of S removed in a 200-bushel corn crop and the reduced amounts of sulfur being delivered from the atmosphere, more response to sidedressed S is expected over time.[4] Scouting and documenting field areas appearing yellow, and confirming it is due to sulfur deficiency through tissue sampling, may help identify fields more likely to see a response to sidedressed S. ATS is readily available and may be easily applied with sidedressed nitrogen. Targeting lower organic matter soils and applying test strips within fields may be another good method to identify responsive fields to ensure a good return on the sidedress investment.

DATE, STAND AND CORN RELATIVE MATURITY ROLE IN REPLANTING

INSIGHTS

- Planting date trials help determine if yield and economic response are significant enough to warrant replanting.
- Costs of replanting must be taken into consideration.
- Avoid switching to relative maturities excessively earlier than a normal short season hybrid.
- Seeding rate adjustments are likely unneeded due to delayed corn planting.

Growers consider replanting corn when plant stands are below optimum or the stands are non-uniform. Reasons for poor stands include planter malfunctions, seed germination, soil conditions, insects, diseases, pesticide or fertilizer injury, flooding, frost and other factors.

MEASURE EXISTING STAND

To decide if it is economically feasible to replant a corn field, specific steps should be followed. First and foremost, determine the existing stand of the field in question. To estimate the stand, count the number of healthy plants in a length of row that equals 1/1,000th of an acre (Table 1) and multiply the number of plants by 1,000. Take several counts throughout areas of the field to get an accurate final stand. If stand loss is occurring in distinct zones, focus stand count measurements in those areas.

ROW SPACING	LENGTH OF ROW
INCHES	FEET INCHES
15	34' 10"
20	26' 1"
22	23' 10"
30	17' 5"
36	14' 6"
38	13' 10"
40	13' 1"

Table 1. Length of row equivalent to 1/1,000th of an acre at various row spacings

EXPECTED YIELD OF REPLANT DATE

After determining current stand, it is important to determine the earliest date replanting could occur so that current and replant yield potential can be compared. Estimating the potential yield of replants at later-than-optimal dates and comparing to the anticipated yield of the current reduced stand can be challenging. Previous research has been conducted evaluating the effect of planting date and plant population on grain yield (Benson, 1990; Nafziger, 1994).[1,4] Golden Harvest has created a replant calculator that can be used to aid in making replant decisions that can be found at https://geodav.syngentadigitalapps.com/ReplantApp/.

By entering current planting date and stand, as well as replant dates and expected costs to replant, the calculator will compare the economic outcomes of replanting to keeping existing stands. When the expected difference in yield returns more money than the cost of replanting, then replanting should be considered.

Many additional factors play into a replant decision, such as crop insurance, the cost of replant seed, seed availability, potential pest problems, nitrogen program, cost arising from higher grain moisture at harvest and more. The cause of the original stand loss is also important. If the poor stand is due to fertilizer injury, herbicide injury, disease or insect infestation, there is potential for the replanted crop to also be affected.

RE-PLANTING SEEDING RATE AND HYBRID DECISIONS

After all factors are examined and the correct economic decision is to replant, seeding rate and hybrid selection must be considered. Previous research studies show contradicting results of an interaction between plant population and hybrid relative maturity and planting date. Nafziger (1994) concluded as planting date is delayed, there is no yield advantage to changing the targeted planting population or to planting a shorter-season hybrid in Illinois.[4] In Ohio, Lindsey et al. (2015) found some environments where populations should be reduced to optimize yield when planting in June.[3] Lauer et al. (1999) determined that switching from full-season to shorter-season hybrids was advantageous when planting was delayed to mid- to late-May in Wisconsin.[2]

Regardless of the yield potential of switching hybrids, it is important to consider the potential risk of a fuller-season hybrid not reaching physiological maturity before a killing fall frost. In addition, the increased risk of fungal leaf diseases, especially gray leaf spot and northern corn leaf blight, with late-planted corn might warrant switching to a more disease-resistant hybrid. Early-planted fields adjacent to later-planted fields can be a source of disease spores that can infect the late-planted corn at a younger stage in the life of the corn plant (Vincelli, 2003).[5]

2020 NEBRASKA PLANTING DATE TRIAL

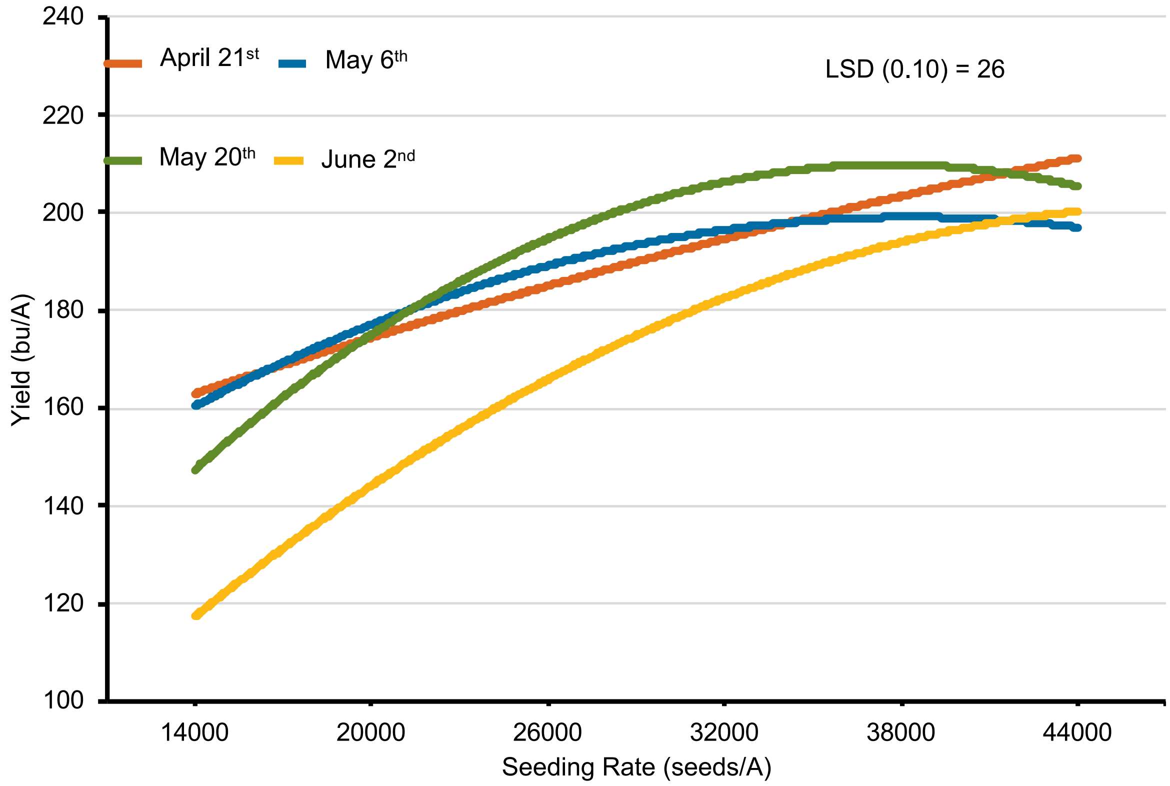
The lack of recent data on replant decisions is a concern, given that planting populations and hybrids have progressed considerably over the past couple decades. The Golden Harvest® Agronomy In Action research team has set out to update replant decision information with new hybrids and updated seeding rates. The wet spring of 2019 and the derecho in 2020 hindered the ability to acquire sufficient data to update recommendations. Only 1 of 6 possible locations over the last two years has provided good results. In 2020 at Seward, Nebraska, six seeding rates were planted ranging from 14,000 to 44,000 seeds/A on four planting dates: April 21, May 6, May 20, and June 2. A mid-season (G09Y24-5222A; 109-day RM) and full-season (G15L32-3330; 115-day RM) hybrid were planted at all seeding rates and planting dates.

PLANTING DATE AND SEEDING RATE INFLUENCE ON GRAIN YIELD

June planting dates yielded 20-23 bu/A less than the earlier planting dates, however there were little differences among earlier planting dates when averaged across seeding rate and hybrids. Planting in April or June achieved the highest yields with a seeding rates of 44,000 seed/A while the May 6 planting date maximized yield at 32,000 seeds/A. Planting 38,000 seeds/A resulted in the highest yield for the May 20 planting date (Graph 1).

Yield reduction from delaying planting until June was further accentuated by poor stand establishment at that planting date. The response to increasing seeding rates in June is largely due to the fact that final stands were significantly less than earlier dates.

Lindsey et al. (2015) attributed the interaction of planting date and plant population on plants being at different growth stages, depending on the planting date, when environmental stresses occurred throughout the season.[3] For



Graph 1. Grain yield response to planting date and seeding rate averaged across two hybrids at Seward, Nebraska, in 2020

example, flowering is a critical growth stage when stresses such as low soil moisture can impact pollination and reduce yield. Drought stress can occur at different points throughout the growing season. If plants from one of the planting dates happened to be flowering during this time, it is likely the higher plant population would be more negatively impacted than the lower plant populations for that planting date. This may partially explain the response to higher seeding rates when planted in April as compared to May in 2020.

WHEN TO THINK ABOUT REPLANTING

Hypothetically, a grower in Seward was targeting 38,000 plants/A to help maximize yield but suffered significant stand loss and could not replant until early June. According to Graph 1, if the original planting date was in late April, the existing stand must be lower than 30,000 before there is a yield advantage for replanting. If the original planting date was in mid- to late May, replanting would achieve a greater yield when the existing stands are lower than 24,000 plants/A. All other costs associated with replanting must be considered before deciding whether to replant.

EFFECT OF RELATIVE MATURITY

When averaged across planting date and plant population, G09Y24-5222A yielded 6 bu/A more than G15L32-3330. In our Nebraska trial, there was no hybrid interaction with planting date suggesting there was no need to change hybrid if planting at a later date. This is likely due to very similar local adaptability and overall yield potential between the two hybrids, regardless of relative maturity. However, when examining historical planting

date trials, there has commonly been a yield advantage for fuller season hybrids in general. Fuller-season hybrids are typically able to have an extended grain fill period, resulting in increased kernel density and depth. However, a killing fall frost is a concern with planting late or a too full-season RM and must be taken into consideration when selecting hybrids. On average, the 109-day relative maturity was 1% drier at harvest than the 115-day hybrids across all planting dates and plant populations.

CONCLUSION

This data is only from one location during one year. The results should be supplemental to previous studies evaluating replant decisions. Hopefully the weather cooperates in the future and the Golden Harvest agronomy research team can add more data points to this study and increase the confidence level of the conclusions. Having sufficient data to recreate a modern replant decision chart and aid growers with the difficult decision on whether to replant is the ultimate goal.

IN-FURROW STARTER FERTILIZER INFLUENCE ON SOYBEAN EMERGENCE AND YIELD POTENTIAL

INSIGHTS

- The potential risk of seedling injury and stand loss with in-furrow starter applications warrants the use of alternative methods of fertilizer placement in soybeans.
- In-furrow starter fertilizer applications consistently reduced final soybean stand.
- Achieving a final soybean stand of at least 100,000 plants/A is important to maximize grain yield potential.

Applying in-furrow starter fertilizer is the practice of placing fertilizer directly on or near the seed in-furrow at planting. The placement of immobile nutrients near the seed at planting has been shown to have both an agronomic and economical benefit in corn (Kaiser et al., 2005 and Kaiser et al., 2016).[1,2] These positive responses are more common in cooler climates where early season root growth may be limited and corn plants struggle to accumulate the necessary amount of nutrients without the aid of in-furrow starter fertilizer.

In-furrow starter fertilizer on soybeans is a less studied and less common practice among growers. Caution must be taken when applying fertilizer in close proximity to germinating soybean seeds because they are more sensitive to excessive concentrations of fertilizer salts than corn. Salt injury occurs when the concentration of ions in the soil is greater than the concentration of ions within the plant cells. The high osmotic pressure created by the fertilizer salts causes water to move out of the plant cells and into the soil. As water moves out of the plant cells, the tissue desiccates and becomes blackened or "burned," eventually leading to death of the plant tissue.

In general, nitrogen- and potassium-containing fertilizers have a higher salt index than phosphorus-containing sources. Due to the potential for salt injury when applying fertilizers near the seed, many fertilizers labeled as "seed-safe" will use potassium acetate as the potassium source, which has a roughly 60% lower salt index than potassium chloride.

Soil conditions play a large role in the potential risk of seedling injury to in-furrow fertilizer applications. Moist soils help dilute fertilizer salts and diffuse away the band reducing the osmotic pressure. In dry soils, little diffusion takes place and the concentration of salts near the seed remains high. Soils with low cation exchange capacity (CEC), coarse-textured soils with low organic matter, have a lesser ability to react with the fertilizer compared to high CEC soils meaning the concentration of fertilizer salts in the soil solution remains higher. Therefore, the potential for fertilizer burn is greater in sandy, low organic matter soils particularly in dry springs.

SOYBEAN STARTER FERTILIZER TRIALS

The Golden Harvest® Agronomy In Action research team implemented 8 trials across the Midwest, evaluating the effects of seeding rate, in-furrow starter fertilizer and variety on final soybean stand and grain yield potential (Figure 1). The soil types at these locations were either loam, silt loam or silty clay loam with organic matter ranging from 1.9 to 4.0% and CEC from 16.9 to 22.2 meq/100g (Table 1). All locations received a minimum of 0.5 inches of precipitation within 2 weeks following planting.

Five targeted seeding rates were planted with and without in-furrow starter fertilizer across two different relative maturity varieties at each location. The fertilizer source was the combination of NACHURS playmaKer® (2-6-16) applied at 2 gal/A and NACHURS CropMax® (2-0-2-0.1B-0.15Cu-0.3Fe-1.5Mn-0.0005Mo-4Zn) applied at 1 pt/A. Either GH2041X and GH2552X, GH2788X and GH3088X, or GH3934X and GH4307X varieties were planted depending on the geography.

TARGETED SEEDING RATE AND IN-FURROW STARTER EFFECT ON FINAL SOYBEAN STAND AND GRAIN YIELD

There was not a significant interaction between targeted seeding rate or in-furrow starter application and location on final soybean stand or grain yield. On average across all locations, final soybean stands ranged from 12 to 29% lower than the targeted seeding rate. Higher targeted seeding rates resulted in a greater percentage of seeds that did not develop into plants (Table 2). When in-furrow starter fertilizer was applied, final soybean stands were an additional 3% lower, on average, across all targeted seeding rates. The lower final soybean stands suggest there was salt injury from applying the in-furrow starter fertilizer in close proximity to the seed.

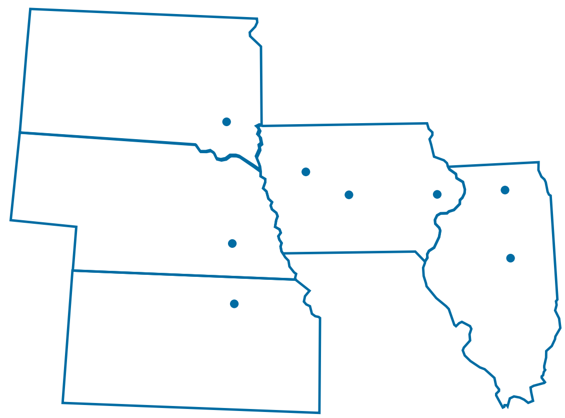


Figure 1. Soybean trial locations in 2020

Similar to previous studies conducted by the Golden Harvest Agronomy In Action research team, yield potential was maximized with a final soybean stand around 100,000 – 120,000 plants/A (Table 2). A final soybean stand below 100,000 plants/A significantly reduced grain yield.

Overall, there was no effect of in-furrow starter applications on grain yield. At each given seeding rate, grain yield was unaffected by in-furrow starter fertilizer applications suggesting the reduction in stand with in-furrow starter fertilizer applications was not enough to significantly impact grain yield (Table 2).

LOCATION	SOIL TYPE	ORGANIC MATTER	CEC	P‡	K‡‡
		%	meq/100g	ppm	ppm
Bridgewater, SD	Loam	2.5	22.2	14	176
Cedar Rapids, IA	Silty Clay Loam	4.0	20.0	39	174
Clay Center, KS	Silt Loam	1.9	16.9	18	328
Clinton, IL	Silt Loam	4.0	18.8	45	266
Malta, IL	Silty Clay Loam	3.8	19.2	21	323
Seward, NE	Silt Loam	2.2	18.1	18	293
Slater, IA	Loam	3.0	18.6	28	151
Storm Lake, IA	Loam	2.2	19.6	50	223

‡ Weak bray test (20-30 ppm considered adequate)
‡‡ Ammonium acetate test (175-250 ppm considered adequate)

Table 1. Soil test values for 8 locations across the Midwest

	NO IN-FURROW STARTER FERTILIZER APPLIED		IN-FURROW STARTER FERTILIZER APPLIED	
Targeted Seeding Rate	Final Soybean Stand	Grain Yield	Final Soybean Stand	Grain Yield
plants/A	plants/A	bu/A	plants/A	bu/A
60,000	52,754	66.9	51,184	66.1
100,000	86,260	72.6	82,968	72.5
140,000	110,339	77.9	107,595	78.1
180,000	139,593	79.7	134,672	78.0
220,000	164,148	78.2	157,163	79.0

LSD (0.10) Grain yield = NS
LSD (0.10) Final soybean stand = NS

Table 2. Effect of targeted seeding rate and in-furrow starter fertilizer on final soybean stand and grain yield averaged across 8 locations and 2 varieties

EFFECT OF VARIETY ON GRAIN YIELD

In general, varieties GH2552X, GH2788X and GH3934X had a greater final stand compared to GH2041X, GH3088X and GH4307X at their respective locations. However, grain yield responses to variety were inconsistent, with 4 out of 8 locations having a significant response to variety. The earlier maturity variety yielded higher in 3 out of the 4 responsive locations. Any targeted seeding rate or in-furrow starter by variety interaction was inconsistent across the 8 locations.

Varieties had similar responses to in-furrow starter fertilizer applications and targeted seeding rates suggesting the selected variety should not impact the targeted seeding rate or decision to apply in-furrow starter fertilizer.

CONCLUSION

Applying fertilizer in a band near a growing plant reduces nutrient tie-up and aids the ability of the plant to utilize those nutrients. Although we did not observe a response in our trials, these application methods have potential to increase yield, but also have beneficial effects on the environment, reducing nutrient loss through leaching or runoff. However, caution must be used when applying fertilizer in-furrow to sensitive crops such as soybeans. This study demonstrates the inherent risk of salt injury and losing final soybean stand when applying starter fertilizer in-furrow. Fertility on soybeans is still critical to attaining high yield potential, and alternative applications methods can be used to reduce the potential risk of injury from fertilizer. These results align closely with previous work looking at the effect of in-furrow starter fertilizer on final plant stand and grain yield (Rehm and Lamb, 2010).[3] Using starter fertilizer out of furrow in a band placed 2 inches to the side and 2 inches below the seed would be a safe alternative to an in-furrow application while still achieving the benefits of nutrients applied in a band near a growing plant.

SALTRO® PERFORMANCE IN 2020 SUDDEN DEATH SYNDROME RESEARCH AND ON-FARM TRIALS

INSIGHTS

- Saltro® fungicide seed treatment has proven to deliver economic returns when sudden death syndrome (SDS) is present and maintain yield potential when SDS is not present.
- Soybeans treated with Saltro outyielded ILEVO® treated soybeans by 1.28 bushels.

SDS is a widely distributed soybean disease that can be economically devastating in some years. The pathogen responsible for SDS, Fusarium virguliforme, overwinters in the soil and crop residue prior to infecting soybean roots early in the season.[1,2,3] Conditions that favor this disease are:

- Early planting into cool soil conditions
- Wet soils that delay emergence
- Excessive precipitation during the growing season, particularly at flowering
- Fields with a history of SDS or soybean cyst nematode (SCN)
- Cooler temperatures during flowering and pod fill stages

MANAGEMENT OPTIONS

Although infection occurs very early, foliar symptoms rarely occur until the late reproductive stages, making in-season foliar applications typically ineffective for SDS management. Delaying the planting date for warmer, drier soils can minimize early infection. However, this can be challenging, depending on the planting capacity of a grower and the number of acres needed to plant. Weather and its influence on favorable planting conditions can also further delay planting dates, resulting in lower yield potential. Selecting varieties based on SDS tolerance has been the best management strategy up until the recent introduction of several seed treatment options. Two of the most common seed treatments offered are

Figure 1. Leaf yellowing and lesions caused by SDS

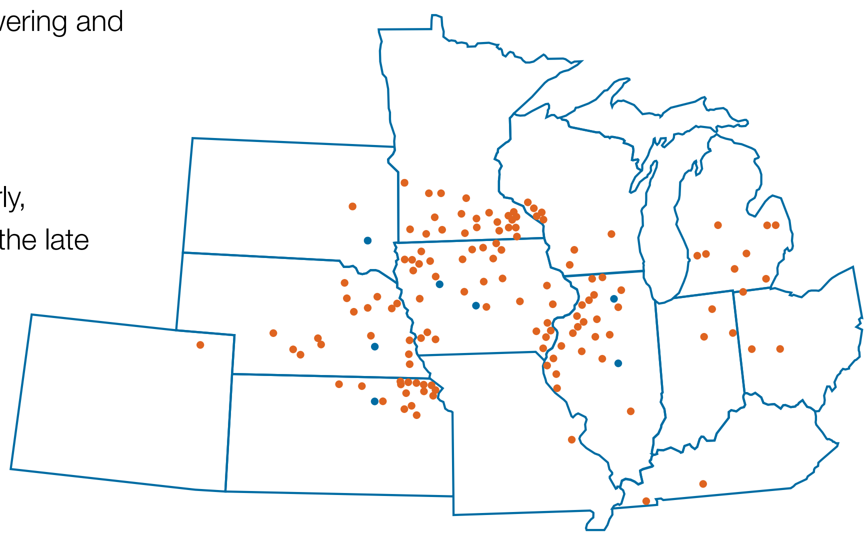
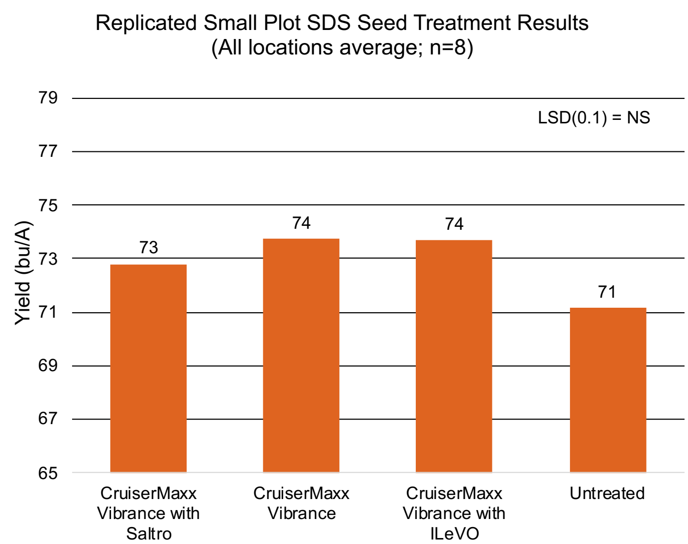


Figure 2. Map of trial locations. Blue dots indicate replicated small plot trials and orange indicate on-farm strip trials.

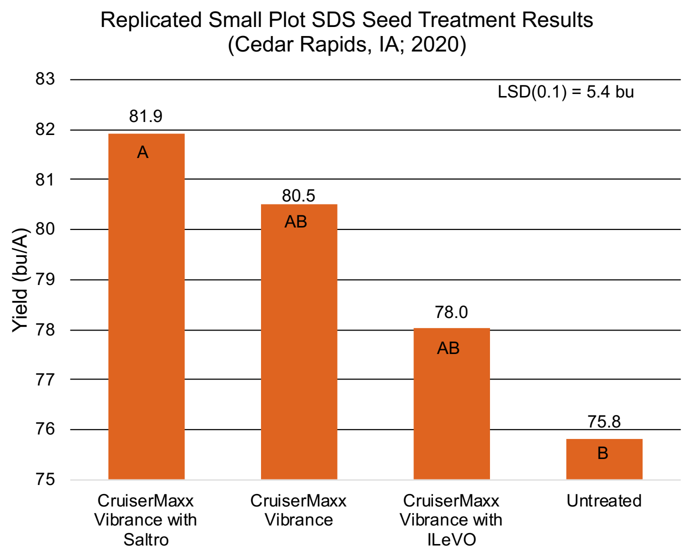
biologicals and succinate dehydrogenase inhibitors (SDHI). The SDHI class of products has proven most effective of the two options at managing SDS in previous trials. Less is known about the need to combine variety tolerance and seed treatment management options as compared to using the two independently.

SDS FIELD TRIALS

A series of both small plot replicated and large plot strip trials were established in the 2020 growing season (Figure 2). Replicated small plot trials were conducted at 8 locations by Golden Harvest® Agronomy In Action research to evaluate variety tolerance and seed treatments independent and combined effectiveness for managing SDS. CruiserMaxx® Vibrance® (CMV) was used as the base fungicide/insecticide treatment. Saltro® and ILEVO® seed treatments were added independently to the CMV treatment base to understand each of their ability to manage SDS and impact on crop safety. A CruiserMaxx Vibrance alone treatment was included to compare both SDS treatments against. All seed treatments were applied to an SDS susceptible (S) and tolerant (T) variety of similar adapted relative maturity (RM) for each location. Depending on the local RM, either GH2537X (S) and GH2788X (T) or GH3546X (T) and GH3759E3S (S) were planted. In addition to small plot trials, 142 on-farm strip trials were conducted with local growers to compare soybean seed treatments across more management practices and a larger geography (Figure 2). Strip trials ranged between 4-54 rows wide and 150–2,000 feet in length. Depending on the location of the strip trials, different combinations of the same four seed treatments previously mentioned were used. Typically, only one soybean variety was planted per strip trial location.



Graph 1. Yield comparison of seed treatments averaged across all locations



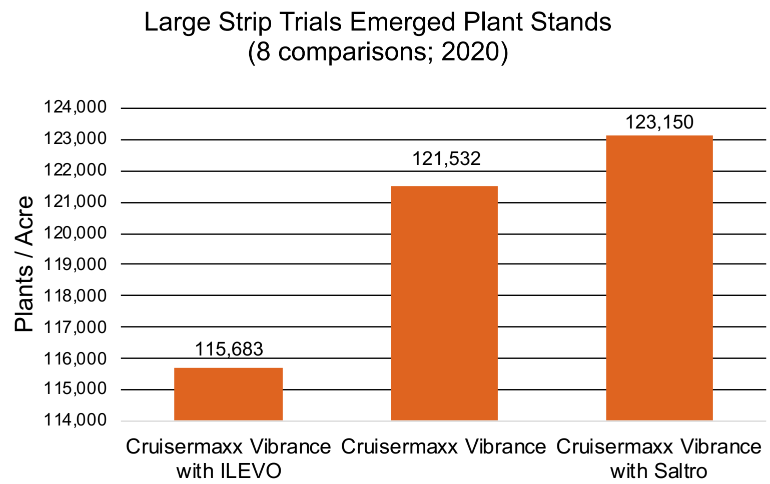
Graph 2. Yield comparison of seed treatments at Cedar Rapids, Iowa

REPLICATED SMALL PLOT RESULTS

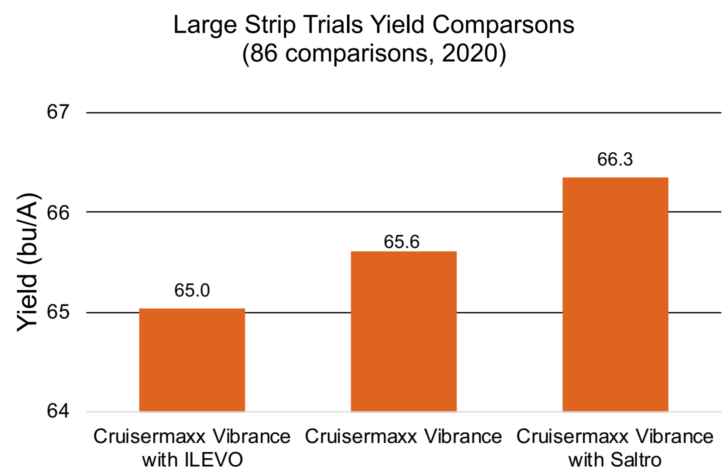
Variety differences were present, but differences between varieties were not consistent across locations. The susceptible variety often was the highest yielding variety at a location. There was not a consistent trend where seed treatment response was increased due to the variety being tolerant or susceptible. This is likely due in part to not having high enough overall SDS disease presence to make any interactions apparent. Very few symptoms of SDS were present in untreated plots at any of the small plot locations, indicating overall, SDS wasn't a major yield limiting factor in these results. This is also likely why SDS susceptible varieties outperformed tolerant varieties at several sites. When averaged across all 8 locations, no SDS seed treatment increased yields over the fungicide/insecticide check, likely due to a lack of SDS presence (Graph 1). Cedar Rapids, Iowa, was the only site with yield differences. Numerically, Saltro added 1.4 more bushels to CMV and statistically yielded 6 bushels more than the untreated entry at Cedar Rapids (Graph 2). Although no foliar symptomology was observed at Cedar Rapids, there was likely minor SDS root infections or other diseases present that led to yield differences.

STRIP TRIAL RESULTS

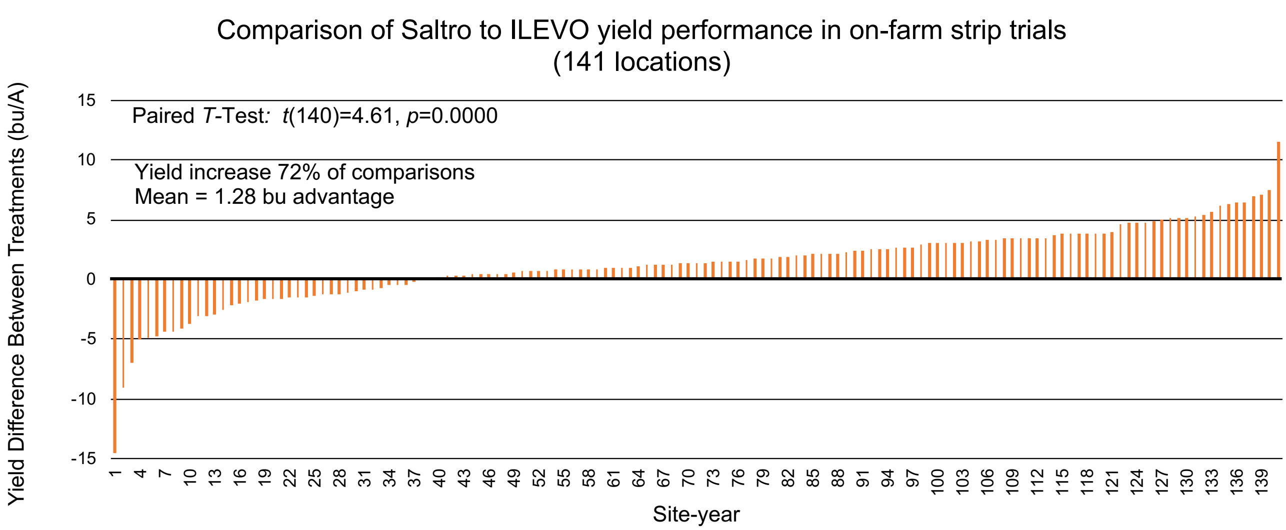
SDS presences was not consistently captured through foliar or root rot ratings at 2020 strip trial locations, making it difficult to quantify



Graph 3. Comparison of seed treatments from large strip trials



Graph 4. Comparison of seed treatments from large strip trials



Graph 5. Saltro win percentage over CruiserMaxx + Vibrance (top panel) and ILeVO (bottom panel) in 2020 strip trials

locations with actual disease presence. However, based upon trial cooperator feedback, SDS foliar symptoms were infrequent at most locations in 2020. Of the eight locations reporting stand establishment, there were differences between treatments showing a reduction in overall stand due to the ILEVO treatment (5,869 plants/ac fewer). Within the same locations there was a slight increase in stand establishment when Saltro was added (1,618 plants/ac more) (Graph 3). Brown necrotic and damaged cotyledons were frequently observed on ILEVO treated plants that were able to emerge. At these locations, adding Saltro to CruiserMaxx Vibrance resulted in yield gains slightly less than 1 bushel, and ILEVO treatments yield slightly less than the non-SDS treatment (Graph 4). Based on cooperator feedback, it is suspected that the lack of reported symptoms of SDS indicate overall low disease development at the majority of the sites and explain not observing larger yield gains from using SDS treatments in 2020. The small yield increase from Saltro treatments in low disease environments does reconfirm the good crop safety of Saltro. Although final stands were not available at the majority of locations, it can be speculated from locations reporting emergence (Graph 3) that reduced stands from ILEVO were likely part of the reason Saltro treated seed outperformed ILEVO in 72% of the 141 comparisons (Graph 5). The 2020 strip trial data show a clear performance advantage of Saltro over ILEVO in both emergence and yield.

Figure 3. Late season plant health benefit from Saltro (left) compared to soybeans without (right)

SUMMARY

Results from these trials show the benefit that seed treatments can provide for managing SDS in soybeans. Due to lack of consistent SDS presence, these trials were unable to determine if the value of an SDS treatment was similar when applied to SDS tolerant varieties as when applied to susceptible varieties. When conditions are conducive for SDS development, adding Saltro will help preserve leaf area, maximizing photosynthesis throughout the season and leading to improved yields. In addition to yield, the phytotoxicity symptoms on cotyledons and reduced early vigor observed with ILEVO results in reduced photosynthetic capacity at the critical plant establishment stage (Figure 3). Reduced stands from ILEVO may not always have direct impact on yield. However previous seeding rate trials indicate that once final stands reach less than 100,000 plants per acre, yield loss occurs more frequently. Fields treated with ILEVO should be monitored closely if weather causes inclement soil conditions for emergence. Overall, Saltro appears to provide improved performance over ILEVO in both yield and crop safety.

PYTHIUM IN CORN AND SOYBEANS

INSIGHTS

- Earlier planting, reduced tillage and increased use of cover crops management practices have inadvertently increased potential for *Pythium* occurrence.
- Improving soil drainage and planting into warmer soil temperatures narrows *Pythium's* critical early infection period.
- The anticipated registration of Vayantis® seed treatment fungicide offers broader protection across *Pythium* species.

Among the most important seed and seedling diseases in U.S. corn and soybean production are those caused by *Pythium* species.[1] Due to seedling establishment challenges, vigor reduction and the associated loss of plant stand caused by species of *Pythium*, this disease is counted among the most economically impactful of the top three corn and soybean pathogens.[1,2] Many of the same *Pythium* species cause significant damage to both corn and soybeans.[3,4]

Soybean and corn *Pythium* species yield losses are predictably highest in years where cool and wet conditions persist.[5] Although most associated with cool soils, *Pythium* species vary in their optimum temperature for growth; with the dominant species in any given area differing across a field during the crop calendar. Complexes of *Pythium* species are often found; not necessarily single species. *Pythium* is most often the first pathogen active in the Midwest during a growing season as it prefers cooler soils, relative to other plant pathogens.[1,6] It also requires free soil water for oospores to germinate and produce mycelium or sporangia (spore cases) which then release mobile zoospores capable of plant infection.[1,6]

Figure 1. Corn plant stand thriftiness and population reduced in southeast Iowa by Pythium infection under conservation tillage system

Why is *Pythium* increasingly important to U.S. corn and soybean production? Many factors promote *Pythium* infection, but cooler, wetter conditions are likely the most important due to earlier planting. Over the last three decades, soil tillage practices have consistently been moving toward reduced field trips with more plant residue left on the soil promoting increased soil protection from erosion. Reduced till and no-till both slow soil temperature increases as compared to traditional full tillage (Figure 1).[7,8] The same is true of soil moisture. Reducing tillage tends to increase early season moisture leading to longer periods of time that soils remain cool and damp.[7,8] Another factor is that increasingly university Extension specialist research has shown planting earlier provides greater access to longer maturity, higher yielding corn hybrids and soybean varieties providing increased final yields while avoiding fall frosts.[2,9] While these factors have encouraged earlier planting, average farm size has also increased significantly over the last fifty years. This has led to earlier planting to achieve more farm acres being planted within the ideal planting date window so that vulnerable flowering periods avoid heat and drought stress in later summer months. In more recent years, cover crop adoption has also increased. Some years, planting prior to terminating cover crops can happen due to spring weather. In these situations, cover crops have been suspected of acting as a bridge crop for disease establishment, intensifying damage from diseases like *Pythium* in corn.

SYMPTOMS

Pythium species are well known to cause seed rot, preemergence damping off disease, root rot, seedling blight and postemergence damping off. The most commonly associated symptoms with field infection of *Pythium* are general loss of early seedling vigor and plant stand.[3] In corn, plant stand loss is most often associated with yield loss proportional to the stand loss. In soybeans, stand loss is less directly correlated to yield loss due to soybean plants being able to compensate because of their physiology and multiple fruiting positions on the plant. The leading soilborne fungi causing corn seed rot and decay of roots are *Pythium* species.[2,6] *Pythium* root rot is found in all soybean and corn producing regions of the United States. These crops are attacked not by one species but a complex of *Pythium* species. Soil temperature and moisture are primary factors influencing infection and largely dictate which *Pythium* species predominate and how disease-causing they are.

Infected seeds often have cracked seed coats and are soft and rotted with a foul odor.[1,6] Within the cooler end of the temperature range for *Pythium*, seeds are slower to germinate and seedling establishment time proportionally longer. This allows greater infection opportunity, increasing stand infection and potential for stand loss in both corn and soybeans.

Seriously infected seedlings exhibit visible lesions and root system discoloration.[1,6]

Figure 2. Postemergence damping off of soybeans caused by Pythium species

Proportionate to infection, some seedlings may not emerge and establish a stand, or what is called preemergence damping off. However, those plants establishing a stand are not out of danger. Soybean infections can occur on the upper hypocotyl (early stem). Within a few days, depending on level of infection and environmental conditions, they may collapse and die, which is referred to as postemergence damping off (Figure 2). *Pythium* lesions can range from so small they are not detectable with the human eye to large areas easily visible. They may be found on hypocotyls and cotyledons (early stem and leaves).[1]

Corn seedlings infected with *Pythium* that do emerge often have visible lesions and root discoloration.[6] Often emerged, infected corn seedlings exhibit variable leaf color from

Figure 3. Corn plant lost to Pythium postemergence damping off

paler yellow to darker blue-green colors as seen in Figure 1. Depending on growing environment (temperature and moisture levels), as well as the level of infection, some seedlings may grow out of the infection while more seriously infected plants are lost to postemergence damping off (Figure 3). If plants don't ultimately die, they will often have much smaller, less developed root systems that continue with discolored rotting regions. Depending on temperature cycling (between warmer and cooler) and the soil moisture regime, these weakened plants may yet succumb to *Pythium* through the V3-V4 growth stages. Conditions that promote rapid germination and seedling stand establishment are advantageous to avoiding serious *Pythium* infection and associated stand losses and yield losses.[1,6]

DISEASE CYCLE

Pythium species that cause corn and soybean disease are soil dwellers and overwinter in the soil and on plant residue as oospores.[1,6] Survival without live plant tissue, as oospores (resting sexual spores) get nourishment from dead or decaying organisms, can occur for many years.[6] Under favorable conditions, oospores germinate and produce mycelia or sporangia which produce and then release zoospores. Both mycelia and zoospores can infect germinating and developing corn and soybean seedlings.[1,6] Disease severity is largely governed by the initial amount of *Pythium* inoculum, susceptible host age and environmental parameters during infection.

Soil temperature and moisture are the principal environmental elements influencing *Pythium* species infection ability. Free water within the soil is required for zoospore release and for movement towards plant infection. *Pythium* species may be organized by the temperature range ideal for infection, which is reported to be between 50-70° F.[6]

MANAGEMENT

Little to no plant genetic source differences have been reported for *Pythium* species resistance through plant breeding.[1,6] Due to the fact that many plants provide host capabilities for *Pythium* species survival,

crop rotation has little impact within cropping systems. Cultural practices increasing the rate of germination and seedling establishment often also reduce *Pythium* infection opportunity. That is, improving soil drainage and planting into warmer soil temperatures narrows the critical early infection period. If no free water is available for zoospores to infect plants, even if cooler temperatures are present, *Pythium* infection is predictably reduced. Planting high quality seed free of chips and cracks has been shown to reduce *Pythium* infection as well.[1,6] Using a fungicide-containing seed treatment including metalaxyl is the most commonly used practice combating *Pythium* species across crops. The commercialization of ethaboxam occurred several years ago with predictable protection improvement. An exciting new development by Syngenta Seedcare will be the introduction of a new novel mode of action in the molecule, picarbutrazox, which will be marketed as the brand Vayantis® once it is registered by the U.S. EPA in late December 2020. Vayantis offers broader *Pythium* protection across species than either metalaxyl or ethaboxam. Increasingly, using two modes of action against *Pythium* is recommended by university Extension plant pathologists.

By protecting from primary pathogen infection, germination, early plant growth and seedling development are protected, leading to more robust root mass accumulation and increased end-of-season yield potential.

Reducing seedling stress and promoting practices that increase early soybean and corn growth and development rates appear correlated to reductions in early season seed rots, damping off and seedling blights including those caused by *Pythium* species.[2,5] Early season herbicide applications, cool soil temperatures, extremely high or low soil pH levels, deficient soil fertility levels and soil compaction all have been linked to increased early season disease.[1,6]

ENHANCING *PYTHIUM* AND *PHYTOPHTHORA* PROTECTION IN SOYBEANS WITH SEED TREATMENT OPTIONS

INSIGHTS

- A novel new *Pythium* and *Phytophthora* fungicide, Vayantis® seed treatment*, provides new options for managing diseases.
- Adding Vayantis seed treatment may benefit soybeans in environments where traditional seed treatments have lost efficacy by adding a second mode of action against *Pythium* spp.

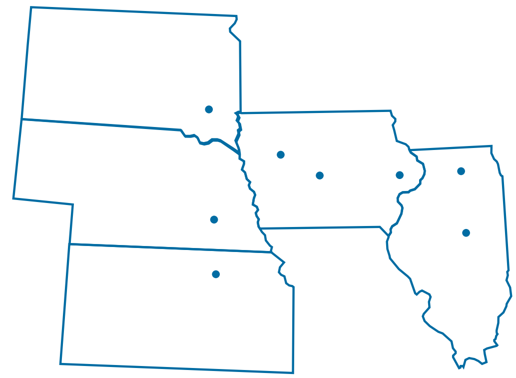


Figure 2. 2020 Golden Harvest Agronomy In Action seed treatment trial locations

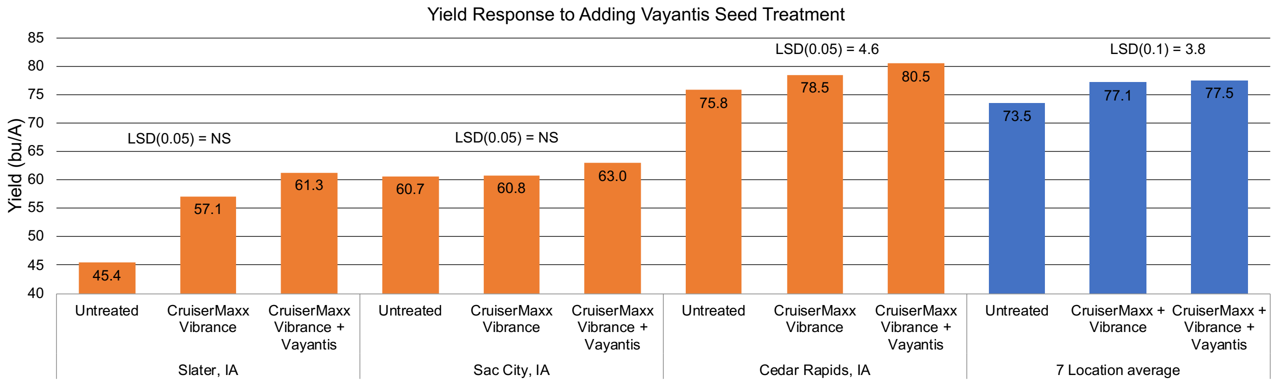
MANAGEMENT OPTIONS

Poor stand establishment in soybeans has several culprits. Early planting into cooler soils can slow emergence and make soybeans vulnerable to soilborne disease or insect damage. Reduced or no-till fields with large amounts of residue can further exacerbate these risks. More than one disease pathogen, such as *Pythium* spp., *Phytophthora* spp., Fusarium spp., or Rhizoctonia spp., can be responsible for poor stand establishment in early planted fields (Figure 1). Planting later into warmer, drier soils can lessen stand establishment risks, but may sacrifice yield advantages often seen with earlier planting. Unforeseen spring weather could further delay planting, resulting in even greater yield loss. Seed treatments such as CruiserMaxx® Vibrance® Beans seed treatment has historically provided good protection against the majority of diseases. However the primary active ingredient for *Pythium* management was introduced almost 4 decades ago and has been highly utilized on both corn and soybean seed. Continued use of a single herbicide, insecticide or fungicide has proven to be unsustainable for resistance management. Thus, the use of multiple pesticides that have different sites of action for an individual pest are recommended. Picarabutrazox, a seed treatment coming soon which will be marketed as Vayantis seed treatment*, is a novel second mode of action (MOA) seed treatment that has shown great activity on both *Pythium* and *Phytophthora* species.

Figure 1. Damping off in soybeans caused by Pythium spp.

SEED TREATMENT TRIALS

Golden Harvest® Agronomy In Action Research conducted trials at 8 locations (Figure 2) in the 2020 growing season to evaluate the potential of Vayantis as a second MOA when added to CruiserMaxx Vibrance base seed treatment. Each location compared untreated, CruiserMaxx Vibrance and CruiserMaxx Vibrance with Vayantis seed

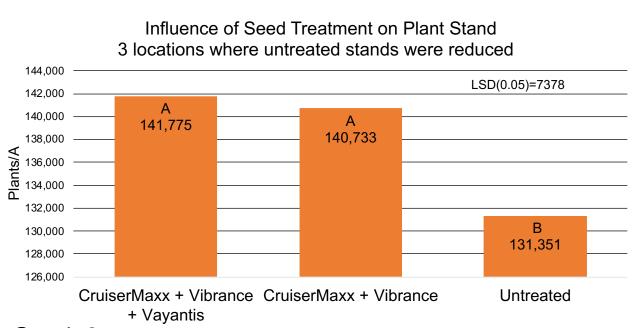


Graph 1. Yield response of seed treatments at locations with stand or yield differences and all location average

treatments on two varieties. The soybean varieties planted were either GH2537X and GH2788X or GH3546X and GH3759E3S depending on which relative maturity (RM) best fit the location.

RESULTS

In general, locations with the 3.4-3.7 RM varieties had good stand establishment and lacked yield differences between treatments due to lack of disease presence. However, many of the 2.5-2.7 RM locations observed yield and or plant stand differences among treatments. Seed treatment responses were similar across the two varieties at each location. Therefore, results were averaged across location to compare seed treatment main affects. Stand loss due to pythium varied across locations, but was most observable at the Slater, Sac City and Cedar Rapids, Iowa locations. Across the three locations having stand reductions, untreated soybeans averaged roughly 9,500 fewer plants per acre than treated soybeans (Graph 2). Vayantis treated seed had roughly 1,000 more plants than the CruiserMaxx Vibrance alone. Vayantis increased stands by 3,000 and 6,000 plants



Graph 2

per acre more than CruiserMaxx Vibrance alone at Slater and Cedar Rapids, Iowa, respectively (data not shown). In addition to improving stands, there was also yield increases from adding Vayantis observed at Slater (4.2 bu), Sac City (2.2 bu) and Cedar Rapids (2 bu). When averaged across all seven location, most of which did not have disease symptoms or stand loss, the yield advantage of adding Vayantis was still 0.4 bushel per acre (Graph 1).

SUMMARY

Although CruiserMaxx Vibrance provided good protection against *Pythium* in 2020 research trials, adding Vayantis increased yield potential by small increments and improved final stands at several locations with higher disease pressure. This indicates that the unique mode of action of Vayantis is a good complimentary fungicide to help ensure continued seed treatment performance in future years as *Pythium* spp. continue to evolve and adapt. Vayantis benefits will likely be more obvious in fields where current seed treatments have not been able to fully achieve maximum stand establishment. Unlike when introducing a new active ingredient for managing a previously uncontrolled disease, the value of Vayantis may not be as easily observed on a frequent basis but should ensure consistent protection in future years.

**A seed treatment coming soon from Syngenta; please check with your local extension service to ensure registration status; Vayantis is currently not registered for sale or use in the U.S. at the time of this being published.*

CHILLING INJURY TO PLANTED CORN AND SOYBEAN SEED

INSIGHTS

- Precipitation and cold temperature fluctuations within the first 48 hours after planting corn or soybeans can severely damage germinating seed and seedlings.
- Soil temperatures should be near 50°F and forecast to continue warming to ensure optimum growth and development after planting.
- Common damage symptoms such as "corkscrewing" and premature leafing are result of damaged outer cell layers of the mesocotyl (first internode of the stem).
- Wait 3-5 days after better weather appears to accurately assess the viability of remaining plants.

Setting crops up for success means planting when soil and environmental conditions are best. Early planting dates to maximize the length of the growing season are equally important to many producers. Limitations of planting capacity (acres per day) and the number of days suitable for field work in the spring can result in disregarding unfavorable weather forecasts to allow planting additional acres before the next storm. Figure 1 demonstrates a rapid drop in soil temperatures across a large geography following a cold front occurring from April 7 through April 14, 2020. Adequate soil temperatures for planting (≥50°F) existed across much of the area prior to this, although soil temperatures rapidly dropped in days following, potentially impacting seed germination and emergence. For example, soil temperatures reached 75°F near Salina, Kansas on April 7, but were at or near 40°F by April 14 and remained below 50°F for several days. There are risks associated with wet, cold soils within the first 48 hours after planting.

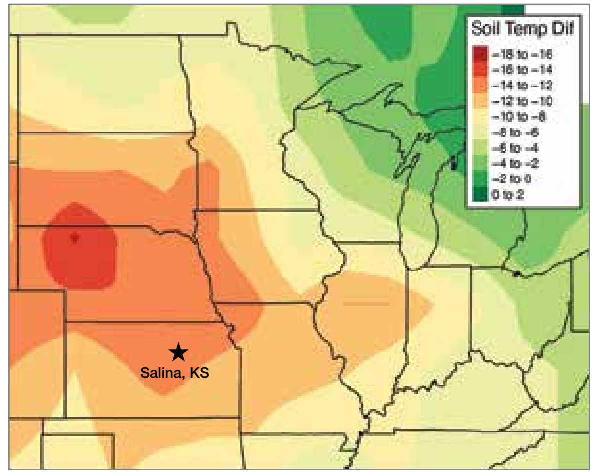
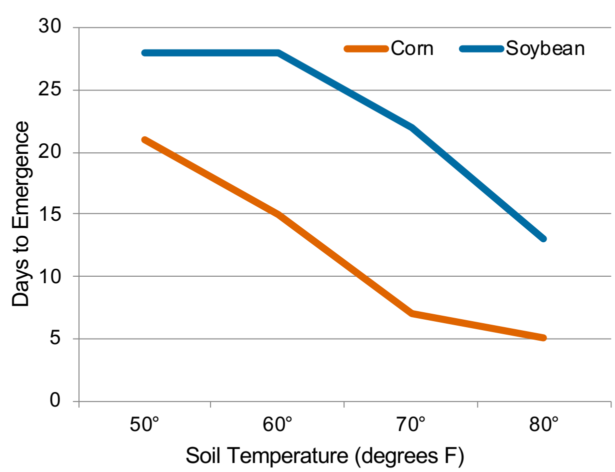


Figure 1. Soil temperature drop between April 7 and April 14, 2020

NORMAL GERMINATION PROCESS

The germination process is driven by soil temperature as much as it is by moisture. Under favorable moisture and temperature conditions, with good seed-to-soil contact, the planting-to-emergence process will take as few as six days for corn (Graph 1), but



Graph 1. Soil temperature influence on days to emergence

can take up to 5 weeks if soil temperatures drop below 50°F (data not shown). Soil temperatures of 50°F and above are needed to start inducing cell division and elongation. Consistent and warm soil temperatures help increase the rate of germination. Soil temperatures less than 50°F can be detrimental if occurring within the first 48 hours after planting.

IMBIBITIONAL CHILLING INJURY

Germination starts as soon as the seed begins to imbibe (absorb) water. A corn kernel will absorb about 30% and soybeans 50% of their seed weight in water, mostly within the first 24-48 hours after planting. This rapid uptake of water rehydrates the embryo of the seed, bringing the seed to life and starting germination. Starch stored within the seed will be the source of energy until roots begin establishing and leaves emerge from the soil to produce additional energy through photosynthesis. Seeds being rehydrated with cold rain or melting snow can result in damage to cell membranes known as imbibitional chilling. Hydration with chilled water can result in ruptured cells and cause swollen kernels, aborted radical development, terminated coleoptile growth and death of the seed. Symptoms of imbibitional chilling injury can appear as prematurely emerging leaves or swollen seed that never germinated. Injury will not always be seen with soil temperatures less than 50°F but will be more visible as temperatures near 40°F and cold rain or snow events occur within 24-48 hours of planting.

PREEMERGENCE FREEZING DAMAGE

Cold temperatures can also impact successfully germinated seeds prior to emerging from the soil. Injury at this timing usually damages the outer cell layers of the mesocotyl causing premature leafing out of the plant. Curved mesocotyl and coleoptile (the protective sheath) symptoms commonly referred to as "corkscrew" can also be observed as a result of fluctuating soil temperatures, signaling the plant to start and stop growth to the soil surface. Cooler temperatures also slow the growth rate of seedlings, further exposing damaged plant tissue to injury from disease infections and insects. Soil moisture levels and texture can also play a role in seedling damage due to their role in crusting of the soil surface that makes emergence more difficult. Finer textured soils with adequate soil moisture can also actually help buffer soil temperature against fluctuating air temperature and better protect seed and seedlings. Drier and courser textured soils will have less capacity to buffer against temperature swings resulting in the seed and seedling being more susceptible to cold injury. Risk of damage from freezing temperatures increases as seedlings emerge

Figure 2. "Corkscrewing" from flucuating soil temperatures

Figure 3. Premature leafing from cold injury to coleoptile of corn plant

and start to add leaves. After emerging, the plant growing point begins to move closer to the soil surface with each leaf that is added, making it even more susceptible to late spring frost occurrences.

DETERMINING EXTENT OF DAMAGE

To determine the extent of damage from cold weather, it is important to wait 3-5 days after the weather has improved and growing conditions are favorable. This allows plants that are still viable to develop once temperatures warm up and give a better indication of what stands will be like. Healthy emerging plants will have white to bright yellow stems and cotyledons that will quickly show new green growth. Seeds that are mushy and have a foul odor are not viable. Seedlings that are discolored and stunted are less likely to survive and produce normal yields.

REDUCING RISK OF IMBIBITIONAL CHILLING STRESS

In 2019, Golden Harvest introduced a new and novel approach to seed vigor testing designed to better mimic imbibitional chilling stress seeds face in less-than-ideal field situations. The new test was validated in actual field emergence trials, and in comparison, with internal and external vigor tests prior to implementation. In addition to planting the highest quality seed, consider delaying planting until you have confidence soil temperatures will be close to or above 50°F for the first 48 hours after planting.

ASSESSING SPRING FROST DAMAGE IN CORN AND SOYBEANS

INSIGHTS

- Temperatures must hold at freezing for at least a couple of hours to cause damage.
- Frost damage indicators typically include a darker looking and/or water-soaked appearance, followed by a browning, necrotic appearance a few days later.
- Corn and soybean survival can be gauged by new leaf growth or the presence of injury to the growing points.
- Allow plants time to recover from frost before making a final management decision on them.

Risk of late spring frost is a yearly concern in most corn and soybean growing areas. Early planting dates have a greater risk of injury due to earlier plant emergence. It is important to be able to diagnose early season frost symptoms, assess damage severity and determine if replanting would provide an economic return.

ASSESSING SYMPTOMS

Freezing temperatures do not automatically imply crop injury will occur. Temperatures of 28-30°F or lower are typically needed for damage to occur. However, there are multiple examples where 28°F may not cause significant damage or stand loss. Temperatures must remain at freezing for more than a couple of hours to impact the crop significantly. Microclimatic conditions, such as air movement (wind), cloud cover and topography, can also increase or decrease risk of frost within local areas.

Figure 1. (Left) Lightly frosted corn plant with watersoaking and necrosis. (Right) More severe frost injury with protected growing point.

Plants damaged by frost will appear darker in color within hours after freezing. Leaves may only appear water-soaked with less severe damage. Damaged plants will start to turn brown and necrotic in appearance over the following days.

FACTORS INCREASING FROST SEVERITY

- Air temperature below 32°F
- Longer exposure time
- Growth point above soil line (V5+)
- Wind speed (calm nights)
- Cloud cover (clear nights)
- Topography (low areas of field)
- High soil residue (cooler soils)

DETERMINING SURVIVAL

Determining survival of corn is highly dependent on the growth stage at the time freezing occurred. During normal plant development, the growing point of corn will remain protected below the soil surface from fluctuating air temperature until reaching the V5-V6 growth stages. Prior to the growing point emerging above the soil line, warm soils can help buffer against fluctuating air temperatures, reducing risk of injury. Upper leaf area may still be damaged from freezing temperatures, but if the growing point is protected, plants will usually recover quickly with warm growing conditions. Corn survival can be gauged by digging up plants and cutting open stems to evaluate the growing point health. A dark yellow to brown growing

Figure 2. Varying levels of soybean frost damage symptoms within a row

point could indicate a damaged plant that is less likely to survive.

Soybeans can generally tolerate slightly cooler temperatures than corn. However, due to the positioning of soybean growing points on the uppermost part of the plant, they are susceptible to freezing damage any time after emerging. Each new node becomes the dominate growing point for soybeans. Taller soybeans experiencing frost damage still have a chance of surviving if lower nodes are insulated enough by upper canopy leaves to protect against freezing. Warm soils can provide additional insulation to lower nodes, usually resulting in regrowth from the uppermost surviving node.

1. Wait two or more days after frost occurrence to evaluate regrowth and growing point health to determine the number of surviving plants remaining.
2. Flag frost-damaged plants and reinspect them after a few days of good weather to determine the number of surviving plants.
3. Compare yield potential of reduced stands to the reduced yield potential with later planting dates.
4. Factor additional costs of replanting, such as seed, fuel and labor expenses, as part of the decision.
5. Refer to the Golden Harvest Replant Calculator as an online resource for corn decisions https://geodav.syngentadigitalapps.com/ReplantApp/.
6. Understand that final soybean stands near 100,000 plants per acre or greater likely will not need replanting.

MANAGEMENT: CLIPPING PLANTS TO SPEED RECOVERY

Many producers and researchers have experimented with cutting off frost-damaged tissue to allow for regrowth to occur more easily and quickly. This method is usually only considered for corn at V5 or larger as a method to remove damaged tissue. Due to the growing point being above the soil line at this stage, caution needs to be taken to avoid further damage while clipping. University research has shown mixed results with this management practice and observed grain yield loss because of clipping. Clipping plants should be reserved for severe cases where you are certain plants will not survive without acting.

Reacting quickly after frost can often be the first response by growers. Unfortunately, frost damage situations require patience and investigation to determine the impact. Getting a good idea of the number of surviving plants will be the most critical decision factor. Allow plants the chance to recover before making a final determination.

CROP RESIDUE INVITES SEEDCORN MAGGOT

INSIGHTS

- Fields with increased residue are more susceptible to seedcorn maggot infestation.
- Seedcorn maggots cause damage by feeding on soybean seed and cotyledons.
- Insecticide seed treatments are the best form of protection against seedcorn maggots.
- Reduce risk by planting into warmer soils, tilling down green manure, and waiting 3-4 weeks after manure applications before planting.

Seedcorn maggot is a slowly increasing below-ground threat to soybean production in many areas. Changes in agronomic practices such as planting cover crops and applying fresh manure leave extra residue on soil surface which attracts adult flies and increases prevalence of this pest in many areas.

Seedcorn maggots overwinter as pupae and emerge as flies in the early spring.[1] They sense degrading organic matter in the soil and are attracted into those fields to lay eggs.[2] Larvae hatch in a few days and begin feeding on planted soybean seeds and young seedlings. It is possible to find maggots (larvae) and pupae at the same time in fields when scouting.

Seedcorn maggots cause damage by feeding on the seed and tunneling within the cotyledons. As a result, some plants will never emerge or begin to wilt and die soon after emerging, leaving large gaps in the soybean stand.[3]

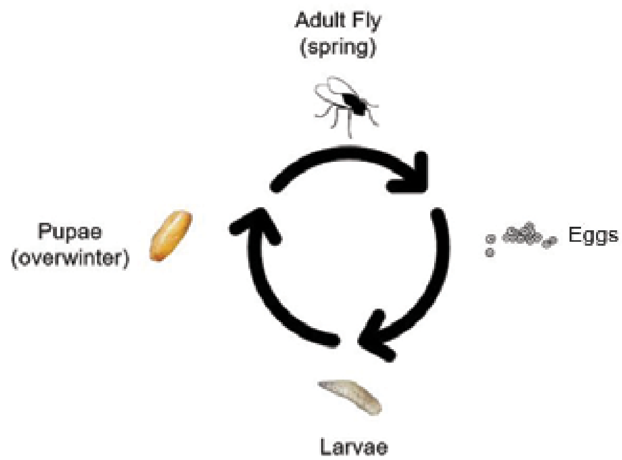


Figure 1. Seedcorn maggot lifecycle

What makes seedcorn maggot so threatening is that it can't always be predicted when they will appear, and no rescue treatments are available. They are more prevalent in high organic matter soils contributed from manure or green plant residue. Some pests can be more easily scouted, such as wireworms and white grubs as they overwinter as larvae.

Figure 2. Seedcorn maggot pupae and larvae

Figure 3. Seedcorn maggot feeding on cotyledons

However, seedcorn maggots overwinter as pupae in the soil. They are very small in size, like a grain of wheat, making them difficult to locate. Even with lack of presence of pupae, adult flies forming from pupae in neighboring fields can migrate in from great distances. Adult female egg laying flies are attracted to recently tilled fields, regardless of soil organic matter content and residue.

Different from other pests, damage can be less patchy within fields and can devastate whole fields when conditions are conducive.[1] Insecticide seed treatments are one of the best options to protect against this pest in fields at high risk.

MANAGEMENT TIPS

- Scout for pupae of seedcorn maggots in the fall.
- Consider delaying planting and increasing seeding rates in fields with a history of seedcorn maggot.
- Delay planting until soil temperatures are warming rapidly to ensure quick emergence.
- Avoid heavy manure applications in the three to four weeks before planting.
- Kill or plow down green manure or cover crops at least three to four weeks ahead of planting

Figure 4. Seedcorn maggot feeding damage on soybean cotyledons

PROTECTION FROM BELOW-GROUND FEEDING

Early-season protection against pests like seedcorn maggot is critical to give soybeans a strong start. Golden Harvest® Preferred Seed Treatment, powered by Cruiser® 5FS seed applied insecticide offers good protection from seedcorn maggots and other soilborne pests. Not all seed treatment packages contain insecticides, so always make sure to ask specifically that a seed-applied insecticide is included.

PHYSODERMA BROWN SPOT AND STALK ROT IN CORN

INSIGHTS

- Environmental conditions that are most conducive to Physoderma brown spot and stalk rot include minimal/no-till ground, continuous corn and increased moisture/precipitation.
- Failing to treat Physoderma brown spot lesions on leaves may lead to an increased risk of a Physoderma stalk rot infection in the lower nodes of the stalk, which can lead to breakage/green snap.
- Hybrids vary in their susceptibility to Physoderma, so be sure to ask about susceptibility ratings for fields with a known history of the disease.

Physoderma stalk rot (PSR) is caused by *Physoderma maydis*, the same fungal pathogen that causes Physoderma brown spot (PBS) in corn.[1] Leaf symptoms of PBS are often thought of as cosmetic however in some years it can evolve into stalk rot within lower nodes, known as Physoderma stalk rot. The rot phase developing within the node can make the stalk more susceptible to breaking and looks similar to "green" or "brittle" snap that can occur earlier in the season.

DISEASE CYCLE AND SYMPTOMS

- Physoderma is more common in reduced tillage and continuous corn systems where the pathogen survives for up to 7 years in the soil and crop residue as sporangia (reproductive structures) that can disperse by wind or be splashed onto corn plants.[2]
- PSR is favorable at temperatures between 73-86o F and with abundant rainfall.
- PBS develops when water is held in the plant whorl, where the sporangia germinate, releasing swimming zoospores that are responsible for infecting the plant and creating small lesions.
- PBS symptoms include dark purple to black oval spots that occur on the midrib of the leaf and usually on the stalk as shown in Figure 1.

Photo source: Dr. Alison Robertson, Iowa State University Extension and Outreach

Figure 1. Dark purple to black oval PBS spots occur down the center of the leaf

Figure 2. Dark purple to black PSR girdling at lower node resulting in breakage similar to green snap

- PSR symptoms include dark purple to black girdling around the lower stalk nodes where the plant becomes susceptible to breakage as shown in Figure 2. Plants often look healthy with large ears and may never exhibit signs of infection until stalk breakage begins to appear.

PLANT STRESSES AND STALK ROT

- Severe PSR outbreaks have been prevalent in recent years across areas of the Corn Belt, associated with exceptionally wet weather.
- Any factor that causes reduced photosynthetic capacity, reduced leaf tissue area, reduced light, water stress, etc. – will cause the corn plant to move more sugars from the stalk to the ears resulting in early plant death.
- Early deterioration of leaves puts more demand on roots, crown and stalks to provide sugars for grain fill. That makes the plant more susceptible to pathogens such as PSR, allowing stalk rot diseases to thrive.
- Over time, stalk strength weakens. That increases the potential for breaking at lower nodes, which negatively impacts yield.
- The presence of PSR is highly variable largely due to environmental interactions.

MANAGEMENT

- It is difficult to predict areas of disease pressure due to variability of environmental conditions year by year, making management complex.
- Hybrids vary in susceptibility to Physoderma. Ask seed providers for more information on hybrid susceptibility for fields with known history of the disease.
- Crop rotation and tillage may help reduce disease development and pressure.
- A fungicide application at R1, such as Trivapro®, may reduce disease severity and improve overall plant health.

MONITORING AND MANAGING ADULT CORN ROOTWORM

INSIGHTS

- Scouting or trapping CRW beetles can help determine future management needs.
- Economic thresholds can indicate if CRW will be problematic the following year.
- Improperly timed insecticide applications may not reduce CRW egg laying.

Corn rootworm continues to be a concern across the Midwest. One of the best ways to manage CRW is to proactively look for signs that would determine if this pest is currently a problem in your fields or soon will become one. To help better understand the regularity of CRW, Golden Harvest utilized CRW sticky traps to monitor its occurrence across the Corn Belt during the 2020 growing season. Adult beetle trapping is one of the most accurate ways to determine if it is economically justifiable to apply a foliar insecticide treatment. Golden Harvest® agronomists and local Seed Advisors worked together to place and monitor hundreds of traps across fields from Kansas to Michigan, with the overarching goal of improving decisions for local CRW management.

Figure 1. Placement of a sticky trap to catch CRW adults in corn

2020 MONITORING PROGRAM

The optimal time to monitor CRW is just prior to silking through grain dent stage of corn (generally mid-July through August, potentially into early-September).[1,2] Non-baited, pheromone sticky traps were placed in fields to evaluate beetle presence on a weekly basis using one of two main approaches. In some cases, a single "Sentinel" trap was placed in the field to provide a quick check. In contrast, a more thorough evaluation was used at many of the sites by placing six sticky traps at 100-foot increments across the field. Traps were attached directly to the corn plant just below the ear (Figure 1) and the number of adult beetles were recorded and traps replaced on a weekly basis. General field information such as previous crop, current crop and management practices, along with the type of species of CRW (Figures 2 and 3) trapped, was also noted. It was also documented if there were gravid (carrying eggs) females present to help


Figure 2. Left: Female Western CRW adult; Right: Male Western CRW adult


Figure 3. Northern CRW adult beetle feeding on silks

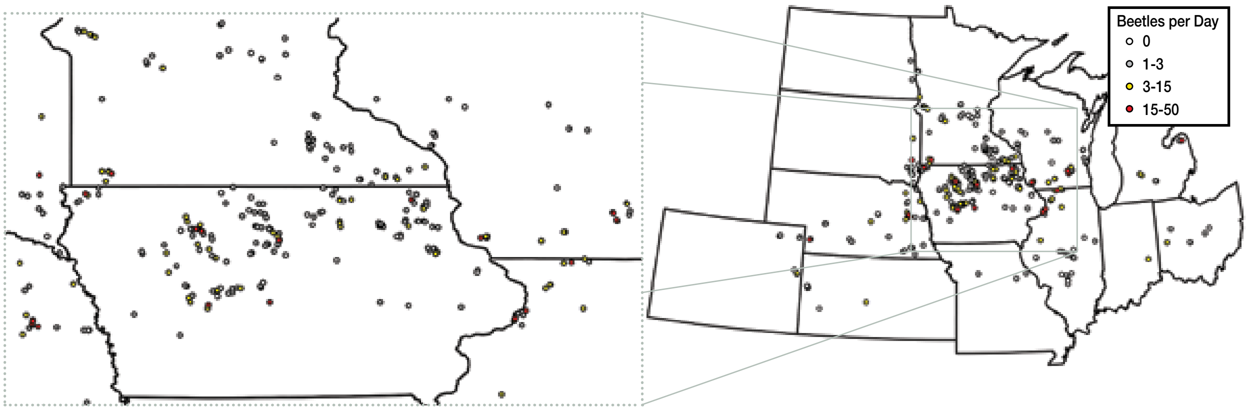


Figure 4. 2020 Adult beetle trap locations and seasonal maximum per day count per location

determine the effectiveness of insecticide application timing for reducing future year populations.

INTERPRETING STICKY TRAP COUNTS

University recommended economic thresholds for deciding when to use insecticides to reduce adult beetle egg laying capacity range from 2+ beetles per trap per day in the central Corn Belt growing areas to as high as 6+ beetles per trap per day in the Northern Corn Belt where winter survival is lower.[1]

FIELD SCOUTING – AN ALTERNATIVE TO TRAPS

Another option in determining the CRW pressure in a field is to perform routine scouting every 3 or so days, starting just before silking and continuing through dent, if beetles are present.[3] Scouting in mornings or late afternoons works best as beetle activity is highest at those times. Select 5-10 random areas of a field for counting beetles. Pick 10 individual corn plants randomly spaced throughout each sample area to get a total of 50-100 plant samples. Check the tassel, silk, ear and top and bottom of the leaves and count how many beetles you observe. Divide the total number of beetles counted in the field by the number of plants to find the per plant average.[4] Thresholds have been established by several universities and vary depending upon the species of CRW present and if it is the first year corn was planted or consecutive years in the field (Table 1). Thresholds will vary slightly by individual universities in a state. If both species are present, use the threshold for the one that is most predominant. Thresholds may be higher in northern growing areas where overwintering survival of eggs may decrease.

ECONOMIC TREATMENT THRESHOLDS FOR CRW ADULT BEETLES (BEETLES/PLANT)		
	First Year Corn	Continuous Corn
Northern CRW	2+	3+
Western CRW	1+	1.5+

Table 1. Recommended thresholds of CRW beetles per plant when field scouting[3]

2020 ADULT CRW TRENDS

CRW populations continued to trend higher across areas of the Corn Belt in 2020. CRW populations are highly variable due to favorable conditions in microenvironments. It is not uncommon to see higher beetle counts in fields that have been consecutively planted to corn for multiple years, although CRW can also be seen in first-year corn frequently in some regions. Variants of both the Northern and Western Corn Rootworms have adapted to overcome rotation effects in some areas by either delaying egg hatch for a year or laying eggs in soybean stubble.[3] Many of the areas where high adult CRW beetle counts were observed are also areas with a higher ratio of corn to bean acres. This ratio is often due to high demand for livestock feed consumption found in Northwest Illinois, Northeast Iowa and Northeast Nebraska (Figure 4). In addition to the several locations with CRW beetle counts above economic thresholds, there were a significant number of locations with populations just below economic threshold levels (white or gray dots, Figure 4). Local university entomologists believe the CRW surge in 2020 is due to environmental conditions. The winter of 2019 was relatively mild compared to other years, which likely helped improve the CRW eggs' ability to overwinter. Unlike recent spring seasons, soil conditions were generally less saturated than normal and warmed up quickly resulting in favorable conditions for egg hatch. It is also speculated that continued selection pressure to Bt traits may be resulting in higher overall CRW survival. Even though there may not be damage to the level of causing lodging, yield potential can still be impacted by CRW larval feeding.

IMPORTANCE OF MANAGING ADULT BEETLES

Scouting and potentially applying foliar insecticide for CRW beetles can be done for different reasons. These reasons vary from protecting silks for good pollination to proactively managing CRW populations in fields intended for corn the next year.

Managing silk clipping: Clipped silks can hinder pollination enough to negatively impact kernel development and yield. If CRW beetle populations reach a point where silks are being clipped to within a half inch or less before 50% pollination, spraying an early insecticide directly after beetle emergence may be warranted.[3] Early applications likely won't reduce the next season's populations, but can protect current year yield potential.

Reducing egg laying: For best results in reducing future CRW populations once economic thresholds have been exceeded, it is beneficial to time insecticide applications when 10% or more female beetles are gravid.[4] This can typically be 3-4 weeks after seeing the first beetles in a field. Male beetles will typically emerge 1-2 weeks prior to females. When females emerge, they will usually feed on pollen and silks an additional 1-2 weeks before laying eggs.[3] Accomplishing silk protection and reducing adult egg laying may not be feasible with one insecticide application. Continue to monitor fields treated early for gravid females in weeks following to determine if a second application is warranted.

Potential for mite flareup: Additionally, consider if spider mites are present. Most pyrethroid and organophosphate insecticides commonly used can also reduce predators of spider mites, leading to potential spider mite population flare in some situations.

COMPLEX CRW MANAGEMENT

Better understanding of when CRW is present and at what level can be a useful tool in shaping future management strategies. The overall severity can help determine if management practices such as crop rotation, soil insecticide application or CRW traited hybrids should be used. Talk to your Golden Harvest Seed Advisor to help build a field-by-field rootworm management plan for next season.

MANAGING CORN ROOTWORM

INSIGHTS

- Corn rootworm (CRW) has adapted to decades of management strategies and continues to be destructive.
- Agrisure Duracade® trait adds a different tool to the toolbox for rootworm management.
- Diversity in management practices is key for long-term success in managing CRW.

Figure 1. Various levels of corn rootworm feeding

Corn rootworm is the most destructive corn pest in the United States and costs growers more than $1 billion annually in reduced grain yield and control measures. Larvae feed on roots, resulting in underdeveloped root systems, reduced nutrient uptake, weak brace roots and lodged corn (Figure 1). Adult CRW beetles can also interfere with pollination by feeding on pollen and clipping silks, resulting in poor ear fill, and lay eggs in the soil that endanger future corn crops.

Corn rootworm is a difficult pest to manage, to the point that repeated use of the same single management practice will eventually end in disappointment. There is no silver bullet for corn rootworm, but smart planning and hybrid selection are key to building a sustainable, multi-year management plan. Developing a multi-year, field-by-field corn rootworm management plan utilizing different control methods in different years is an important part of addressing one of the most damaging insect pests to corn and ensuring hybrids reach their full yield potential. Understanding if CRW is currently present in fields through scouting or beetle trapping is an important first step in developing management plans. Once the relative risk of CRW is understood, the following management options can be considered independently or in combination as part of multi-year integrated management plan.

- Crop Rotation – rotate to non-host crops like soybeans to break up CRW's normal lifecycle. Adapted variants of CRW known as western CRW variant or northern CRW with extended diapause, have changed their lifecycles to overcome single-year rotation (Figure 2). Be aware if present locally and its impact on rotation effectiveness.

Geographic Distribution of Northern and Western Corn Rootworm and Variants

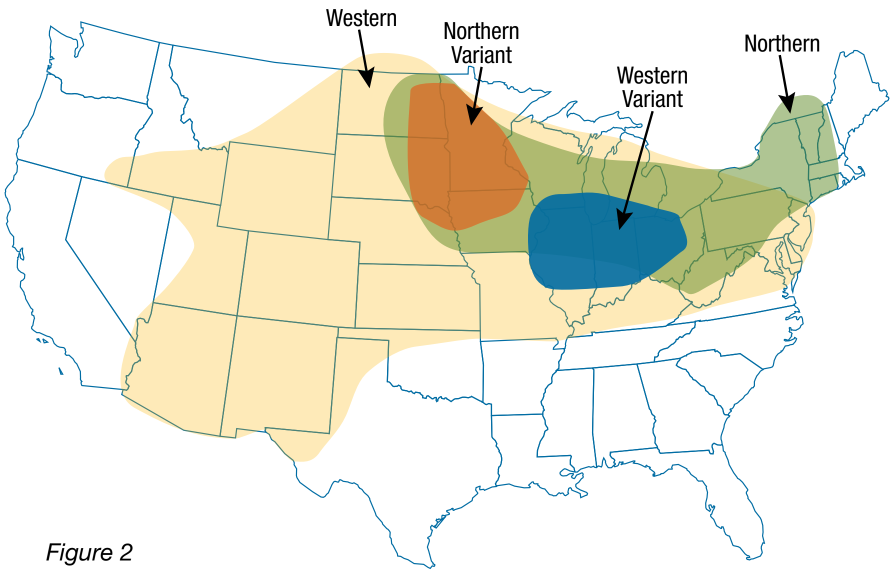


Figure 2

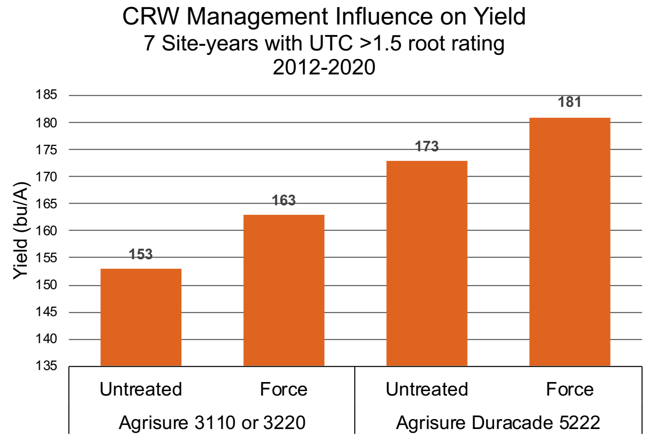
PLANT GROWTH

- Dual mode of action CRW traits – use different CRW traits like Agrisure Duracade® and Agrisure® 3122 trait stacks that have more than one CRW trait.
- Soil-applied insecticides like Force® for larvae control.
- Foliar-applied insecticides like Warrior II with Zeon Technology® for adult beetles to minimize silk clipping and reduce egg laying.

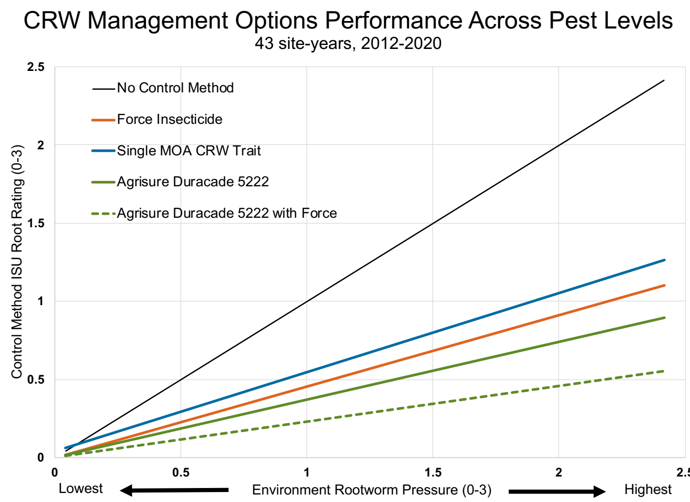
Plans should include the use of different corn rootworm control methods in different years to help minimize the adaptation of corn rootworm to one technology. The plan may need to change each season, depending on pressure, but having it in place gives growers a head start.

The Agrisure Duracade trait, the most recently registered CRW trait, expresses a protein that binds differently in the gut of CRW than any other trait on the market. Additionally, it is always stacked with a second mode of action against CRW, making it a good tool for managing CRW (Figure 3). Agronomy In Action research trials have evaluated the effectiveness of Agrisure Durcade across multiple years and demonstrated improved root protection (Graph 2) and yield (Graph 1) when used alone or in combination with soil-applied insecticides across many different pest levels. Whether trying to protect yield or preserve effectiveness of current management practices, effective CRW management will require the integration of multiple control practices, not a singular technology.

Figure 3. CRW damage shown with 2, 1 & 0 CRW modes of action (left to right; Agrisure Duracade, single CRW event, no insect trait)



Graph 1. Yield comparison of CRW control method



Graph 2. CRW root damage comparison of control methods

MANAGING LOW PRESSURE CORN ROOTWORM

If little to no previous signs of larval feeding or adult beetle populations have been observed and planting corn is selected for areas with western CRW variant, northern CRW extended diapause or corn following corn, consider using at least one of following management practices:

1. Multiple mode of action CRW traited hybrids
2. Non-CRW traited hybrid with Force soil insecticide

If planting first-year corn in areas where CRW have not yet been known to have adapted to corn rotation management, consider using a non-CRW traited hybrid, such as an Agrisure 3220 traited hybrid, that provides broad-spectrum control of above-ground pests. If other soil insects are present, consider adding Force soil insecticide.

OPTIONS FOR MANAGING HEAVY CORN ROOTWORM PRESSURE

1. Crop rotation – Breaking up CRW cycle by rotating to non-host crops, such as soybeans, in fields with a history of high CRW presence or injury should be considered.
2. Traited corn hybrids:
   a. If NO history of root injury on traited hybrids:
      i. Use hybrids with multiple CRW traits
      ii. Scout and consider beetle control with a foliar insecticide to minimize silk clipping and reduce female egg laying.

   b. If there is a history of feeding damage to traited hybrid and unable to rotate, use combination of:
      i. Hybrids with multiple CRW traits
      ii. Use soil-applied insecticide with traits
      iii. Scout and consider beetle control with a foliar insecticide.

Long-term corn rootworm management requires a multi-year, whole-farm approach (Figure 4). There is an important balance between CRW control, yield protection and resistance management. It is not a one-size-fits-all approach. Effective CRW management will require the integration of multiple control measures, not a singular technology.

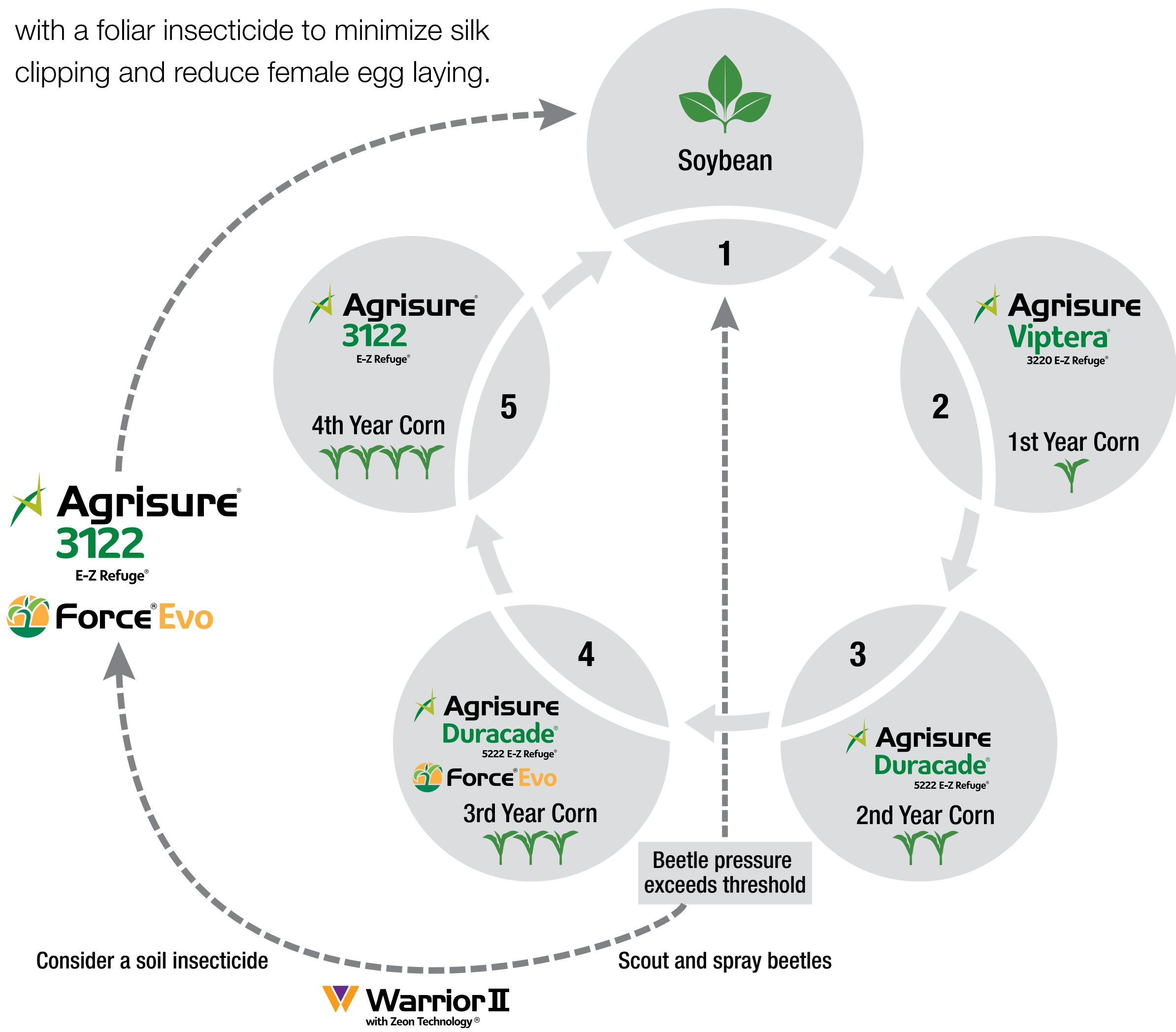


Figure 4. Example of a multi-year corn rootworm management plan

POTASSIUM AND FUNGICIDE IMPACT ON CORN YIELD POTENTIAL AND STALK QUALITY

INSIGHTS

- Potassium (K) is essential for plant growth and function and commonly associated with stalk strength and reduced disease.
- Potassium uptake can be limited in soils with adequate K levels due to restricted root development.
- Soil conditions, compaction issues, moisture, pH and a balance of soil fertility levels all play a role in plant stalk strength and disease development.

INTRODUCTION

Potassium is an essential nutrient for plant growth. It plays an important role in functions such as opening and closing leaf stomates, which regulate the amount of water vapor, oxygen and carbon dioxide that can pass through. This, in turn, impacts the movement of water, nutrients and carbohydrates throughout the plant. Potassium is also associated with susceptibility to disease and stalk strength.

Figure 2. Additional potassium being applied at V3 growth stage

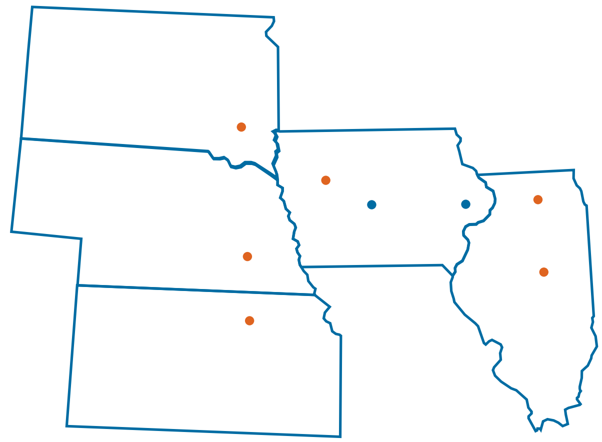


Figure 1. Trial locations in 2020, locations lost to derecho in blue

FACTORS AFFECTING K AVAILABILITY

Only a small percentage of the total potassium in the soil is readily available to plants, sometimes resulting in deficiencies. K deficiency appears in older corn leaves as yellowing or necrotic tissue along the leaf margin. Symptoms may not always be the result of low soil fertility. K is mostly immobile in the soil, requiring roots to physically intercept available soil K as compared to more mobile nutrients like nitrogen. Healthy, unrestricted roots are critical for ensuring K uptake of properly fertilized fields. Limited root growth due to drought, saturated soils, soil compaction, low soil temperature or insect damage can all limit nutrient uptake in soils with sufficient K levels.

ROLE OF K IN DISEASE SUSCEPTIBILITY

Not unlike humans, healthier plants are much more resistant to attack from disease. Although genetic resistance is important for managing disease, ensuring that nutrient levels are adequate helps boost a plant's natural disease defense. Plant disease can rarely be eliminated or cured by a fertilizer application, but the extent of disease severity may be reduced by the presence of certain nutrients. The ratio of all nutrients both in the soil and in the plant may be as important as the level of any one nutrient.[1] Disease protection as a result of an effect from potassium is influenced by the availability of soil potassium and its interaction with other nutrients, as well as by environmental factors.[1]

K ROLE IN STALK STRENGTH

K deficiencies can result in weakened stalks and lodging. Although K is fairly immobile in the soil, it is highly mobile inside the plant. Due to this, when a deficiency is sensed, K is moved from older tissue to newer growing leaves which may compromise lower stalk strength. Unfortunately, once symptoms are visible, in-season correction for the problem is difficult since most corn plant K uptake is completed prior to tassel and it is difficult to quickly deliver to the plant due to limited soil mobility.

Similarly, fungicide also plays an important role in disease management and preserving lower stalk health. Due to joint roles in stalk strength, greater understanding of K fertility and fungicide response by hybrids is needed in order to develop better individual hybrid management plans.

2020 K AND FUNGICIDE TRIALS

Golden Harvest® Agronomy In Action research trials were established in 2020 at eight locations to investigate the ability to improve standability and yield potential of hybrids through K and fungicide management. A late-season derecho led to the loss of two research locations, leaving six harvested locations (Figure 1). Trials were established using a split-split plot design with fungicide as the main factor and the rate of K as the subfactor with 4 hybrids nested within K blocks. The design resulted in each hybrid receiving the following four individual treatments: additional K, R1 fungicide, additional K with R1 fungicide and untreated. Two hybrids of adapted relative maturity (RM) with excellent stalk strength and two rated with less stalk strength were chosen for each location (Table 1). A total of 40 lbs per acre of potassium (0-0-24, NACHURS K-Fuel®) was applied as a split application, 33% in-furrow at planting followed by the remaining 66% in a 4" X 4" placement prior to V3 (Figure 2), to designated plots to mitigate the potential for root injury. Miravis® Neo was applied at the VT-R1 growth stage with a high-clearance sprayer to designated plots. Plant stand counts and push-test ratings were taken prior to harvest to assess stalk quality. Individual plot yield, moisture and test weight data were recorded at the time of harvest.

LOCATION HYBRID SETS			
Stalk Strength	Bridgewater, SD Sac City, IA	Clinton, IL Oregon, IL Seward, NE	Clay Center, KS
	98-103 RM	110-112 RM	114-116RM
-	G98L17-5122	G10L16	G15J91-3220
-	G03C84-5122	G11V76-5122	G15L32-3330
+	G00H12-5122	G11A33-5222	G14R38-3120
+	G03R40-5222	G12S75-5122	G16K01-3111

Table 1. Hybrid sets by RM and location

RESULTS

Growing environments and weather conditions varied across locations. Most locations received less rainfall in 2020 than compared to the previous 20-year average rainfall (Table 2). In Bridgewater, South Dakota, and Sac City, Iowa, the growing season rainfall

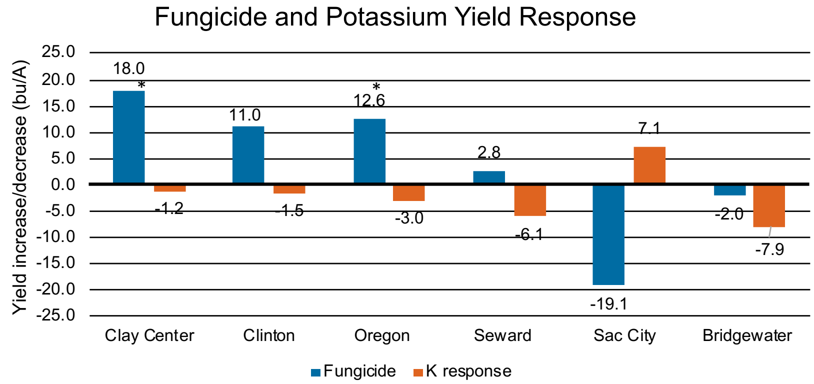
SOIL TEST RESULTS			
Location	K ppm	2020 Precip (in)	20 yr avg Precip. (in)
Bridgewater, SD	231 H	12.3	25.6
Clay Center, KS	260 VH	20.7	29.5
Clinton, IL	186 H	21.5	38.4
Oregon, IL	204 VH	22.8	39
Seward, NE	272 VH	17.5	27.5
Sac City, IA	360 VH	14.7	36.4

Table 2. Soil test potassium values and 2020 rainfall vs. 20-year average rainfall by location

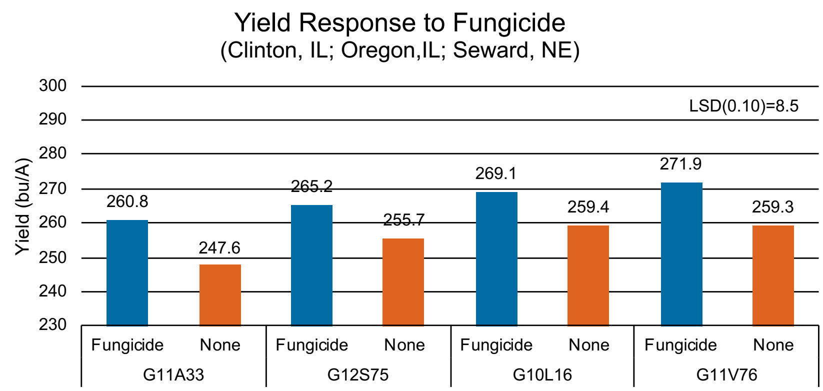
amounts were less than half of the average rainfall amount from the prior 20-year average. Available crop water is a large factor in nutrient exchange in the root zone and in determining yield potential. The amount of water used by the plant varies based on plant growth stage and growing environment. A typical 200 bushel/A corn crop uses about 20 inches of water.[2]

RESPONSE TO ADDITIONAL K

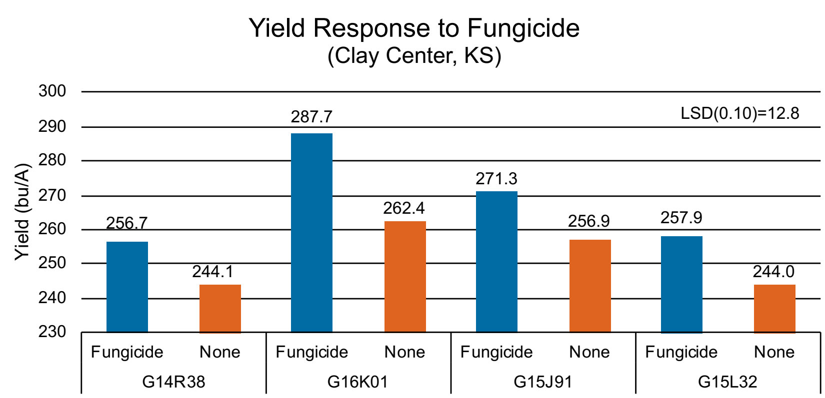
The primary objective of this trial was to better understand how soil K availability can influence yield potential and stalk integrity. There was no significant yield or stalk quality improvement resulting from additional K observed at any of the locations with an exception of a small yield response at Sac City (Graph 1). Preexisting high to very high K levels at each location (Table 2) likely resulted in the lack of response from supplemental K.



Graph 1. Fungicide and potassium response by location



Graph 2. Fungicide yield response at mid-RM locations



Graph 3. Fungicide yield response at full-RM locations

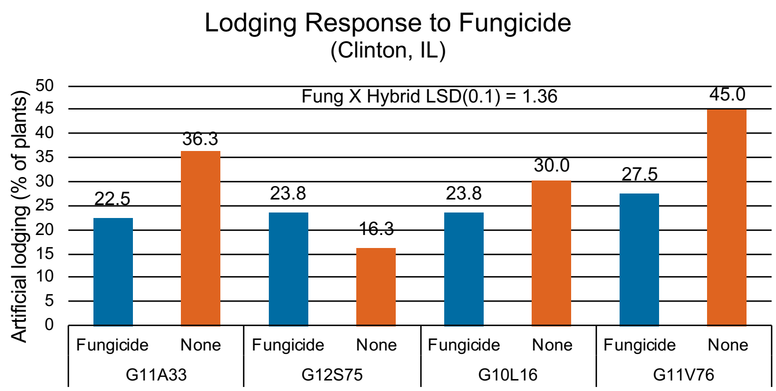
RESPONSE TO FUNGICIDE

Four of the six trial locations showed a positive yield response to fungicide, ranging from 2.8 to 18 bu/A (Graph 1). Individual hybrid yield responses were similar when averaged across locations which had a response to fungicide (Graphs 2 and 3).

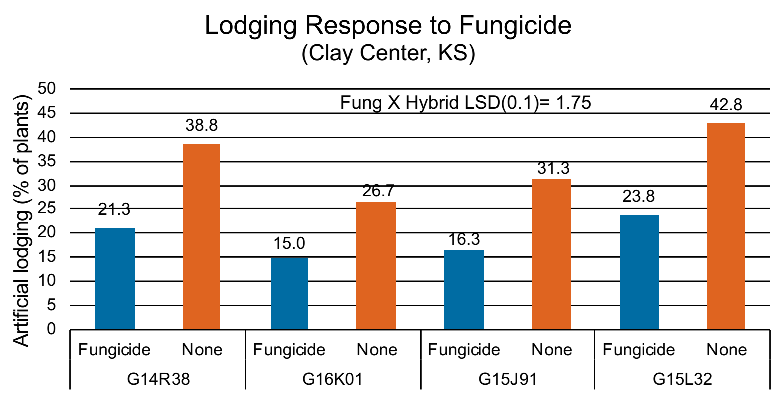
Standability at harvest time was also quantified at each location by artificially applying pressure horizontally to multiple plants within each plot and recording the percentage of plants that lodged. Two of the locations with the largest yield response, Clay Center, Kansas, and Clinton, Illinois, also had significantly less artificial lodging as a result of fungicide applications (Graphs 4 and 5). Hybrid standability was improved in some hybrids more than others due to fungicide applications. It was anticipated that hybrids with lower stalk quality ratings would benefit more from fungicide applications. However, both G11A33 and G14R38, two hybrids with better stalk strength ratings, benefited the most from fungicide application (Graphs 4 and 5).

DISCUSSION

Overall, incremental K had no effect on late-season standability or yield in these trials. Fungicide use did improve yield in many cases. Fungicides also improved late-season standability in multiple trials, which in some years may provide more financial benefits than a yield increase. While results from this study were mixed due to high soil K levels and excessively dry conditions, future investigation into the effects of potassium application on stalk strength and yield potential is warranted. Trials repeated in locations with lower overall soil K levels and increased soil moisture may be better able to demonstrate the importance that maintaining adequate K soil fertility may have for managing hybrid late-season standability and maximizing yield potential.



Graph 4. Fungicide stalk response at Clinton, Illinois



Graph 5. Fungicide stalk response at Clay Center, Kansas

VOLUNTEER CORN MANAGEMENT

INSIGHTS

- Volunteer corn has been shown to reduce yields by up to 20% in corn and up to 56% in soybeans if left untreated.
- Minimizing harvest losses, stalk lodging and opportunities for germination are effective measures to proactively manage a potential volunteer corn escape the following season.
- Each management strategy for volunteer corn must be tailored to the specific crop being planted next, with respect to the traits incorporated into it.

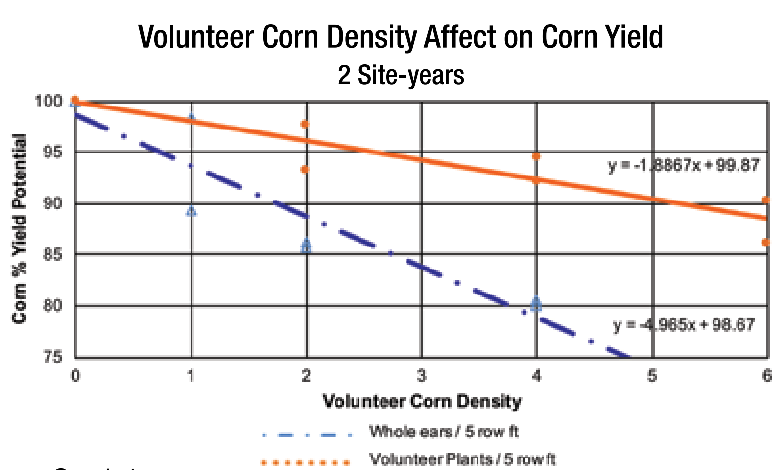
Volunteer corn is a competitive weed. It deprives corn and soybeans of water, nutrients, light and space, which consequently reduces yield. Management of volunteer corn plants in crop production has traditionally involved a combination of cultural and mechanical practices. Herbicide tolerant crops now offer more options with non-selective herbicides that control all treated plant material. This requires more advanced planning because most volunteer corn will be tolerant to non-selective herbicides, such as glyphosate or glufosinate, if the hybrid planted the prior year contained traits resistant to those herbicides.

The Golden Harvest® Agronomy In Action research team conducted trials to understand the effect of volunteer corn on both corn and soybean yields. Trials were conducted in Iowa, Illinois and Nebraska using volunteer corn arranged in consistent patterns and various densities. Conventional corn, not having any herbicide tolerance, was harvested the previous fall for use as volunteer corn. The corn hybrids used in the trials were herbicide tolerant to both glyphosate and glufosinate. Comparisons were made showing the effectiveness on volunteer corn between the two non-selective herbicides. Multiple herbicide application timings were used to evaluate the importance of application timing on volunteer corn.

Figure 1. Four whole ears of volunteer corn per 5 feet

EFFECT OF VOLUNTEER CORN ON CORN AND SOYBEAN YIELDS

- Volunteers reduced corn yield by up to 20% (Graph 1).
- Volunteers reduced soybean yield by up to 56% (Graph 2).



Graph 1

- Volunteers became more competitive in both corn and soybeans as the density increased.
- Low densities of < 2 individual volunteer plants did not economically affect corn yield while all densities reduced soybean yield significantly.

APPLICATION TIMING IS CRITICAL

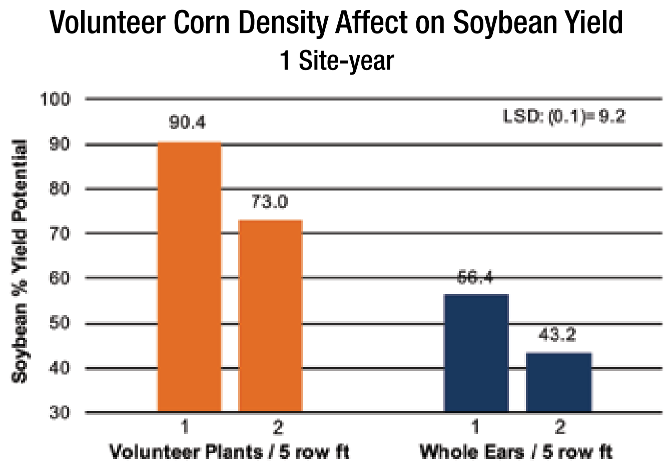
Like any other weed, volunteer corn starts competing with crops at early growth stages, so it is imperative to control volunteers early in the season to maintain corn and soybean yield potential.

APPLICATION TIMING INFLUENCE ON CORN AND SOYBEAN YIELD

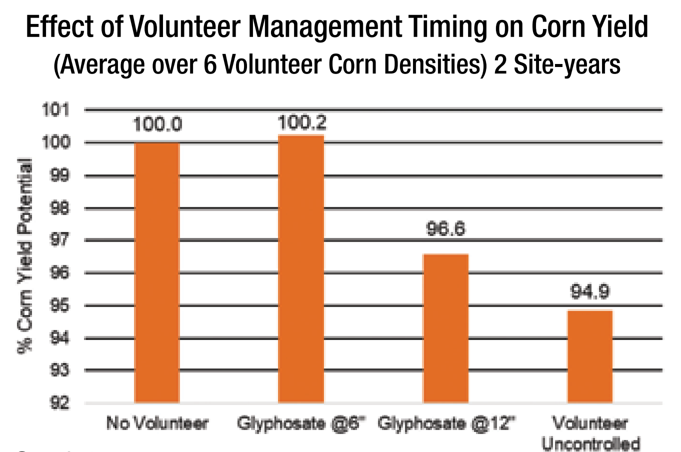
- Controlling volunteers at 6 inches versus 12 inches tall increased:
  – Corn yields by 4% (Graph 3)
  – Soybeans yields by 7.5 bu/A (Graph 4)
- Controlling volunteers early reduces competition and increases yields for corn or soybean crops.

GENERAL STRATEGIES TO REDUCE AND MANAGE VOLUNTEER CORN

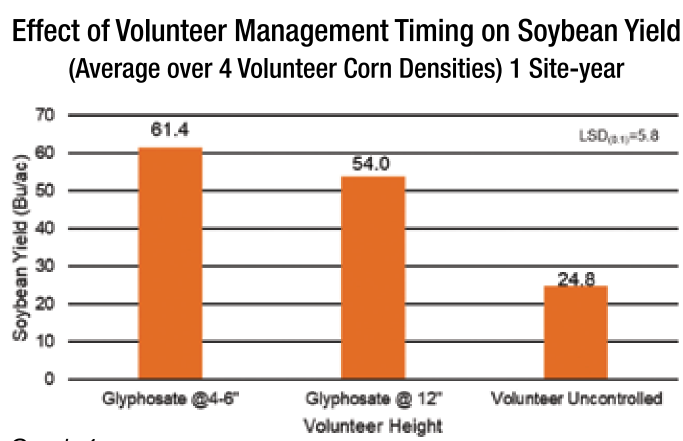
- Use Agrisure Viptera® corn hybrids to manage insect damage that could contribute to ear drop from insect feeding in the ear shank.
- Use Agrisure Duracade® hybrids alone or in combination with Force® insecticides to prevent root lodging from corn rootworm root damage.
- Schedule field harvest based on scouting for fields at an elevated risk of lodging and ear drop.
- Properly adjust combine to minimize harvest losses.



Graph 2



Graph 3



Graph 4

PLANT GROWTH

Figure 2. Liberty® herbicide applied to 12 inch volunteer corn

- Complete fall tillage early to promote volunteer growth before a killing freeze.
- Consider no-till to minimize seed-to-soil contact and reduce volunteer germination.
- Graze cattle in fields with lodging and ear drop to minimize germination of volunteers the following year.
- For fields with high quantities of dropped corn, delay field planting to allow early germination prior to planting.

MANAGING VOLUNTEER CORN WITHIN CORN

If volunteer corn wasn't successfully managed the previous year and rotating to soybeans is not an option, there are limited herbicide options that exist for corn. It is important to have good planting records from the previous year to understand the herbicide tolerance of the volunteers in the current field.

1) No herbicide trait the prior year: If a herbicide tolerant hybrid was not planted the previous year, an opportunity exists to plant a hybrid with gylphosate or glufosinate tolerance and manage volunteer corn.

2) Previous year hybrid only contained glyphosate tolerance: Many herbicide tolerant corn hybrids offer tolerance to both glyphosate and glufosinate. However some only offer glyphosate tolerance and DO NOT provide tolerance to glufosinate. A solution for fields where these traits were planted in the prior year is to plant an Agrisure® traited hybrid containing tolerance to both glyphosate and glufosinate and make a timely application of a glufosinate-based herbicide to manage small volunteer corn plants (Figure 2). Consult the bag tag labels for Agrisure® E-Z Refuge®

product herbicide options, always read and follow label and bag tag instructions. Only those labeled as tolerant to glufosinate may be sprayed with glufosinate ammonium-based herbicides.

MANAGING VOLUNTEER CORN WITHIN SOYBEANS

Volunteer corn resulting from any traited hybrid in soybeans can be controlled effectively with several graminicide herbicides, although the potential control can be reduced when applied in a tankmix with an auxin herbicide[1] (Figures 3 and 4). In Roundup Ready 2 Xtend® soybeans or XtendFlex® soybeans, Fusilade® DX herbicide is available for use as a tankmix partner with XtendiMax® with VaporGrip® Technology (requires drift reducing adjuvant) or Engenia®. Fusilade DX herbicide may also be tankmixed with Enlist One® or Enlist Duo® herbicides and offers superior control of volunteer corn with less risk of antagonism over Clethodim 2EC herbicide. In Enlist E3® soybean systems, refer to EnlistTankMix.com for other approved graminicide herbicide tankmix partners with Enlist One or Enlist Duo herbicides. Liberty® herbicide (glufosinate) may be used to control volunteers in Enlist E3 soybeans and now XtendFlex soybeans, but not Roundup Ready 2 Xtend soybeans. It will only be effective if the hybrid corn planted the prior year was not LibertyLink®. Antagonism has not been documented between graminicides and glufosinate herbicides, however, glufosinate control can be impacted by factors such as application time of day, relative humidity and cloud cover.

Figure 3. Clethodim 2EC 6 fl oz/A, XtendiMax® with VaporGrip® Technology 22 fl oz/A, Roundup PowerMAX® 27 fl oz/A, AG 13063 1% v/v, Superb® HC 0.5% v/v

Figure 4. Fusilade® DX 6 fl oz/A, XtendiMax® with VaporGrip® Technology 22 fl oz/A, Roundup PowerMAX® 27 fl oz/A, AG 13063 1% v/v, Superb® HC 0.5% v/v Springfield, NE; 21 DAT - HWHLSO74-2017US

IDENTIFY SOUTHERN RUST FROM COMMON RUST

INSIGHTS

- Southern rust causes light orange or brown pustules on the top of leaves, whereas common rust forms on both sides.
- Selecting hybrids with higher tolerance to southern rust and applying a foliar fungicide if disease is present or anticipated are the best management options.

Figure 1. Southern rust pustules forming on upper leaf surface differentiate it from less damaging common rust which forms on both sides.

Common and southern rust do not overwinter in central corn growing areas. Windblown spores overwinter and move in from southern geographies in early June until mid-July.[1] Common rust typically isn't an economic concern in commercial corn hybrids, however southern rust can seriously impact susceptible hybrids. The impact on yield potential from southern rust is dependent on how early infection occurs, severity of the infection and how far up in the canopy infection moves.

On July 14, 2020, southern rust was found in north central Kansas with additional reports along the Nebraska/Kansas border. Reports of southern rust were made earlier in the 2020 season than in previous years, sparking the potential for higher risk of infection than in years past.

DISEASE SYMPTOMS

- Southern rust causes light orange or brown, densely packed, clustered pustules only on the top of leaves and are small in size relative to common rust. Pustules can also be found on the stalk, husks and leaf sheaths. Heavy leaf pustule presence can lead to leaf blight, which is ultimately what causes yield reduction in the corn plant.[2]
- Common rust forms on both sides of leaves, where they begin as small, brownish-red circular lesions and are more sparsely spread throughout. As the lesions mature, they elongate to approximately 1/4-1/8 inches in length and form a yellow halo around the edges.[3] The pustules will typically turn black by the end of the season. Younger leaves are generally more susceptible to the disease than older ones.
- Symptoms of both pathogens are usually the heaviest post-tassel stage.

ENVIRONMENTAL TRIGGERS

- Southern rust is more likely to develop in moderate temperatures ranging from 77–82°F, whereas the risk of common rust is higher when temperatures are cooler, about 60–75°F.[4]

- Heavy dews and high relative humidity, above-average soil nitrogen levels and late-planted fields can increase chances of southern and common rust.
- Due to the wind-dispersed nature of the pathogens, optimal wind conditions can also produce new common and southern rust infections every 7-14 days or so throughout the growing season.

FUNGICIDE APPLICATIONS

During the season, scout fields based on hybrid susceptibility (Table 2) for disease presence. If southern rust is confirmed early enough and environmental symptoms outlined above exist, consider applying a foliar fungicide to help prevent disease (Table1).

Golden Harvest® recommends Trivapro® fungicide at 13.7 fl oz per acre for southern rust through the R1 (silking) stage. Delayed applications of Trivapro can allow southern rust to establish and begin reducing yield potential. Trivapro fungicide offers residual control of southern rust from the tassel stage through grain fill. Miravis® Neo and Quilt Xcel® are also labeled for southern rust.

FUNGICIDE	USE RATE	TIMING	KEY CORE DISEASES*	RESIDUAL ACTIVITY
Trivapro®	13.7 oz	R1	GLS, NCLB, An, R, SR**, ES	40+ Days
Miravis® Neo	13.7 oz	R1	GLS, NCLB, An, R, SR, ES, TS	40+ Days
Quilt Xcel®	10.5 oz	R1	GLS, NCLB, An, R, SR, ES	21-24 Days

*GLS: Gray Leaf Spot; NCLB: Northern Corn Leaf Blight; ALB: Anthracnose Leaf Blight; R:Rust; SR: Southern Rust; ES: Eyespot; TS: Tar Spot

**Trivapro provides excellent control and residual activity on rusts including southern rust.

In higher risk areas for southern rust pressures, Trivapro is the preferred treatment option.

Product performance assumes disease presence.

Note: Follow label directions for the addition of NIS adjuvants.

Table 1. Fungicide residual activity against key diseases

GOLDEN HARVEST HYBRID SERIES	RM	SOUTHERN RUST RATING (1-9)	GOLDEN HARVEST HYBRID SERIES	RM	SOUTHERN RUST RATING (1-9)
G03C84	103	4	G11B63	111	5
G03H42	103	3	G11F16	111	4
G03R40	103	3	G11V76	111	4
G04G36	104	5	G12J11	112	3
G05B91	105	4	G12S75	112	4
G05K08	105	5	G12W66	112	4
G06Q68	106	4	G13M88	113	4
G07F23	107	6	G13N18	113	6
G08D29	108	5	G13T41	113	4
G08M20	108	5	G13Z50	113	5
G07B39	109	6	G14H66	114	4
G09A86	109	4	G14N11	114	5
G09Y24	109	5	G14R38	114	4
G10C45	110	6	G14V04	114	3
G10D21	110	4	G15J91	115	4
G10L16	110	4	G15L32	115	5
G10S30	110	4	G15Q98	115	3
G10T63	110	3	G16K01	116	5
G11A33	111	3	G18D87	118	3

Table 2. Golden Harvest hybrid Southern Rust 1-9 rating 1= best 9= worst

Figure 2. Common rust is observed by infection on both sides of corn leaves.

WIREWORMS IN CORN

INSIGHTS

- Wireworms can be a perennial problem in fields where damage is observed since they have up to a 6-year lifecycle.
- Fields at most risk for infestation were most recently Conservation Reserve Program (CRP) land, pasture, no-till, small grains, forages or had grassy weed pressure.
- Uneven stand emergence and gaps are good indicators of wireworm presence.
- With no in-season rescue treatments available, preventative management practices are important.

Wireworms are an early season pest that may surprise growers as they are usually not considered a widespread threat. Although relatively uncommon, wireworms can become a severe and systemic problem in some areas. Included in this article are some ways you can detect and prevent an infestation in your fields.

Figure 1. Wireworm larvae

IDENTIFICATION AND LIFE CYCLE

Hard-bodied, slender and ranging from a shiny white, yellow, orange or light to dark brown in color, wireworms are the larva of click beetles. They are named for their wire-like appearance, given their long, sleek bodies (0.5-1.5 inches in length), distinct head and coil-like indentations throughout.[1]

If conditions are conducive, wireworms may be the first pest of the growing season to impact a corn crop, which is why newly planted seed is most vulnerable to feeding. Corn is targeted by wireworms from mid-April to as far out as the end of June, where they reside in the first few inches of soil. As the season progresses and temperatures warm, larvae typically migrate deeper in the soil where they no longer cause damage to the crop.

Once emerged from their eggs, wireworms can remain in the larval stage for anywhere from 1 to 6 years (depending on the species). As they mature, they progressively cause more feeding damage and will reoccur within a field across successive crop years. Pupation then occurs in the soil in August or September and is about a month in duration. The pupa will emerge as an adult click beetle that will overwinter in the soil. In the spring, adult beetles lay eggs near grass roots or the roots of grass-type crops.

SUSCEPTIBLE ENVIRONMENTS

The most preferable environments for wireworms have a history of, or currently contain, grass or forage species. Fields that were previously sod, grass cover crops, small grains, alfalfa, pasture, high residue/ no-till, CRP land or even had high grass weed pressure are most susceptible.[2] Cooler soil temperature and higher moisture are also favorable conditions for wireworms. Common instances of wireworm pest pressure often consist of planting corn early just before a period of cooler temperatures. The extended cool period allows larvae to stay closer to soil surface damaging crops for longer periods of time on already weather-compromised corn plants.

SCOUTING AND MANAGEMENT

The largest indicator of a wireworm problem is uneven stand emergence, which can be observed most notably when scouting emerging to 5-leaf corn.[3] Digging in the top 6 inches of soil in the weeks following planting, especially near grassy weeds or residue-heavy areas, is a way to gauge the amount of pressure, if any, that the field may experience.

The use of bait stations is a common way to sample for larvae and determine risk prior to planting.[2,4] This can be done by selecting five random areas of the field and burying a couple of handfuls of untreated corn and wheat seed about 6 inches deep. Cover these areas with black plastic and mark with a flag. It is recommended that these bait stations be established about 2-3 weeks before planting and dug up when it's time to put seed in the ground. An economic threshold is estimated to be an average of one wireworm per station and then management tools should be considered.

Although wireworms cannot be managed in-season via a rescue treatment, there are some preventative measures that can be taken to help mitigate feeding damage for corn that is at risk. Consider planting later for fields with active larvae populations, utilizing an appropriate seed treatment, and/or applying a soil insecticide pre-plant or during planting. For severe, postemergence infestations, a replant might be warranted depending on the impact on population.

Figure 2. Wireworm damage in corn

THE EFFECT OF HAIL ON CORN

DAVID SCHLAKE AND BLAKE MUMM

Hail can be one of the most unpredictable and destructible natural events to impact a growing corn crop. In a matter of minutes, healthy corn can be reduced to a twisted mess of plant material. Witnessing the damage from hail can be very emotional, however, corn is an amazing plant that has the ability to recover quickly depending on the growth stage at the time of the hail event. The resiliency of corn helps maintain as much yield potential as possible.

PERCENT YIELD POTENTIAL BY EMERGED STAND AND PLANTING DATE
Corn Harvested as Grain in Central and Southern Geographies

Established Stand	Planting Date				
	May 1 and Earlier	May 10	May 20	May 30	June 10
32,000	100	98	92	86	80
28,000	97	95	89	83	78
22,000	90	88	83	77	72
16,000	82	80	75	71	66
10,000	70	69	64	60	56

Table 1. Percent yield potential of an emerged corn stand based on planting date

The greatest losses to corn from hail are defoliation, especially during the pollination stage. Hail also impacts yield potential from direct plant damage (wounds) and reducing plant stands, depending on the crop stage when the event occurred.[1] When corn reaches the V6 growth stage, the growing point emerges from the soil surface. A hail event can significantly impact the growing point of the plant, resulting in reduced plant stand and yield potential. Assessing plant stand and plant health of a field following a hail event is important for replant decisions.[2] A healthy growing point will have a light-colored appearance with a firm texture. New leaves emerging every three to five days indicate normal growth. A damaged growing point will have a distinct yellow to brown, water-soaked appearance with a mushy texture.

EVALUATING STANDS: PLANT POPULATION AND DISTRIBUTION

It is important to determine the plant population and distribution (uniformity) of the existing stands. Count the number of viable plants in 1/1,000th of an acre and multiply by 1,000 to obtain plant population per acre. Take enough counts in the field to represent the existing stand. Sometimes, plants that are weak or questionable in growth should not be counted.

After plant population and health have been evaluated, yield potential of the current stand versus replanting can be determined. Table 1 can be used to estimate stand potential. The yield values (expressed as a percent of maximum) are based on uniform distribution of plants within the row(s), which is not usually the case after a hail event.

SIMULATED HAIL AGRONOMY IN ACTION TRIAL

To help visualize the effect of hail on a growing corn crop, a trial at York, Nebraska, was used. Damage treatments were applied to cause a similar loss in leaf area, of varying degrees of severity, as a hail event to a plant stand. A string trimmer was used to cause the simulated damage at approximately the V7-V8 growth stage. Four individual rows were damaged to various levels ranging from 10 to 100% loss of leaf area (Figure 1). No stand loss resulted in this simulated event. Regrowth was monitored weekly up to flowering (Figures 2 and 3).

Figure 1. Simulated hail damage to 4 rows at various treatment (defoliation) levels on June 19, 2020, at York, Nebraska

Figure 2. Regrowth monitoring, June 22, 2020, at York, Nebraska

RECOVERING LEAF AREA LOSS

The plants with simulated hail damage defoliation were quickly able to recover, with new leaves emerging from the whorl within three days of the original loss. Within twenty days of the simulated event, well over 50% of the defoliation was able to recover even in the most severe treatment. This study saw no "buggy whipping" or twisting of the plant leaf whorl that is sometimes associated with hail events.[3]

Figure 3. Regrowth monitoring, July 7, 2020, at York, Nebraska

IMPACT ON YIELD POTENTIAL

Hail can reduce corn yield potential in two direct ways; by the reduction of crop stand and the loss of leaf area. Final yield is dependent on the severity of damage and the crop growth stage when the hail event occurred. Previous researchers have reported minimal reduction in yield with early season defoliation. For example, at V13, a

60% loss in leaf area only resulted in a 13% loss in yield (Table 2).

Small reductions in final stands prior to V8 typically also result in minimal yield penalty due to the ability of a corn plant to compensate for the stand loss early. However, later season stand loss usually results in a one-for-one ratio in yield loss. For example, a 10 percent reduction in stand will result in a 10 percent reduction in yield potential.[3]

STAGE[1]	PERCENT LEAF AREA DESTROYED									
	10	20	30	40	50	60	70	80	90	100
V7	0	0	0	1	2	4	5	6	8	9
V10	0	0	2	4	6	8	9	11	14	16
V13	0	1	3	6	10	13	17	22	28	34
V16	1	3	6	11	18	23	31	40	49	61
V18	2	5	9	15	24	33	44	56	69	84
VT - Tassel	3	7	13	21	31	42	55	68	83	100
R1 - Silk	3	7	12	20	29	39	51	65	80	97
R2 - Blister	2	5	10	16	22	30	39	50	60	73
R3 - Milk	1	3	7	12	18	24	32	41	49	59
R4 - Dough	1	2	4	8	12	17	23	29	35	41
R5 - Dent	0	0	2	4	7	10	14	17	20	23
R6 - Mature	0	0	0	0	0	0	0	0	0	0

Source: USDA

[1]Leaf-collar vegetative staging method

Table 2. Estimated percent yield reduction based on percent leaf area loss by hail damage

DEMO HARVEST RESULTS

Corn ears were hand harvested at 15% moisture from each treatment row in the demo (Table 3). The row with 100% loss of leaf area resulted in an 18% reduction in yield compared to the other rows with less severe loss of leaf area. Current USDA percent leaf area loss charts based off more extensive trialing suggests 100% leaf loss at V7-V10 would only result in a 9%-16% yield loss (Table 2). The other damaged rows saw no significant variation of yield due to leaf loss.

TREATMENT	YIELD
100% Leaf Loss	163 bu/A
70% Leaf Loss	214 bu/A
30% Leaf Loss	203 bu/A
10% Leaf Loss	200 bu/A

Table 3. Yield of simulated yield treatments

SUMMARY

While hail may be one of the most destructive events to a corn crop, corn plants can recover quickly under good growing conditions, depending on the timing of the event and growth of the corn. Hail can be devastating to any crop. Allowing the crop to recover, by assessing the field 5-7 days after a hail event will help make the most informed replant and management decisions.

SOYBEAN SULFUR MANAGEMENT FOR MAXIMIZING YIELD POTENTIAL

INSIGHTS

- Nitrogen (N) and sulfur (S) are key elements for protein synthesis in soybeans.
- Supplemental sulfur application was observed to impact measured yields at locations with low soil pH.
- Growing environment and variety selection affected protein and oil content more than sulfur.

INTRODUCTION

Soybeans are a high protein grain that is processed for oil and commonly used in animal feed. The high level of protein and energy supplied from soybean meal is an essential feed component in livestock production. With an increasing global population, the need for economical and efficient sources of protein in animal agriculture will continue to grow as well.[1] While soybeans are an adequate protein source, increasing the nutritional feed value of soybeans could be useful in meeting the rising demand for protein in livestock production.

Sulfur is absorbed by plant roots in the sulfate form. Sulfur deficiency symptoms in soybeans appear as chlorosis in younger plant leaves due to limited ability to remobilize in the plant.[3] One of the roles of sulfur in the plant is storing energy and making energy transfer easier. The protein synthesis process in plants depends on both nitrogen and sulfur. Sulfur is a component of proteins and certain amino acids in soybeans. One of the goals of this study was to determine if supplementing sulfur fertilizer could alter grain yield and protein content in selected soybean varieties.

2020 SOYBEAN SULFUR TRIALS

Trials were established at 8 locations across Illinois, Iowa, South Dakota and Nebraska to understand the effects of different sulfur-containing fertilizers on soybean yield and protein content (Figure 1). To understand if soybean yield and composition responses to sulfur are similar, or if varieties respond differently to supplemental sulfur, multiple varieties were chosen. Six soybean varieties were selected within either a 2.2-2.7 RM or 2.9-3.5 RM range and planted at 5 and 3 locations respectively, in which best fit that maturity zone. Within each location, 3 different forms of sulfur were applied to all varieties shortly after emergence and compared to treatments receiving sulfur. Each combination of variety and sulfur was repeated 3 times within each location. Two of the applied sulfur sources, ammonium sulfate (AMS) and calcium sulfate, were in the form of sulfate and

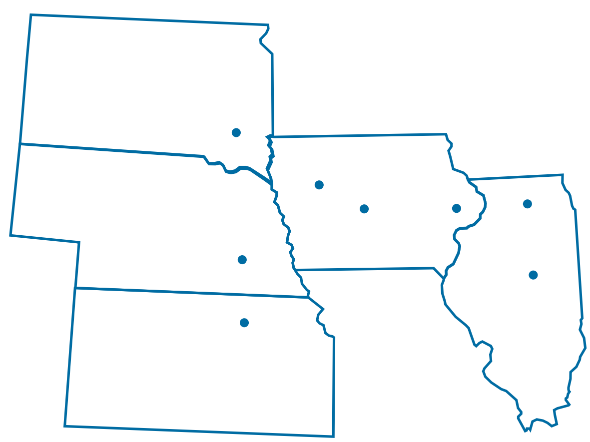


Figure 1. Soybean trial locations in 2020

PLANT GROWTH

the third source, Mosaic MicroEssentials® S10® (MES 10), delivered equal parts of sulfate and elemental sulfur. Rates of ammonium sulfate fertilizer (21-0-0-24 S), pelletized gypsum (14% S) and MES 10 (10% S) were applied to deliver a 25 lb/A sulfur rate to selected treatment strips. As a result of standardizing sulfur rates across forms, some treatments received additional nutrients (Table 1). Applications were made using a calibrated spinner spreader to deliver the desired rate of each fertilizer shortly after planting. Similar to nitrate, sulfur is relatively mobile in the soil. With fertilizer being applied soon after crop emergence, rainfall was relied on to incorporate fertilizer into the soil. Plots were harvested with a research combine at maturity, and grain yield and moisture were collected at the time of harvest.

	NUTRIENTS DELIVERED BY TREATMENT (lbs/A)			
	N	P	S	Ca
AMS	21.4	0	25	
Gypsum			25	51
MES-10	30	100	25	

Table 1. Total nutrients delivered per form of sulfur treatment

	Soil S ppm	Soil pH
Bridgewater, SD	57 VH	6.3
Clinton, IL	9 L	6.4
Malta, IL	4 VL	6.6
Cedar Rapids, IA	7 L	6.6
Slater, IA	6 VL	5.4
Sac City, IA	7 L	6.4
Seward, NE	7 L	5.8
Clay Center, NE	8 L	6.7

Table 2. Soil pH and nutrient availability across trial locations

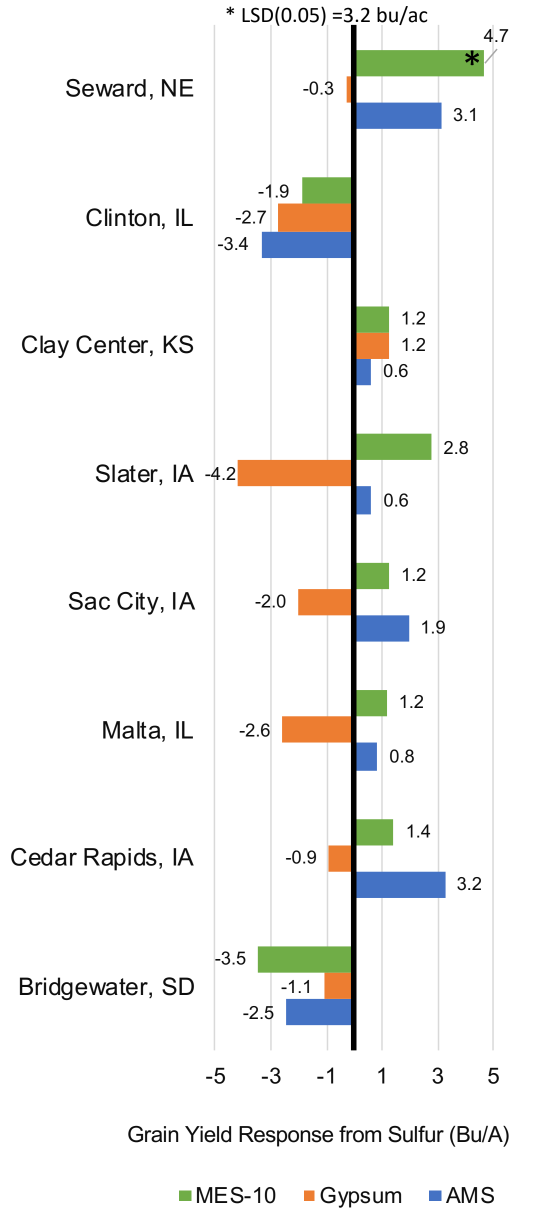
TRIAL RESULTS

There was a lack of yield response to gypsum sulfur across all locations (Graph 1). However, there were responses from AMS and MES 10 applications at most of the locations. Seward, Nebraska, had a 4.7 bu/A response to MES 10 and was the only site in which the responses were significantly greater than unfertilized check plots. The second largest response resulted from AMS applications at the Cedar Rapids, Iowa, site. Slater, Iowa, had the third largest response to S treatments, and combined with Seward, shared a commonality of both sites having lower soil pH values of 5.4 and 5.8, respectively.

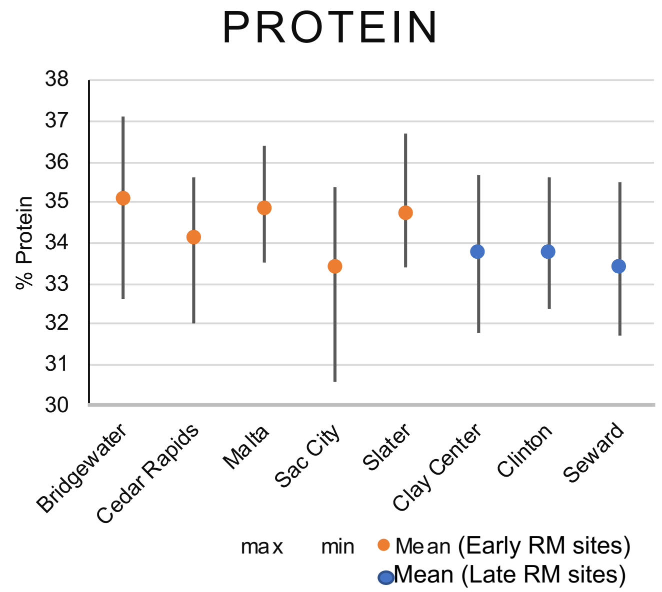
Availability of sulfur tends to decline with lower soil pH levels, making yield responses from supplemental sulfur applications more likely at these sites. There were yield differences between individual varieties within and across sites, however, all varieties responded similarly to sulfur applications.

Due to the role of sulfur in protein production, grain samples were also collected for all varieties and sulfur treatments and analyzed using near-infrared (NIR) spectroscopy to understand oil and protein differences. Increases in protein levels from sulfur were only observed at Cedar Rapids and occurred with all three forms of sulfur application. Protein levels were more consistently influenced by soybean variety and growing environment (Graphs 2 and 4).

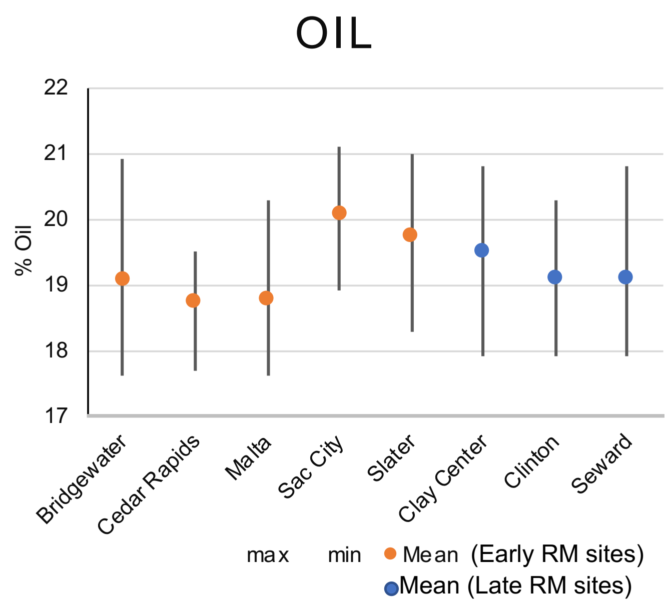
Oil content varied depending on location. No consistent changes in oil levels due to sulfur application was noticed when comparing individual locations and varieties. Similarly to protein, variety selection and growing environment had more influence on oil content than sulfur applications (Graphs 3 and 4). Previous studies have shown changes in management practices sometimes result in reduced oil and increased protein level. In



Graph 1. Grain yield response from sulfur across trial locations



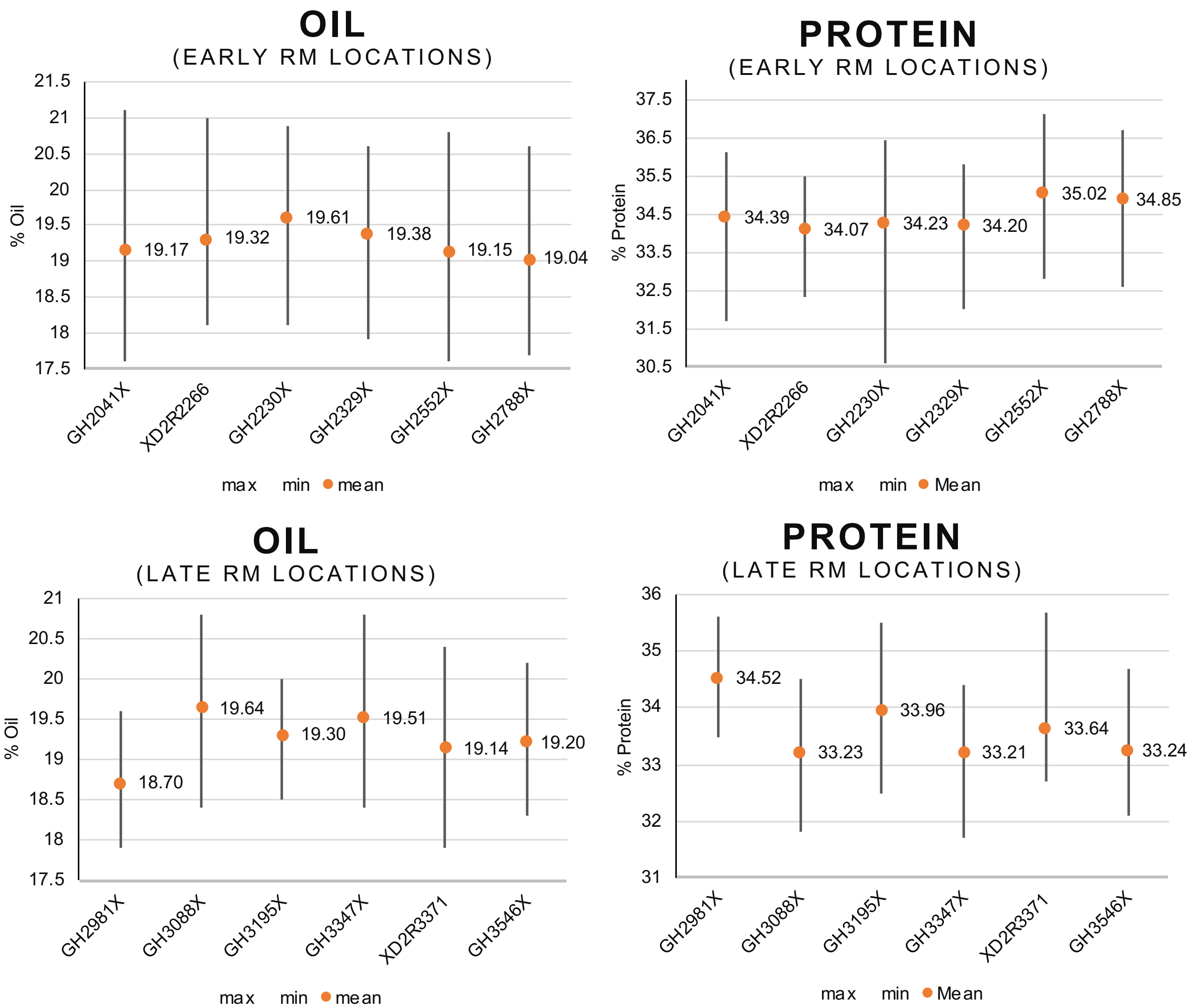
Graph 2. Soybean protein content across trial locations



Graph 3. Soybean oil content across trial locations

this study, there were several locations and soybean varieties that similarly showed that as protein or oil increased, the other decreased (Graphs 2 and 3).

Sulfur deficiency is becoming more common in crop production today. As environmental emissions of sulfur continue to be cleaned up, mitigation of sulfur deficiency is becoming more apparent. Soil tests can be used to evaluate soil sulfur levels, but no response thresholds have been established for interpreting results. Because sulfur is mobile in the soil, test results could over- or underestimate sulfur levels with variation in the amount of sulfate that has moved through the soil profile compared to sampling depth. Testing methods can vary between labs, but ideally sulfur levels will fall in the 10-20 ppm range. Fertilizers in the sulfate form are more readily available to plants compared to elemental sulfur. which must first be converted to the sulfate form before becoming available to plants. Plant tissue sampling is helpful in determining in-season sulfur deficiency and is more accurate in determining sulfur needs that require immediate correction. Monitoring soil sulfur levels through soil testing and utilizing plant tissue sampling to identify and correct deficiencies can ensure plants have adequate sulfur throughout the growing season.



Graph 4. Oil and protein levels by soybean variety

SOYBEAN TOLERANCE TO HERBICIDES

INSIGHTS

- There is potential for soybeans to experience sulfentrazone or metribuzin injury, but not all soybean varieties respond.
- Golden Harvest has evaluated variety response in order to understand the injury risk for the planned weed control program.

SULFENTRAZONE HERBICIDE INJURY

Crop response to sulfentrazone, and most other PPO herbicides *(flumioxazin, saflufenacil, etc.)*, often occurs when the herbicide is splashed on the plant's hypocotyls, cotyledons and growing points from heavy rainfall during soybean emergence. Cool, wet and cloudy conditions following heavy rainfall will reduce the ability of the plant to metabolize the herbicide and may lead to crop response or visual injury. PPO herbicide preemergence applications may still cause hypocotyl injury, plant stunting and, if severe, cause growing point injury or death.[1]

METRIBUZIN HERBICIDE INJURY

Metribuzin and other triazine herbicides (atrazine) show soybean injury in high pH soils due to triazine herbicides being more available for plant uptake from soil. Soybean response to triazine is exhibited by interveinal yellowing or chlorosis in the lower leaves with dying or necrotic margins. In severe cases, leaves fall off the plant and sometimes result in complete plant death.

Figure 2. Soybean crop response to metribuzin

Figure 1. Soybean crop response to sulfentrazone
Photo courtesy of Phil Krieg

RESPONSE TO SULFENTRAZONE AND METRIBUZIN HERBICIDES

Numerous university studies have documented differing levels of soybean sensitivity across varieties from sulfentrazone and metribuzin herbicides used for soybean weed control. Each year, Golden Harvest® Agronomy In Action Research screens soybean lines for sulfentrazone and metribuzin tolerance. Sulfentrazone and metribuzin are applied preemergence at 2x rates using a sandy soil with ample irrigation to amplify herbicide injury. Each variety is evaluated using a 1 to 9 scale (1 is most tolerant and 9 is least tolerant.) The ratings are categorized into three groups:

- **Best** (ratings 1 to 2) – None, to slight visual herbicide injury risk
- **Average** (ratings 3 to 7) – Slight to moderate visual herbicide injury risk
- **Poor** (ratings 8 to 9) – Moderate to high visual herbicide injury risk

PLANT GROWTH

HERBICIDE RESPONSE RATINGS

A rating of Poor signifies a higher risk of injury when metribuzin or sulfentrazone herbicide containing weed control programs are planned. Injury may not be observed with normal growing conditions and rates. However, when conditions are favorable for injury (cool and wet, intense rainfall during seedling emergence, high pH soil, etc.), there is elevated potential for injury with these specific varieties. Varieties having average or best sensitivity ratings can be treated with herbicide safely but may still exhibit crop response levels that are unlikely to impact yield.

Golden Harvest Hybrid	Trait Stack	Relative Maturity	Herbicide Tolerance		Golden Harvest Hybrid	Trait Stack	Relative Maturity	Herbicide Tolerance	
			Sulfentrazone	Metribuzin				Sulfentrazone	Metribuzin
GH00629X	RR2X	0.06	Best	Best	GH2788X	RR2X	2.7	Average	Average
GH00833E3	E3	0.08	Best	Average	GH2727LG	LL GT27	2.7	Average	Average
GH00866	GENRR2Y	0.08	Best	Average	GH2818E3	E3	2.8	Average	Best
GH0145X	RR2X	0.1	Best	Best	GH2981X	RR2X	2.9	Average	Best
GH0294E3	E3	0.2	Average	Best	GH3088X	RR2X	3.0	Best	Best
GH0339X	RR2X	0.3	Best	Average	GH3042E3	E3	3.0	Best	Best
GH0325E3	E3	0.3	Average	Best	GH3027LG	LL GT27	3.0	Best	Average
GH0391	GENRR2Y	0.3	Best	Average	GH3195X	RR2X	3.1	Average	Average
GH0308X	RR2X	0.3	Best	Best	GH3152E3S	E3/STS	3.1	Best	NR
GH0443X	RR2X	0.4	Best	Average	GH3380E3	E3	3.3	Best	Average
GH0581E3	E3	0.5	Best	Average	GH3347X	RR2X	3.3	Best	Best
GH0593E3	E3	0.5	Average	Average	GH3427LG	LL GT27	3.4	Best	Best
GH0543X	RR2X	0.5	Best	Best	GH3475X	RR2X	3.4	Best	Average
GH0670L	LL	0.6	NR	Average	GH3582E3	E3	3.5	Best	Best
GH0749X	RR2X	0.7	Best	Best	GH3546X	RR2X	3.5	Best	Best
GH0715E3	E3	0.7	Best	Best	GH3624E3	E3	3.6	Average	Best
GH0913E3	E3	0.9	Best	Average	GH3759E3S	E3/STS	3.7	Best	Best
GH0936X	RR2X	0.9	Best	Best	GH3727LG	LL GT27	3.7	Best	Average
GH1012E3	E3	1.0	Best	Average	GH3728X	RR2X	3.7	Average	Best
GH1225X	RR2X	1.2	Best	Best	GH3918E3S	E3/STS	3.9	Average	Best
GH1227LG	LL GT27	1.2	Best	Average	GH3934X	RR2X	3.9	Average	Best
GH1362E3	E3	1.3	Best	Best	GH3922E3	E3	3.9	Best	Average
GH1317X	RR2X	1.3	Average	Average	GH3927LG	LL GT27	3.9	Best	Best
GH1414X	RR2X	1.4	Best	Best	GH3982X	RR2X	3.9	Best	Average
GH1557E3	E3	1.5	Best	Average	GH4155E3	E3	4.1	Average	Average
GH1638X	RR2X	1.6	Best	Best	GH4201E3	E3	4.2	Best	Average
GH1627LG	LL GT27	1.6	Best	Best	GH4240XS	RR2X/STS	4.2	Average	Best
GH1619X	RR2X	1.6	Average	Best	GH4227LGS	LL GT27/STS	4.2	Average	Average
GH1763E3	E3	1.7	Best	Best	GH4314E3	E3	4.3	Average	Average
GH1852X	RR2X	1.8	Best	Best	GH4307X	RR2X	4.3	Average	Average
GH1827LG	LL GT27	1.8	Best	Average	GH4474E3	E3	4.4	Average	Average
GH1955E3	E3	1.9	Best	Average	GH4531XS	RR2X/STS	4.5	Average	Average
GH1944E3	E3	1.9	Best	Best	GH4589X	RR2X	4.5	Average	Best
GH1915X	RR2X	1.9	Best	Average	GH4627LG	LL GT27	4.6	NR	Average
GH2011E3	E3	2.0	Average	Best	GH4612E3S	E3/STS	4.6	Average	Average
GH2041X	RR2X	2.0	Best	Best	GH4628X	RR2X	4.6	Poor	Best
GH2027LG	LL GT27	2.0	Best	Best	GH4741X	RR2X	4.7	Poor	Best
GH2279E3	E3	2.2	Best	Average	GH4838E3S	E3/STS	4.8	Average	Average
GH2230X	RR2X	2.2	Best	Best	GH4877E3S	E3/STS	4.8	Best	Best
GH2329X	RR2X	2.3	Best	Best	GH4823XS	RR2X/STS	4.8	Average	Average
GH2420E3	E3	2.4	Best	Best	GH4917XS	RR2X/STS	4.9	Average	Average
GH2427LG	LL GT27	2.4	Best	Best	GH5016E3S	E3/STS	5.0	Average	Average
GH2505E3	E3	2.5	Best	Average	GH5189E3	E3	5.1	Average	Average
GH2523E3	E3	2.5	Best	Average	GH5175XS	RR2X/STS	5.1	Average	Average
GH2552X	RR2X	2.5	Best	Best	GH5270X	RR2X	5.2	Average	Best
GH2610E3	E3	2.6	Average	Best	GH5367X	RR2X	5.3	Average	Average

Metribuzin and Sulfentrazone Herbicide Key Recommendations: Best | Average | Poor | No Rating

RR2X=Roundup Ready 2 Xtend®, E3=Enlist E3®, LLGT27=Liberty Link® GT27™, GENRR2Y=Genuity® Roundup Ready 2 Yield®

No Rating

Best — None to slight visual herbicide injury risk on this variety, depending on the environment

Average — Slight to moderate visual herbicide injury risk on this variety, depending on the environment

Poor — Moderate to high visual herbicide injury risk on this variety, depending on the environment

THISTLE CATERPILLAR IN SOYBEANS

INSIGHTS

- Thistle caterpillars are the larvae of the painted lady butterfly, which overwinters in the southern U.S. and Mexico and migrates to the Corn Belt during early to mid-season.
- Caterpillars tend to congregate around field edges first and then work their way into the interior.
- An insecticide treatment typically offers the most effective solution to an infestation.

The relatively well-known larvae of the painted lady butterfly, thistle caterpillars, can wreak havoc on soybean fields early to mid-season if left unchecked. Below are some insights to keep in mind as the annual migration begins.

IDENTIFICATION

Eggs: Barrel shaped; white to light green in color.

Larvae: Caterpillars are around one and one quarter inch in length and are covered in branching spines with small hairs protruding from them. Their colors can range from a light, creamy white to dark brown and even black, often accompanied with a long yellow stripe along the top of their body.

Photo source: University of Nebraska-Lincoln Entomology

Figure 1. Thistle caterpillar

Figure 2. Adult painted lady butterfly

Adults: Closely resembling that of Monarch butterflies, painted lady butterflies are known for their unique black and orange "splatter" pattern with distinct white eyespots on the edges of the wings. Body length is usually around one inch long and wingspan ranges from two to three inches in width.

LIFE CYCLE

Painted lady butterflies don't overwinter in Corn and Soybean Belt states. They migrate north from the Southern U.S. and Mexico, where they then arrive and lay their eggs on soybeans. Eggs typically take a week to develop and hatch. Feeding of the larvae (thistle caterpillars) can last anywhere from 2-6 weeks until they reach the pupation period, which lasts around 7-17 days. Each season usually sees two generations of the butterfly until they migrate back south in September.

MANAGEMENT THRESHOLDS

University thresholds typically state that if caterpillars are currently present in the field, it is justifiable to consider treatment solutions, such as an insecticide application, at the following recommended guidelines.[1] Be sure to inspect at least 10 plants at several areas of the field for feeding symptoms before making a final decision.

- Vegetative stages (any time before flowering): leaf defoliation at 30% or greater
- Reproductive stages: leaf defoliation at 20% or greater

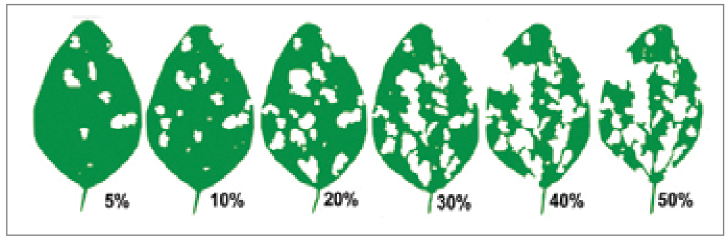


Photo source: University of Nebraska-Lincoln CropWatch

Figure 3. Defoliation levels on soybean leaves. The impact of losing leaf area depends on the soybean growth stage.

ADDITIONAL CONSIDERATIONS

Additional insight to keep in mind around the management of this insect:

- Thistle caterpillars typically congregate more toward field edges, especially if Canada thistle plants are present.[2]
- Most soybean plant injury is caused by caterpillar feeding in the V3-V4 stages.[2]
- Sunflowers are another significant attractant to thistle caterpillars. If a field is present nearby, be sure to pay extra attention to any soybeans planted in close vicinity to it.[2]

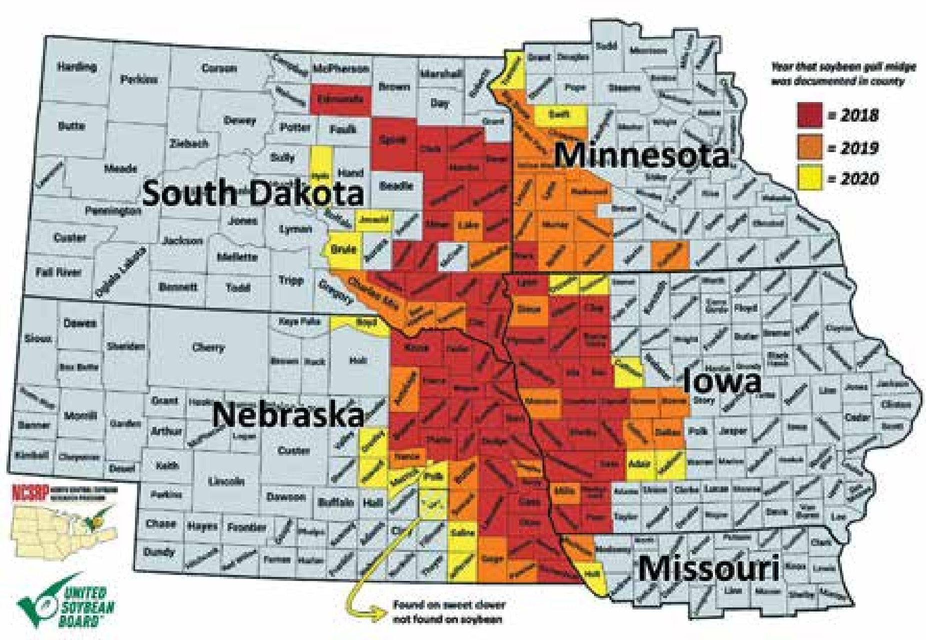
Some regions may experience increased populations of thistle caterpillars, so it is important to scout for damage. Please contact your local Golden Harvest® Seed Advisor or Agronomist with any questions or with help identifying pests.

Figure 4. Thistle caterpillar on soybean surrounded by its distinctive webbing

SOYBEAN GALL MIDGE

INSIGHTS

- Plants are most susceptible to soybean gall midge at the V3 stage and beyond, exhibiting symptoms of wilting around 20 days post adult emergence.[1]
- Confirmed hosts include alfalfa, sweet clover and native lead plant.
- There are no known "sure fire" management techniques, but mitigation measures such as mowing densely vegetated field edges, spring tillage, late planting and insecticides (foliar and seed treatments) can help lessen impact.



Source: Soybean Gall Midge Adult Emergence Alert Network

Figure 1. Counties with soybean gall midge detection in 2018/2019/2020

Since the massive increase of infestations in 2018, the spread of this newly identified species of true fly has continued to increase. The 2019 growing season saw many fields fall victim to an outbreak of gall midge that had otherwise remained untouched, which provides ample reason to predict some rather critical years ahead in monitoring the spread of the insect throughout the Midwest.

GEOGRAPHIC DISTRIBUTION

Soybean gall midge (SGM), Resseliella maxima, has been reported and confirmed in 114 counties (19 new) across 5 states in 2020 (Figure 1).[2] Infestations have primarily occurred in Eastern Nebraska, Eastern South Dakota, and Western Iowa and have spread most recently into Southwestern Minnesota and surrounding areas.

LIFE AND FEEDING CYCLE

The cycle begins with 3rd Instar larvae overwintering in the soil from the prior season (Figure 2). After pupating in the spring, the adult flies emerge, mate and lay eggs at the base of soybean plants. About nine days following adult emergence, 1st and 2nd Instar larvae are present and begin to feed on roots and the vascular system on the plant, causing structural damage and disrupting nutrient and

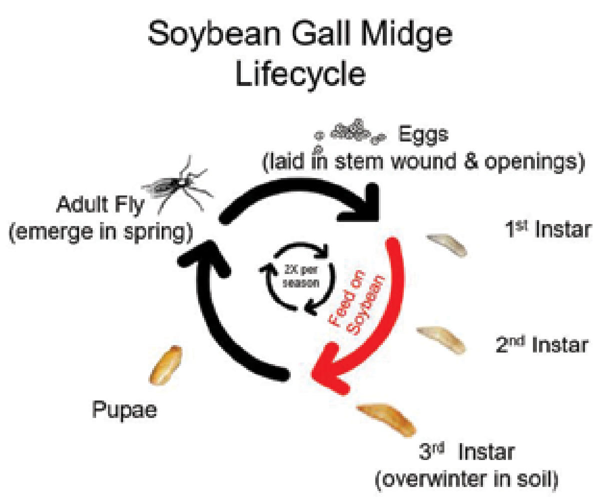


Figure 2. Soybean gall midge life cycle

moisture flow. Around 12 days post-adult emergence, many of the larvae transition to 3rd instar. Symptoms of plant wilt will then begin to appear roughly eight days following the 3rd instar transition.

SCOUTING CONSIDERATIONS

- Confirmed hosts of SGM include alfalfa, sweet clover and native lead plant.
- SGM are observed to work their way in from field edges which are often the hardest hit field areas.
- Plants are most susceptible at the V3 stage or later (cracks and fissures in the ground may be necessary for egg laying).
- Wilted plants and darkened stems (at ground level) are the most notable symptoms (Figure 3).
- Split the soybean stem and look under the stem epidermis to look for larvae (Figure 4).[3]

MANAGEMENT

While there is no tried-and-true way to manage soybean gall midge at this time, there are measures that can be taken to reduce their impact – especially on high pressure fields. Mowing densely vegetated field borders before adults emerge was proven in one trial to reduce infestation by 50%. Spring tillage

Figure 3. Stem expansion - stretch marks and tissue damage

also serves as a viable mechanical option to control, as it has been shown to slightly reduce the emergence of overwintering adults. An insecticide could be effective as a foliar treatment (pyrethroid) at V3 if SGM adults are still present in the field. Due to potential for multiple lifecycles per season, proper timing of foliar insecticides can be challenging.[1] To further mitigate infestations, higher risk fields should be planted last, as the delayed soybean growth will potentially not align with adult emergence and egg laying.

Source: Dr. Justin McMechan, University of Nebraska-Lincoln

Figure 4. Field view diagram – (a) 3rd instar larvae are orange; (b) 1st and 2nd instar larvae are white; (c) sporadic feeding damage (dead plants) in a field

SOYBEAN CYST NEMATODE AND ACTIONS TO REDUCE DAMAGE

INSIGHTS

- Soybean yields may be reduced by soybean cyst nematode (SCN) without growers knowing it.
- The goal of managing SCN is to achieve improved, sustainable soybean yield over time through the proper use of all available management tools.
- Improvements to soybean production and reduction from the impact of SCN on the bottom line can be accomplished through a purposeful, comprehensive SCN management program.

HOW SERIOUS IS SOYBEAN CYST NEMATODE?

SCN can lead to an estimated loss of more than 125 million bushels in total U.S. production annually, based on a survey from the University of Missouri.[1] As the number 1 pest in soybeans, Extension nematologists and plant pathologists estimate that SCN robs more yield per year than the next five soybean pathogens combined[1], with an estimated $1.5 billion in annual soybean yield losses.

According to the University of Illinois, SCN can lead to losses up to 80 percent.[2] However, the most common SCN losses up to 40 percent are not obvious enough to be visible from above-ground symptoms.[3,4] This means soybean yields may be reduced by SCN without any realization. Once SCN is introduced into a field, it can never be eradicated. Once it is in the field, it is there forever. Because of that, it is a pest that must be managed; otherwise, it will eventually become a significant problem. Losses associated with SCN in any given year will be directly dependent on environmental factors, such as drought or other natural events. However, through planning and use of SCN management strategies, the impact of these SCN-related losses can be reduced.[5]

IDENTIFICATION AND LIFE CYCLE

SCN are microscopic roundworms that invade and infest soybean roots. Multiple generations of SCN occur each year in the U.S. within a single growing season, with as few as two in the north and as many as six in the southern U.S. There are three major life cycle stages of SCN: egg, juvenile and adult. The egg is the overwintering SCN stage that hatches as a juvenile roundworm and is attracted to young developing roots early in the season (see Figure 1).

Figure 1. Soybean cyst nematode and eggs

SCN juveniles enter the soybean root and move toward vascular tissue – the tissue that transports moisture and nutrients throughout the plant. The juveniles modify plant cells and begin to feed, robbing nutrients and damaging their host. SCN females continue to feed inside the root but eventually grow large enough to burst outside the root, while the males leave the root to mate with exposed

Figure 2. Cysts and cysts on roots

females. The female SCN continue to feed, with the largest portion of the developing body exposed on the root exterior (see Figure 2).[6]

The young, exposed, developing female is initially white in color but becomes yellow to brown with age. Following fertilization, the female produces up to 200-500 eggs. As her life cycle is completed, the female dies and changes from yellow to brown. Some of the maturing eggs will immediately develop and hatch, starting the lifecycle over again (see Figure 3).[6] The remaining female's body becomes the familiar "cyst" structure, which can act as a long-term, resilient casing helping some eggs to survive for years. SCN's ability to overcome management practices is largely due to extended egg hatch timing, increasing the chances of successful life cycle completion across years.[4]

SCN commonly complete 3-5 generations per growing season in the U.S. based primarily on the following (in no particular order):[5]

- Planting date
- Soil temperature
- Host suitability
- Geographic location
- Presence of alternative hosts
- Length of growing season

During the soybean growing season, the most typical SCN life cycle can be completed in 24-30 days, based largely on environmental conditions such as temperature and moisture levels.

SCN IMPACT ON SOYBEANS

SCN reduces soybean performance and yield in several ways. The greatest impact is caused by SCN juveniles establishing themselves within the root and causing vascular plant tissue disruption. As the juveniles develop into full-grown adults, the efficiency of moisture and nutrient transport within the infected plant is drastically affected. Secondary effects of SCN infection include:

- Stunting and damage of developing soybean root system
- Reduction of nitrogen-fixing Rhizobium bacteria root nodules
- Stress interactions with any number of pests which flare within stressed soybeans
- Disease introduction through SCN entry points within the root

A common pest introduced through SCN feeding is *Fusarium virguliforme*, the causal organism of sudden death syndrome (SDS). This disease is often closely associated with SCN. Other diseases associated with SCN are brown stem rot, *Pythium*, *Phytophthora* and iron deficiency chlorosis (IDC).

MANAGEMENT

Although SCN can have drastic effects on soybean yield, there are management strategies that have predictably positive results over time.

Identify field presence: Soil sampling is reported to be the most reliable means of confirming and monitoring SCN levels.[7] Initially, SCN soil sampling is recommended to provide a baseline. Then, a regular soil sampling program once every 3-5 years will provide a picture of whether management practices are producing the desired result. Due to the irregular distribution of SCN within fields, its best to use soil sampling only as a means to confirm presence of SCN and monitor changes in SCN pressure over years.

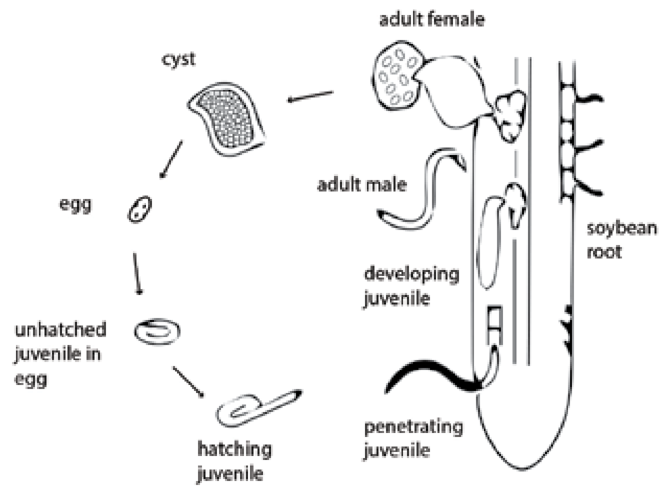
Weed management: Soybeans are not the only host for SCN. An Indiana agricultural field survey determined that known SCN-host winter weeds were present in 93 percent of surveyed fields.[8] According to Purdue University Extension, there are six known winter weeds that allow various levels of successful SCN reproduction[9], and management of these weeds should be an important goal:

- Purple deadnettle (strong host)
- Henbit (strong host)
- Field pennycress (moderate host)
- Shepherd's purse (weak host)
- Small-flowered bittercrest (weak host)
- Common chickweed (weak host)

Crop rotation: Non-host crop rotation is a foundational principle in managing SCN. Table 1 shows several commonly grown U.S. crops that are not SCN hosts. Use of non-host crops provides the unique opportunity to reduce fieldwide SCN numbers by disrupting the SCN life cycle. Although reductions are possible, several consecutive rotations with non-host crops are needed for significant population decreases, and total elimination will not be feasible. It is possible to see greater reduction with rotation in longer growing season regions as result of hatch events extending out over longer time frames. Note however, that rotating out of soybeans for more than three years has been found to offer little value in further reduction of SCN egg numbers. All the susceptible SCN eggs that will hatch without a host present have hatched and the overwintering egg numbers stabilize.

ALFALFA	**COTTON**
BARLEY	**GRAIN SORGHUM**
CANOLA	**OATS**
CORN	**WHEAT**

Table 1. Common SCN non-host crops



Source: Iowa State University

Figure 3. Soybean cyst nematode life cycle

SCN-resistant varieties: If SCN is confirmed in fields planned for soybeans, SCN-resistant varieties are strongly recommended. SCN-resistant varieties reduce the ability of SCN to successfully colonize the soybean root leading to a reduction of the SCN reproduction rate. Considering SCN can have 3-5 generations per year where each female in each generation produces 200-500 eggs, any reduction in their reproduction rate can have impactful reductions in the end-of-season SCN egg numbers. Planting varieties without SCN resistance may not always result in noticeable yield loss, however repeated use will enable higher SCN reproduction rates, increasing the risk of SCN exploding into a significant yield-limiting pest in later years.

Alternate source of SCN resistance: There are 7 different sources of SCN resistance that have been identified and utilized by soybean breeders for addressing SCN management over the years. Sources of resistance are often referenced by a Plant Introduction (PI) number. Although 7 sources of resistance have been identified, only two are frequently utilized by breeders. The most utilized source is PI 88788, representing more than 90% of commercial varieties sold today. PI 58402, also known as Peking, is utilized within a limited number of varieties sold. SCN resistant varieties limit SCN egg laying capacity within soybean roots, but do not completely prevent reproduction. Up to 10% of normal reproduction can still occur on SCN resistant varieties. Due to long-term use of predominately one source of resistance, field populations of SCN have slowly adapted to PI 88788 and it's not uncommon to observe reproduction rates greater than 10% with some populations. SCN populations will likely slowly increase due to continued adaptation to PI 88788.

Golden Harvest has introduced a new source of SCN resistance, PI 89772, and is working to provide new commercially available varieties with this source of resistance. Continued use of crop rotation to non-host crops will remain critical. If unable to rotate sources of resistance, attempt rotating to a different variety that utilized PI 88788 as reproductions can vary between varieties.[6]

Seed-applied nematicide: The last element of a comprehensive SCN management program is considering use of a seed-applied nematicide. In combination with all the management tools outlined, a seed-applied nematicide can offer additional protection against nematodes. Since healthy root development is vital to establishing the most yield potential, nematicides have been one of the most anticipated seed-applied technologies offered in recent years.

Golden Harvest offers two seed-applied nematicide options: Clariva® Complete Beans seed treatment, a combination of separately registered products, for season-long SCN protection; and Saltro® seed treatment which is available to add to existing fungicide/insecticide seed treatment options. Saltro provides protection against sudden death syndrome as well as provides robust activity against SCN, root knot, reniform, lesion and lance nematodes.

CONTROL OPTIONS FOR FROGEYE LEAF SPOT

INSIGHTS

- Frogeye leaf spot (FLS) can be easily mistaken for other diseases or herbicide injury.
- There is currently no economic threshold in place for frogeye leaf spot management.
- Confirmed cases of resistance have grown rapidly in recent years, making it imperative to be conscientious about fungicide choice.

Source: University of Nebraska-Lincoln; CropWatch

Figure 1. Frogeye leaf spot on a soybean leaf

SIGNS, SYMPTOMS AND DIAGNOSIS

Frogeye leaf spot (FLS), caused by the fungus *Cercospora sojina*, produces lesions mostly found in the upper canopy of soybean plants. They begin as small, circular and dark water-soaked marks on the tissue, but will become larger, more angular, and lighten in color throughout the season, fading from gray, to brown, to tan, and surrounded by a thin, purple margin. In some late-season cases, lesions can also be found on the pods and stems, where they will sometimes appear more oblong (pods) and elongated (stems) than on the leaves. Severe cases on pods may cause infection in seeds and sometimes, but not always, causing a purple or gray discoloration. When conditions are right, fungal sporulation (spore formation) occurs, adding a gray and fuzzy appearance to the undersides of the lesions.[1] In advanced cases, coalescence of the lesions may cause a blight of the leaves. Defoliation will result when the disease reaches its greatest severity.

Frogeye leaf spot can be easily mistaken for similar looking diseases and plant injuries, such as herbicide burn. In order to get the most complete and accurate diagnosis, it is recommended that a symptomatic sample be sent to a lab for official verification. The following are some common conditions that are often confused with frogeye leaf spot and how to distinguish them:

- Phyllosticta leaf spot: Small black specks of fungi can form inside the older lesions but will not be present in FLS.
- Target spot: Most common in southern states, target spot secondary lesions lack a yellow halo. "Target zone" like rings can appear similar to FLS but purple lesion margins will be absent.
- PPO herbicide injury: Herbicide injury is easily visible across larger, uniform areas following spray boom widths and new growth is typically unaffected.
- Paraquat herbicide injury: Differentiated from FLS by having healthy new growth on the plant, spray patterns are easily observed, and similar injury is found on weeds and other plants within the canopy.

DISEASE CYCLE AND CONDUCIVE CONDITIONS

Hosts of frogeye leaf spot fungus include infested soybean residue, with initial research suggesting some weeds, cover crops and other legumes potentially being hosts as well. The disease is spread via wind and water splashing the spores onto nearby plants, and in very rare instances, through infected seed. Wind dispersal can carry the disease into fields beyond the ones initially infected. Any stage of soybean growth can be at risk, but infection is most prevalent from R1-R7 (flowering through early maturity), mostly impacting the upper canopy of the crop. The most likely conditions to contribute to infection include frequent bouts of precipitation and/or overhead irrigation, periods of overcast lasting a few days or more, and warm, humid weather occurring for extended periods of time. Fields that are continuous soybean, have short rotations between soybean crops, are conservation or no-tillage, are planted with a susceptible variety, or have a history of frogeye leaf spot are also at a greater risk for infection.[1]

YIELD POTENTIAL IMPACT

Minimal or no yield potential impact:

- Low disease severity
- Disease occurs in reproductive stages (post R5.5)

Yield potential losses up to 35%:

- Early disease outbreak (before or just after flowering)
- Favorable environmental conditions

MANAGEMENT

There are several approaches to managing FLS in both proactive and reactive measures. Most notably, this includes planting a soybean variety containing the *Rcs3* gene, which is the only gene currently available that is resistant to all strains of the frogeye leaf spot fungus.[1] A variety labeled “resistant” without the presence of the gene is only partially resistant to the disease, not providing full coverage to all strains in existence. Residue management is also a tool that can be used to help mitigate future impacts of a previously infected field. Tillage and crop rotation are viable options to consider that help break up and lessen overwintering host residues in the field, thereby reducing the risk of future infections.

A foliar fungicide application, when applied at the proper stages of R3-R4, can be effective in controlling FLS. Golden Harvest® recommends Miravis® Top fungicide at 13.7 oz/acre rate for the most optimal control of frogeye leaf spot, providing additional coverage against Cercospora leaf blight and pod and stem blight. Trivapro® broad-spectrum fungicide is also rated for control of FLS and may be considered as a management option. It is important to keep in mind that there is no official economic threshold for treating this disease.

Environmental conditions, field susceptibility and disease severity should all be considered when choosing a management plan for your field.

RESISTANCE

Since 2010, resistance among almost all strains of frogeye leaf spot toward the QoI (Group 11) class of fungicides has continued to increase substantially.[2] Strobilurins are the most well-known type of fungicide to fall into this class. As of February 2020, the states with confirmed resistance include Alabama, Arkansas, Delaware, Illinois, Indiana, Iowa, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, North Carolina, Michigan, Minnesota, Ohio, Tennessee and Virginia.[2] When resistance is found in a field, it can be assumed to be widely present across the growing area, and management plans should be adjusted accordingly to avoid Group 11 chemistries in the next application. Miravis Top fungicide is approved for use and effective against strobilurin-resistant FLS infections.

DECTES STEM BORER IN SOYBEANS

INSIGHTS

- Dectes stem borer has increased at alarming rates throughout many areas previously unaffected.
- No- or minimal-tillage systems may be at greater risk for Dectes stem borer.
- There are currently no insecticides labeled for Dectes stem borer larvae control, making alternative management practices critical for mitigating future damage.

INTRODUCTION

The instances of Dectes (or soybean) stem borer infestations have increased notably throughout recent years. This insect pest has an extensive reach, from the Southeastern U.S. and Great Plains, reaching as far north as North Dakota and far south as Texas, with sightings also being recorded more frequently in areas throughout the Midwest. The ever-expanding geography of this relatively new pest will be a critical factor to consider in future soybean management.

IDENTIFICATION AND LIFE CYCLE

The Dectes stem borer beetle has one generation per growing season. Larvae overwinter in the base of the stem of the host plant. In the spring, the overwintering larvae enter an 8-10 day long pupal stage after which they emerge as adult beetles. Adults are light gray in color, approximately 3/8-1/2 an inch in length, with long, slightly curved antennae. Adult stem borers mate soon after they emerge, and females lay eggs in soybean leaf petioles around mid-canopy. Larvae hatch and are light, creamy white in color, but darken upon maturing. The bodies of the larvae are "accordion-like" in appearance with

Figure 1. Dectes stem borer larva

reddish-orange or brown colored heads and typically grow to 1/2-5/8 inches in length. They feed on the plant by tunneling through the petiole into the stem, impacting the soybean plant. Usually, only one mature larva will be found per plant because they are cannibalistic.

INJURY TO SOYBEANS

The greatest contributing factor to yield loss as a result of Dectes stem borer is soybean lodging, ultimately due to girdling of the lower stem brought about by the larva feeding on the plant pith and frass buildup. An outside force, such as high winds or heavy rain, are usually needed however, for lodging to occur. Excessive pith and vascular tissue feeding weakens the plant structure and restricts moisture and nutrient flow, effectively reducing pod fill and therefore, yield, in heavily impacted fields. An indicator of an infestation can be the wilting or senescence of the upper canopy leaves due to the larval entrance points and feeding.[1]

Figure 2. Damage from Dectes stem borer larva inside a soybean stem

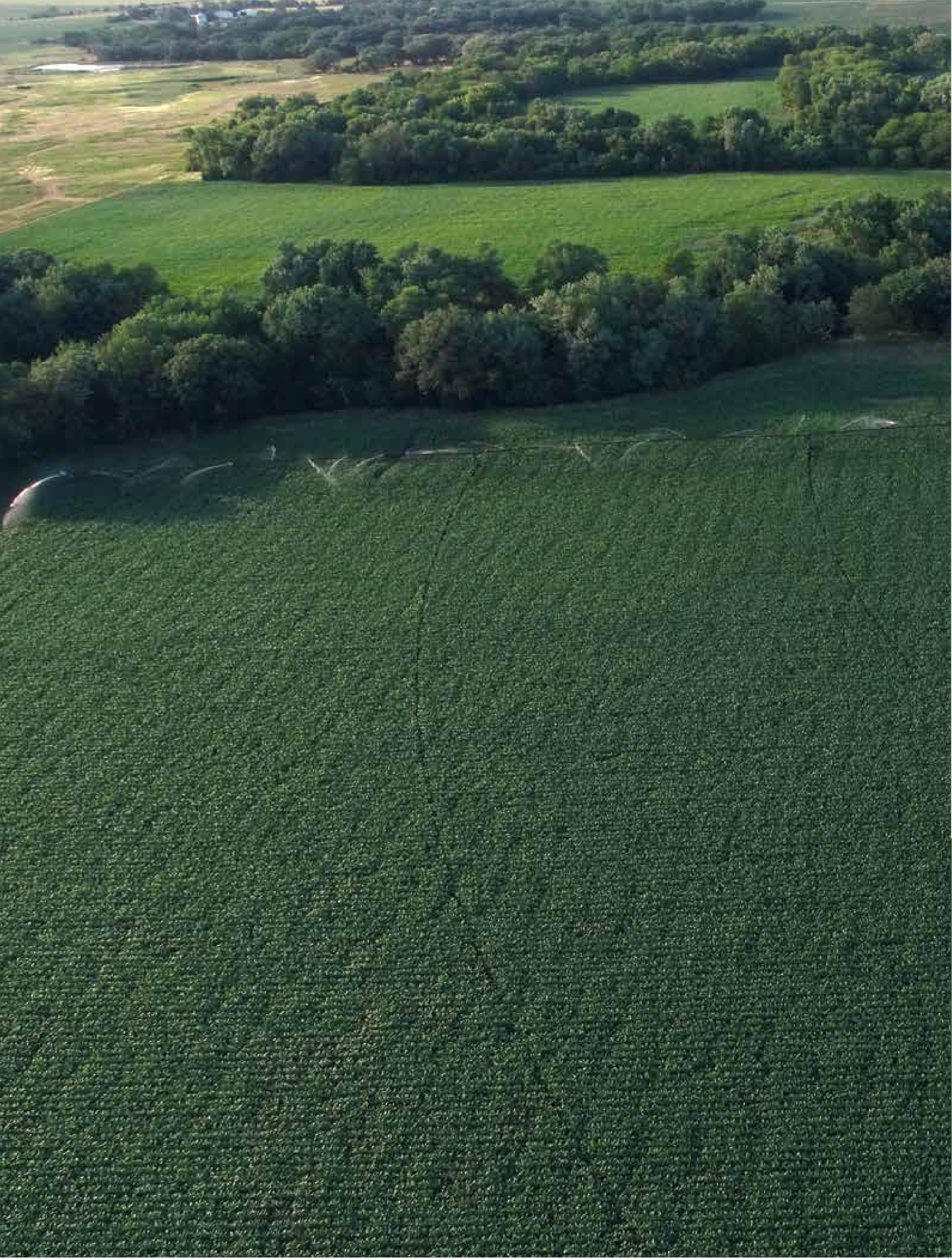
Figure 3. Dectes stem borer adult longhorn beetle

MANAGEMENT AND ADDITIONAL CONSIDERATIONS

The most conducive conditions for the Dectes stem borer are thought to be conservation or no tillage systems, where a buildup of minimally disturbed residue provides hosts for larvae to overwinter.[2] Several weeds are also hosts to the Dectes stem borer, such as cocklebur and giant ragweed. Fields with increased presence of these weeds are more likely to harbor the pest and increase the risk of infestation. Soybean field edges are also typically more susceptible and are oftentimes more heavily impacted.[3]

Treatment options are limited at this time as there are currently no insecticides labeled for burrowed larvae, and resistant soybean varieties have not yet been developed. There are several cultural practices, however, that can be used to mitigate the impacts of the pest:

- Harvest soybeans as soon as possible after maturing to limit opportunity for lodging to occur.
- Utilize effective weed management techniques to control hosts such as cocklebur and giant ragweed in and around the field.
- Fall tillage has been shown to significantly reduce survival rates of overwintering larvae.
- Consider increased crop rotation and avoid planting soybeans near recently infested fields.



CORN YIELD IMPACT FROM LATE-SEASON ROOT LODGING

INSIGHTS

- Corn has little ability to goosneck upward when lodging after pollination.
- Late-season root lodging can cause 5-31%, yield loss, depending on timing.[1]
- Reducing combine speed, utilizing a reel system and harvesting at an earlier date help minimize harvest loss.

The historic derecho storm event that passed through the corn belt August 10, 2020, left a wide path of destruction. Millions of acres of corn across Iowa, Illinois and areas of Wisconsin were affected. There are a few key considerations and takeaways to keep in mind when managing wind-damaged corn.

- The growth stage of the crop at the time of a weather event is a key factor in yield impact.
- Whether the plants experienced root lodging or stalk crimping impacts the grain fill potential.
- Yield losses due to reduced harvestability should be expected.

ROOT LODGING

The most significant phenomenon that resulted from the storm was root lodging, which occurs when high winds force corn roots to lose hold and tip the plant over at the soil line without breaking. The incredibly high winds, with significant downdraft, flattened corn fields (Figure 1). The problem can be worsened in saturated soils often brought about by heavy rains that can accompany a large thunderstorm.

Figure 1. Severe root lodging during grain fill period in 2020

Factors that can contribute to root lodging:

- Differences in hybrid root architecture and growth habits
- Compaction, excessive early season soil moisture, delayed planting dates and high seeding rates reducing early season root development
- Corn rootworm feeding damage

The growth stage of corn plays a significant role as to how the plant responds to root lodging. Prior to tasseling, corn internodes are still elongating. Lodging prior to tasseling will induce a plant growth hormone response resulting in "goosenecking" of stalks as the plant begins to grow back upright.[2] Auxin, a plant growth hormone, encourages stalk elongation on the side closest to the soil to help the plant begin to grow up vertically again. The August 10 wind event

Figure 2. Corn plants in early September, following pre-tassel root lodging in July. Left to right are control (no lodging) and lodging treatments at V10, V13 and V17 stages.[1]

Figure 3. Corn plants bending and kinking between nodes, reducing plants' ability to provide nutrients to developing kernels

occurred post-pollination for most fields. Due to the plants post-pollination focus on grain fill, corn had minimal goosenecking back up from soil surface, making harvest even more challenging.

EXPECTATIONS BASED ON CROP STAGE AT TIME OF WIND EVENT

V13-15: Plants begin to gooseneck upward rapidly within 6 days of lodging with minimal effects on harvestability but a 5-15% yield reduction may occur (Figure 2 and Table 1).[1]

During pollination (VT): Pollination can be reduced causing poor kernel set. Disruptions of photosynthesis at key timing results in greater yield loss potential.[3] Minimal goosenecking and increased impact on harvestability is possible. A 12-31%[1] yield reduction may be expected, most likely on the higher end of the range if pollination/ kernel set is affected.[4]

Post-Pollination/Grain Fill: Light, nutrients and soil moisture can be greatly reduced during important grain filling stages. Stalk quality may deteriorate quickly due to reduced photosynthesis and the reallocation of nutrients within the stalk to the developing ear to better support grain fill. Plants will no longer gooseneck upward, increasing harvest challenges. Little data exists on yield impact of corn lodged at the R2 growth stage, which is the stage where most corn was on August 10. University of Wisconsin trial results suggested up to 25% yield reduction as late as R1. Greater yield losses are unlikely if just roots lodged. Additional yield losses due to harvestability should also be expected.

LODGING TRT GROWTH STAGE - YEAR 1	EAR NODE HEIGHT (INCHES)	BELOW-EAR STALK ANGLE (DEGREES)	GRAIN YIELD (BU/A)
Control	57	90	199
V10	52	85	191
V13-V14	41	61	182
V17-R1	29	36	151
LSD (0.05)	3	4	20
LODGING TRT GROWTH STAGE - YEAR 2	**EAR NODE HEIGHT (INCHES)**	**BELOW-EAR STALK ANGLE (DEGREES)**	**GRAIN YIELD (BU/A)**
Control	52	90	187
V11-V12	41	73	181
V15	33	50	168
VT	18	22	160
LSD (0.05)	6	9	10

Table 1. Simulated root lodging at different corn growth stages influence plant factors, including grain yield. Each value is the average of three hybrids.[1]

In addition to root lodging, many fields encountered stalks bending or kinking between nodes (Figure 3). It's important to understand in these scenarios the plant is no longer able to transport nutrients to developing ears. This will result in much greater yield loss and reduced test weight.

HARVESTABILITY AND ADJUSTMENTS TO CONSIDER

In addition to physiological yield reduction, harvest losses can be quite large in some situations. Harvestable yield will be impacted depending upon how much the plants are able to gooseneck and elevate the ear off the ground. When root lodging occurs post-pollination, goosenecking will be minimal. Root-lodged corn usually requires slower harvest speeds and has the potential for further yield loss from ear drop during harvest. Lodged corn will also be more predisposed to stalk rots. As the plant cannibalizes the stalk for nutrients due to reduced soil nutrient uptake, it is more vulnerable to stalk rot diseases. Stalk rot diseases can further impact the harvestability of the lodged corn.

OPTIONS TO CONSIDER FOR MAXIMIZING HARVESTABILITY

- Harvest earlier to take advantage of early stalk strength
- Reduce harvest speed
- Harvest in one direction depending upon direction of lodging
- Utilize a "reel" to help stalk material feed into the corn head
- Adjust gathering chain speed to match ground speed
- Adjust the stripper plates and make them wider to allow plants to flow in
- Guidance systems will help keep you on the row, but header height and alignment between the rows will need to be adjusted for each situation

NIGHT TEMPERATURE INFLUENCE ON CORN GRAIN FILL PERIOD AND YIELD POTENTIAL

INSIGHTS

- Night temperatures play an important role in maximizing grain fill potential.
- Historical data has shown a 2.8-4.7 bu/A yield decline for every 1 degree F increase in July and August average night temperatures.
- Both night and day temperatures independently influence yield potential.

UNDERSTANDING GRAIN FILL AND STRESS

Corn yield potential determination starts almost as soon as the seed is planted and continues to evolve throughout the growing season. Pollination is undoubtedly the time period when corn is the most sensitive to yield loss. However, the 60-day period following, known as "grain fill", and its role in differentiating between an above or below average yield, is often overlooked.

Achieving a slow, long and stress-free grain fill period is key to maximizing overall yield potential. During this time, a corn plant primarily directs sugars derived from photosynthesis into kernel development. Additionally, the plant will reallocate small amounts of sugars from other parts of the plant to support grain fill. In times of stress, when the plant is unable to produce enough photosynthate to meet demands, it will prioritize kernel development over maintaining root, lower stalk and overall plant health. It is not uncommon to see plant agronomics impacted, which may result in harvest challenges. When crop stress occurs close to black layer, it limits the ability of the plant to extend grain fill time, resulting in reduced kernel size and weight. Maintaining good fertility, adequate soil moisture and a disease-free canopy are key factors to extending the grain fill period. Night temperatures throughout July, August and early September are less controllable, but equally important in maximizing grain fill.

Figure 1. Kernel size differences attributed to stress during grain fill

COMPONENTS OF EXTENDED GRAIN FILL PERIOD

1. Night temperatures not exceeding 70°F
2. Adequate late-season water availability
3. Healthy and disease-free upper canopy to promote continued photosynthesis
4. Late-season nutrient availability

NIGHT TEMPERATURE INFLUENCE ON CORN YIELD

Domestication of corn is believed to have begun in the Central Highlands of Mexico and continued to evolve with cultivation in the South American Andes. From early days of domestication in higher elevation areas, maize adapted to warm days and cool nights. Producers today commonly recognize the sensitivity of corn to temperature swings occurring throughout the grain fill stages of development. Analysis of historical county-level yield, along with minimum daily temperatures (night temperature lows), compiled over the last 64 years illustrates how yield is impacted during years with warmer July-August night temperatures.

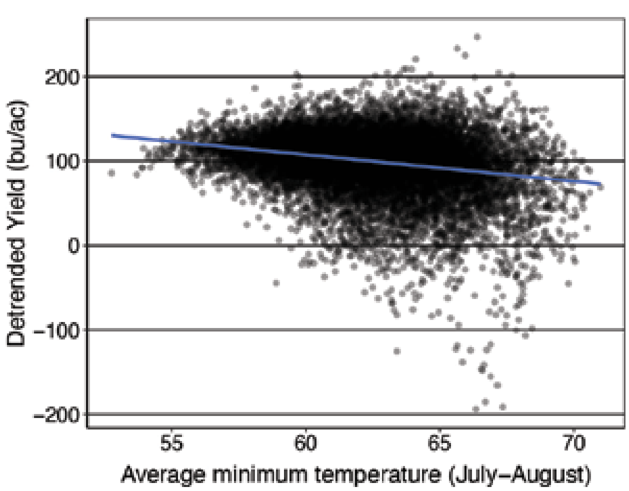
On average, Iowa, Illinois and Indiana experienced 2.8 fewer bu/A for every 1°F increase in July and August average minimum temperature (Graph 1a). Sharper yield declines of 4.7 bu/A for every 1°F increase in July and August average minimum temperature were seen in Kansas and Missouri (Graph 1b). An increase in night temperature is usually accompanied by higher-than-average day time temperature as well as drier soil moisture levels. Because of this, it is difficult to look solely at historic temperature responses and separate out the overall influence of nighttime temperatures.

Previous field studies which controlled day and night temperatures at sufficient soil moisture levels can give more insight to understanding the direct impact of temperature. Heat stress occurring prior to silking and 1-2 weeks following can cause kernel abortion.[1] Post-silking heat stress is a critical factor impacting grain size. Delaying heat stress 18 days after silking showed no reduction in kernel count at varying day and night temperatures.[2] The same study did show decreased grain ear weights with increasing nighttime temperatures. Yields were decreased even more if day and night temperatures were increased simultaneously. Elevating daytime temperature had more of a negative impact than increasing night temperatures. This indicates that both night and day temperatures independently influence yield. The changes in yield were directly caused by a reduction in kernel size. Smaller kernel size is most likely a result of having a shortened grain fill period. An increase in temperature shortened grain fill duration by 8 days (night °F increase), 15 days (day °F increase) and 18 days (day and night °F increase).

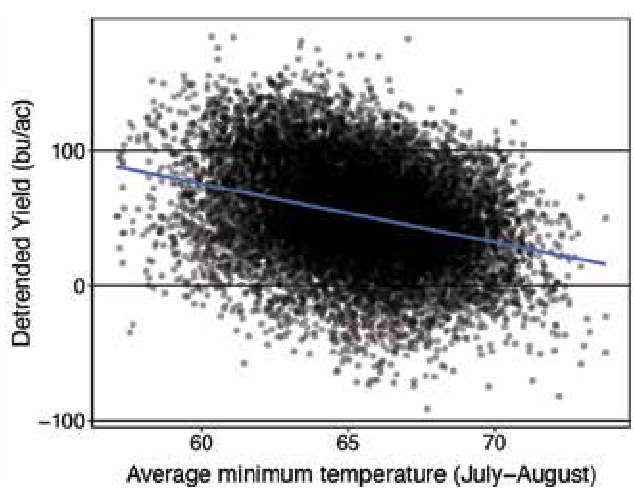
SUGGESTED REASONS NIGHT TEMPERATURES INFLUENCE GRAIN YIELD

Nightly temperatures are typically recognized as the lowest overall temperature throughout the entire day. The difference between 65°F and 75°F seems trivial in most cases because in general, most night temperatures feel mild

Night Temperature Influence on Grain Yield
(1956-2019 County Level NASS & NOAA data analysis)



Graph 1a. Iowa-Illinois-Indiana



Graph 1b. Kansas - Missouri

TEMPERATURE		GRAIN EAR WEIGHT	KERNEL SIZE	GRAIN FILL DURATION
Day (°F)	Night (°F)	(g)	(mg)	(days - silk to blacklayer)
77	59	124 a	213 a	57 a
77	77	103 b	175 b	49 b
95	59	72 c	130 c	42 c
95	77	69 c	119 c	39 d

Table 1. Effect of day and night temperature on grain fill duration and ear/kernel weights[2]

to humans compared to much higher daytime temperatures. There are two common beliefs as to why increased night temperatures have a negative effect during grain fill:

1) **Excessive burning of energy by the plant at night (increased respiration rates):** Corn uses photosynthesis during the day to produce and store sugars and starches that support normal plant growth and eventually go into producing a seed. At night, when light for photosynthesis is unavailable, the plant undergoes a separate process referred to as dark respiration. Respiration utilizes a portion of the energy created during the day to maintain growth and development at night. Respiration also uses energy to repair damaged cells and support plant cooling. Higher day and night temperatures result in increased respiration rates. Although increased temperature does speed up respiration rates, previous research suggests it is unlikely that the overall increase is enough to cause significant impacts on corn yield.[1,3]

2) **Accelerated growth and development:** Previous research suggests that accelerated growth and development during grain fill triggered by higher temperatures also reduces the total number of days a plant will have available to conduct photosynthesis. The net reduction in seasonal photosynthesis lessens the amount of sugars the plant can produce and later convert to starch within grain. Controlled studies showed yield reductions with increased day and night temperatures confirming that accelerated growth resulted in grain fill periods 8-15 day shorter than normal (Table 1).[2]

CORN RESPONSE TO WESTERN CORN BELT HIGH PH SOILS

INSIGHTS

- Soil pH is a critical component to understanding soil nutrient availability.
- Corn hybrid response to soil pH varies by the actual pH level and from genetic tolerance.

WHAT IS SOIL PH?

Soil pH is measured using a scale of 0 to 14, with pH less than 7 considered acidic and pH greater than 7 considered alkaline or basic. pH is a measurement of the concentration of hydrogen ions.[1,2] Soil pH is affected by several factors. Environmental factors, such as precipitation, temperature and the soil composition, both physically and chemically, play a role in soil pH. Rain, specifically, is naturally slightly acidic due to atmospheric CO2. The soil composition foundation or the parent material will determine subsoil pH based on chemical composition. Other factors related to crop management also directly impact soil pH. Nitrogen fertilizers may form ammonium in the soil, which, if not absorbed by a plant, will cause soil acidification. Legumes like soybeans and alfalfa will uptake more positive-charged cations than negative-charged anions, which leads to soil acidification. The application of lime (calcium carbonate) to soil will cause a chemical reaction forming a strong base (calcium hydroxide) and a weak acid (carbonic acid), making the soil more alkaline or raising the pH.

WHY IS SOIL PH IMPORTANT?

In agriculture, soil pH plays a major role in crop production. Plants obtain 14 of their 17 essential nutrients exclusively from the soil. Soil pH influences those nutrients' solubility, and thus availability, in the soil (Figure 1), leading to plant stress from deficiencies (Figure 2) or toxicities. Basic soils (pH > 7) lead to toxicity of aluminum while acidic soils lead to toxicity of manganese where these elements are present in sufficient amounts. Slightly acidic soils quickly begin to hold on more tightly to essential elements like phosphorus, calcium and magnesium, which makes them less available to the plant.

Soil pH can also impact potential plant pests and pathogens, such as certain fungi and soybean cyst nematode (SCN). Many fungi (*Pythium* spp. in particular) seem to perform well in slightly acidic soils.[3] According to Michigan State University studies, basic soils

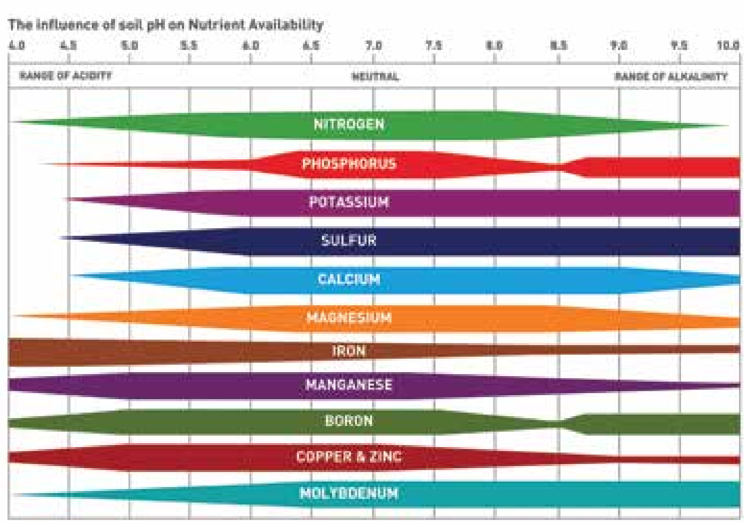


Figure 1. Soil pH effects on nutrient availability

Figure 2. High soil pH symptoms still present on susceptible hybrid late in season

Figure 3. Non-tolerant hybrid (left) and tolerant hybrid (right) showing how high soil pH can shorten the plants

have been shown to harbor higher populations of SCN than slightly acidic and neutral soils.[4] Low pH in soils causes many plant nutrients to be less accessible, but can also interfere with the breakdown of certain pesticides, leading to carryover issues and reduced efficacy. Low pH in soils can be managed by applying lime.

The optimum soil pH range for corn is 5.6 to 7.5. Soil pH levels of 7.8 or greater can limit corn growth and yield potential. The severity of corn response to soil pH higher than 7.8 is greatly influenced by the amount of available calcium (also expressed as excess lime and/or percent carbonate) and sodium in the soil solution. Greater amounts of one or both of these elements are typically more detrimental to the crop. If soil pH is high enough to influence corn development, plants often appear stunted and chlorotic (yellowing leaves) and yields can be reduced. High pH tolerance due to genetic variation among corn hybrids can result in stark visual differences (Figure 3). Hybrids that are not tolerant to high pH will appear stunted and pale to bleached in color.

Hybrid selection for high pH soils requires consideration of management factors:

1) Document soil pH
   - Utilize yield maps, aerial imagery and/or plant symptoms to identify potential high pH areas of a field.
   - Use soil sample results to evaluate pH, excess lime rating and sodium levels. Understanding the relationship between calcium, sodium and salt in the soil is important to properly classifying a soil saline (high salt), sodic (high sodium), or saline-sodic with each classification carrying different management implications. Saline soils make water uptake more difficult and are best

managed by selecting a hybrid with an optimal drought tolerance rating.

- Create a soil map from results to visualize pH distribution in the field.

2) Match hybrid to field

- Hybrid selection should be based on pH severity profile of the field (Table 1).

Consider hybrid performance, not just for pH, but also for ear and plant height. In droughty conditions, a taller plant with higher ear placement may perform better and have more harvestable ears than a shorter hybrid or a hybrid with ears too low to the ground which can be exacerbated by soil pH.

HYBRID	RELATIVE MATURITY	PLANT HEIGHT[1]	EAR HEIGHT[1]	DROUGHT PRONE[2]	HIGH PH[3]	HYBRID	RELATIVE MATURITY	PLANT HEIGHT	EAR HEIGHT	DROUGHT PRONE	HIGH PH
G78C29	78	4	3	2	Good	G07F23	107	5	5	1	Poor
G80Q01	80	5	4	1	Good	G07H81	107	2	4	1	Fair
G82M47	82	4	4	3	Fair	G07V88	107	3	3	1	Fair
G84B99	84	6	6	1	Fair	G07G73	107	3	4	1	Good
G85A33	85	3	5	2	Fair	E107C1	107	1	4	2	Poor
G85Z56	85	3	4	1	Good	G08D29	108	4	5	1	Fair
G84J92	86	3	5	1	Fair	G08M20	108	5	5	2	Good
G88F37	88	3	5	1	Fair	G08R52	108	5	5	1	Fair
G89A09	89	3	5	3	Fair	G09T26	109	6	4	3	Fair
G90S99	90	2	2	1	Fair	G10L16	110	5	6	1	Fair
G91V51	91	3	4	1	Poor	G10K03	110	3	3	2	Good
G90Y04	92	2	2	1	Good	E110F4	110	4	3	3	Good
G94P48	94	3	2	1	Good	G11B63	111	3	3	1	Good
G95M41	95	3	4	3	Good	G11V76	111	4	6	2	Good
G95D32	95	3	4	1	Good	G12J11	112	3	2	1	Poor
G96V99	96	4	4	3	Good	G12S75	112	2	4	3	Fair
G97N86	97	3	2	4	Fair	G12U17	112	3	3	3	Good
G98L17	98	2	2	2	Best	G13H15	113	3	3	2	Fair
G98M44	98	4	4	1	Good	G13Z50	113	4	4	2	Good
G00H12	100	5	5	2	Best	G13D55	113	3	3	2	Good
G01D24	101	2	2	2	Good	G13P84	113	5	5	3	Poor
G02K39	102	5	5	1	Fair	G14V04	114	3	3	1	Best
G03R40	103	4	4	2	Good	G14N11	114	3	2	2	Good
G03B96	103	4	3	3	Good	G15L32	115	4	5	2	Best
G03C84	103	3	3	1	Fair	G16K01	116	4	4	1	Poor
G05K08	105	5	6	1	Fair	G16Q82	116	3	3	1	Good
G06Q68	106	4	5	1	Fair	G17E95	117	2	3	3	Fair
G07A24	107	5	6	4	Good						

[1]Plant and Ear height based on 1-9 scale, 1=Tall, 9=Short. [2]Drought Prone indicates drought tolerance on 1-4 scale, 1=Excellent drought tolerance and 4=Poor drought tolerance. [3]High pH ratings, Best high pH tolerance to Poor high pH tolerance.

Table 1. Hybrid ratings for plant and ear height, drought tolerance, and high pH tolerance

High Ph Ratings Chart Key: Best | Good | Fair | Poor

CORN HYBRID RESPONSE TO FOLIAR FUNGICIDES

INSIGHTS

- Making fungicide decisions can be complex.
- Understanding hybrid susceptibility to disease and response to fungicide help the decision process.

There are many factors that go into making fungicide application decisions. Scouting and timely applications should always be the biggest drivers in the final decision. There are many levels of complexity beyond scouting that go into making farm-by-farm fungicide decisions. Golden Harvest® Agronomy In Action research conducts a yearly study that provides results to better understand the potential of individual hybrids to respond to fungicide treatment. Understanding hybrid susceptibility to a disease is extremely important in fields where disease pressure is highly predictable. It is more challenging to forecast an economic response within fields that rarely have noticeable disease presence. Results from this study will help utilize both elements to increase the chances of seeing a consistent fungicide response. Hybrid ratings for disease susceptibility and consistency of R1 foliar fungicide response in lower disease environments are provided as a decision-making tool for high and low disease risk fields.

Figure 1. Fungicide being applied at R1, individual plots driven on were not harvested for yield

ESTIMATING RESPONSE WITH LOW DISEASE PRESENCE

Roughly 30 fungicide trials are established each year using Miravis® Neo fungicide applied at the R1 growth stage (Figure 1) to evaluate consistency of individual hybrids response. Yield response varied greatly across hybrids and locations (Figure 2), allowing response ratings in both high and low disease environments. Yield response was used to rate the potential for fungicide response of each hybrid in the following method:

- Compare yield benefits of each hybrid to the same hybrid without fungicide
- Evaluate individual hybrid response relative to the response of other hybrids in the trial
- Understand the frequency of response across trials
- Combine results into four response potential categories: Best, Good, Fair, Poor

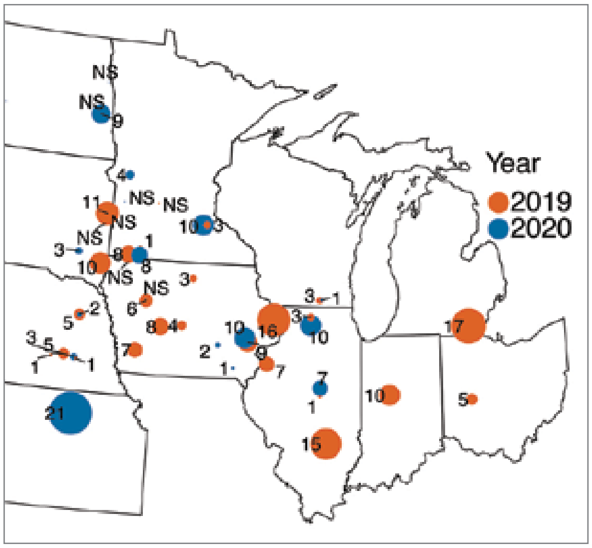


Figure 2. Differences in fungicide response across 2019 and 2020 hybrid screening trial locations; the bubble size indicates the size of response at that site, NS represents sites not responding

PREDICTING DISEASE RISK FOR EACH FIELD

Predicting disease development is challenging. However timely fungicide applications prior to disease establishment almost always pay off. If disease risk is high, it is important to plant hybrids with good disease tolerance to the specific disease risk of the field. The following factors increase likelihood of disease presence:

- Continuous corn rotation
- High residue levels for opportunities for pathogens to overwinter due to reduced tillage
- Favorable weather patterns, such as high precipitation and warm temperatures that are advantageous for disease development
- History of standability issues
- Observations of disease presence across multiple years
- Early signs of disease infection on lower leaves

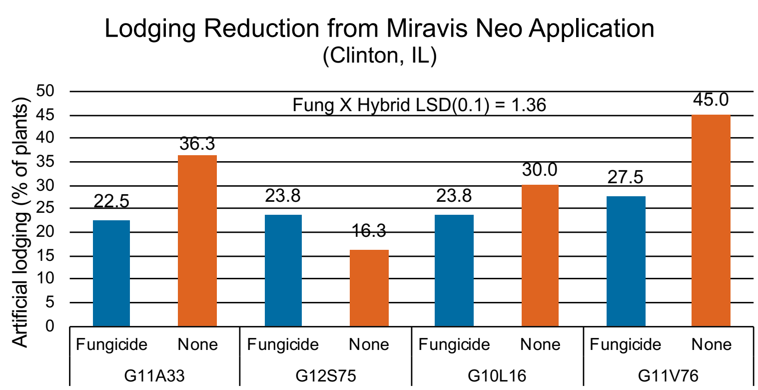
BENEFITS BEYOND YIELD – STRONGER STALKS

In addition to disease control and potential yield response benefits, there are additional benefits from a fungicide application. Stalk strength of multiple hybrids were evaluated in 2020 for response to Miravis Neo fungicide application. Consistent force was applied to multiple stalks and plants breaking were recorded as % of plants artificially lodging. This illustrated the inherit differences in stalk strength between hybrids (compare orange bars), as well as the ability to improve stalk strength of specific hybrids that may be more prone to lodging (Graph 1).

Results indicate that utilizing a foliar fungicide can:

- Significantly improve stalk integrity
- Reduce stalk lodging
- Decrease harvest losses
- Reduce harvest time

An additional benefit observed with Miravis Neo treatment is plants often stay green longer, allowing longer periods of photosynthesis for more plant growth and extended grain fill time. Also, in short periods of drought, water loss has been found to be reduced, helping corn better tolerate stress.



Graph 1. Improved stalk quality from Miravis Neo fungicide application in 2020 at Clinton, Illinois

DECISION PROCESS FOR FUNGICIDE APPLICATION

1. Select best suited hybrid for field based on adaptability, agronomics and relative maturity.
2. Determine disease risk potential of field and use appropriate decision tool.

LOW DISEASE FUNGICIDE RESPONSE

- Utilize "Low Disease Fungicide Response ratings" to understand which hybrids have the best chance of responding in these conditions.
- Best or Good indicates the hybrid responded more often and at a greater magnitude.
- Fair or Poor indicates responses may be smaller and less consistent.

HIGH DISEASE FUNGICIDE RESPONSE

- Utilize hybrid diseases susceptibility ratings specific to disease of concern from chart below to understand which hybrids are more vulnerable to yield loss.
- Scout fields and apply timely fungicide at sight of symptoms, focusing on most susceptible hybrids at first.

Golden Harvest Hybrid Series	RM	Low Disease Fungicide Response	High Disease Rating					
			GLS	NCLB	SCLB	ES	ANT	TS
G78C29	78	Good	-	-	-	4	-	-
G80Q01	80	Best	-	4	-	3	-	-
G85Z56	85	Good	-	3	-	3	-	-
G84J92	86	Good	-	3	-	3	2	-
G88F37	88	Best	-	3	-	3	3	-
G89A09	89	Fair	-	4	-	3	3	-
G90S99	90	Best	-	3	-	-	3	-
G91V51	91	Good	-	3	-	3	4	3
G90Y04	92	Fair	-	3	-	3	3	4
G94P48	94	Good	-	3	-	3	3	7
G95D32	95	Good	4	5	-	2	3	4
G95M41	95	Good	-	4	-	3	4	6
G96R61	96	Good	-	2	-	3	3	3
G97N86	97	Good	4	4	-	3	-	3
G98L17	98	Best	5	5	-	5	3	-
G98M44	98	Good	5	4	4	-	5	5
G99E68	99	Good	2	2	-	3	3	4
G00H12	100	Fair	3	5	-	3	-	2
G01P52	101	Best	4	5	-	3	3	3
G02K39	102	Good	3	4	-	3	-	3
G02W74	102	Good	3	2	-	4	4	4
G03B96	103	Good	5	3	4	-	5	4
G03C84	103	Best	4	3	3	3	4	3
G03J49	103	Good	4	6	4	4	5	-
G03R40	103	Best	4	5	5	3	-	3
G04G36	104	Best	3	3	3	4	5	3
G04S19	104	Good	4	4	4	2	2	4
G05K08	105	Good	4	3	4	3	4	5
G06K93	106	Fair	5	4	3	4	4	-
G06Q68	106	Fair	5	2	3	5	-	4
G07F23	107	Fair	3	2	5	3	-	3
G07G73	107	Fair	3	3	5	-	3	5
G07V88	107	Fair	5	3	3	5	4	-
G08D29	108	Best	4	2	6	4	-	4

Golden Harvest Hybrid Series	RM	Low Disease Fungicide Response	High Disease Rating					
			GLS	NCLB	SCLB	ES	ANT	TS
G08M20	108	Good	3	3	4	4	-	6
G08R52	108	Best	5	3	5	-	-	-
G07B39	109	Best	5	4	5	3	4	-
G09A86	109	Fair	2	5	4	5	-	4
G09T26	109	Fair	4	3	5	-	5	3
G09Y24	109	Good	5	2	4	3	-	4
G10C45	110	Good	3	3	4	3	-	-
G10D21	110	Good	2	2	-	-	2	3
G10K03	110	Best	5	3	5	-	-	-
G10L16	110	Good	4	6	4	3	-	-
G10S30	110	Best	6	2	4	2	-	-
G11A33	111	Good	3	3	4	2	-	4
G11B63	111	Fair	4	4	5	3	-	-
G11F16	111	Fair	4	3	4	2	-	5
G11V76	111	Best	4	3	6	-	3	3
G12S75	112	Fair	3	3	6	-	3	2
G12U17	112	Best	4	3	5	-	-	-
G13D55	113	Fair	3	3	3	-	5	3
G13E90	113	Best	6	3	3	-	-	-
G13H15	113	Poor	3	4	5	-	-	-
G13M88	113	Fair	3	3	3	5	-	-
G13N18	113	Best	6	4	2	6	4	-
G13P84	113	Fair	4	2	3	-	5	4
G13T41	113	Good	4	2	4	2	-	-
G13Z50	113	Good	4	3	4	4	-	-
G14K50	114	Best	6	3	3	5	4	-
G14N11	114	Best	5	5	4	3	-	-
G14R38	114	Fair	5	4	4	3	4	-
G15J91	115	Best	4	2	3	-	2	2
G15L32	115	Best	3	4	3	3	-	-
G16K01	116	Fair	5	4	3	5	3	-
G16Q82	116	Best	3	3	3	-	4	5
G17E95	117	Good	3	4	4	-	-	-
G18D87	118	Fair	3	3	3	5	-	-

Hybrid Response Ratings: Best | Good | Fair | Poor

Disease Resistance Rating Scale: 1-2 = Highly Resistant; 3-4 = Resistant; 5-6 = Moderately Resistant; 7-8 = Moderately Susceptible; 9 = Susceptible; - = Insufficient data: ES = Eyespot; NCLB = Northern Corn Leaf Blight; SCLB = Southern Corn Leaf Blight; GLS = Gray Leaf Spot; ANT = Anthracnose; TS = Tarspot

HIGH-YIELD CORN MANAGEMENT

ERIC T. WINANS AND FREDERICK E. BELOW

Crop Physiology Laboratory, Department of Crop Sciences, University of Illinois at Urbana-Champaign

Corn yields in the U.S. have improved over time, as steady gains have been made in genetic yield potential, plant protection technologies and tolerance to stresses. However, typical observed corn yields are only a fraction of the maximum yield potential of today's corn hybrids, and only with adequate environmental conditions and agronomic management can growers increase yields or minimize the potential for yield loss. There is a need for a better understanding of which agronomic management practices have the greatest impact on corn yield and how these practices interact. Therefore, the Crop Physiology Laboratory at the University of Illinois set out to (i) demonstrate the potential for yield improvement with enhanced crop management, (ii) quantify the impact of different management factors on corn yield, and (iii) determine the synergisms of these factors when combined together in an agronomic system.

AGRONOMIC MANAGEMENT SYSTEMS

In six environments in Illinois from 2014-2018, five management factors were assessed for their individual and cumulative impact on corn grain yield under corn-soybean rotation and conventional tillage. The five agronomic management factors considered were: 1) fertility to include phosphorus (P), potassium (K), sulfur (S), zinc (Zn) and boron (B); 2) nitrogen (N) fertility; 3) plant population; 4) foliar fungicide; and 5) row spacing. Each factor consisted of two levels representing either the "Standard" or "Enhanced" system (Table 1). For the first factor, no added fertility, based on adequate soil test values, was applied in the standard system. MicroEssentials-SZ [12-40-0-10(S)-1(Zn)] was banded 4-6" beneath the future crop row for 100 lbs P2O5, 25 lbs S and 2.5 lbs Zn/A and Aspire [0-0-58-0.5(B)] was broadcast applied with light incorporation for 75 lbs K2O and 0.6 lbs B/A in the enhanced system. Nitrogen was broadcast applied in the spring as UAN for 180 lbs N/A with the enhanced level receiving an additional 60 lbs N/A sidedressed at V6. Target final plant stands were 32,000 and 44,000 plants/A in the standard and enhanced systems, respectively. To determine the influence of fungicide on plant health and yield, the enhanced system received a foliar application of Quilt Xcel® or Trivapro® at flowering (VT/R1) while the standard system received none. The trial was planted in both

FACTOR	STANDARD	ENHANCED
Fertility	P & K based on soil test, no S or micros	Banded MicroEssentials-SZ for (lbs/acre) 30 N, 100 P2O5, 25 S, & 2.5 Zn, and Broadcast Aspire for (lbs/acre)75 K2O & 0.6 B
Nitrogen	180 lbs N/acre preplant as UAN	180 lbs N/acre UAN preplant + 60 lbs/acre Sidedress (240 lbs total)
Population	32,000 plants/acre	44,000 plants/acre
Fungicide	No fungicide	Quilt-Xcel or Trivapro at VT/R1
Row Spacing	30 inches	20 inches

Table 1. Corn management factors and treatment levels for Standard and Enhanced agronomic systems evaluated in six trials in Illinois from 2014-2018

ENVIRONMENT	HYBRID	STANDARD	ENHANCED	Δ
		----------------bu/A----------------		
2014 - Champaign	G09E98-3000GT	187	241	+54*
2015 - Champaign	G12J11-3111A	185	250	+65*
2015 - DeKalb	G06N80-3111	192	228	+36*
2016 - Champaign	G14R38-3000GT	229	274	+45*
2017 - Champaign	G10T63-3122	219	274	+55*
2018 - Champaign	G11F16-3111A	241	299	+58*
	Average	209	261	+52*

*Significant increase over Standard at P ≤ 0.05

Table 2. Corn yield in Standard and Enhanced systems at Champaign or DeKalb, Illinois, from 2014-2018 and the hybrid planted in each of those environments. Grain yields are reported at 15.5% moisture.

TREATMENT		FACTOR				
System	**Exception**	**Band P-S-Zn**	**Broad. K-B**	**Nitrogen**	**Population**	**Fungicide**
Standard	None	None	None	Base	32,000	None
Standard	+Band P-S-Zn	P-S-Zn	None	Base	32,000	None
Standard	+Broad K-B	None	K-B	Base	32,000	None
Standard	+P-S-Zn & K-B	P-S-Zn	K-B	Base	32,000	None
Standard	+Sidedress N	None	None	Base + Sidedress	32,000	None
Standard	+Population	None	None	Base	44,000	None
Standard	+Fungicide	None	None	Base	32,000	Yes
Enhanced	None	P-S-Zn	K-B	Base + Sidedress	44,000	Yes
Enhanced	-Band P-S-Zn	None	K-B	Base + Sidedress	44,000	Yes
Enhanced	-Broad K-B	P-S-Zn	None	Base + Sidedress	44,000	Yes
Enhanced	-P-S-Zn & K-B	None	None	Base + Sidedress	44,000	Yes
Enhanced	-Sidedress N	P-S-Zn	K-B	Base	44,000	Yes
Enhanced	-Population	P-S-Zn	K-B	Base + Sidedress	32,000	Yes
Enhanced	-Fungicide	P-S-Zn	K-B	Base + Sidedress	44,000	None

Table 3. Addition and omission treatment structure: The treatment exceptions are either added (+factor) to the standard system control or omitted (-factor) from the enhanced system control. Controls are indicated by exception none.

30- and 20-inch rows with the narrower spacing considered the enhanced practice. The best "racehorse" hybrid was chosen for each environment with the goal of maximizing yield responses to the enhanced management factors (Table 2).

With all enhanced factors combined as an agronomic package and compared to the standard system, corn grain yield increased by an average of 52 bu/A (+25%) across the six environments and ranged from 36-65 bu/A (+19-35%) (Table 2). These yield improvements can be attributed to maximizing early-season light interception through narrower row spacing and higher plant density, providing season-long nutrition and lengthening photosynthetic duration with fungicide application. Additionally, the yield level in both the standard and enhanced systems tended to increase from 2014-2018, which is likely attributed, in part, to improved plant genetics and hybrid selection.

MOST IMPORTANT FACTORS

To determine the individual and combined impact of each management factor, an addition/omission treatment structure was used (Table 3). Additionally, the fertility factor was evaluated in three components: Banded P-S-Zn, Broadcast K-B and both. Seven additional treatments (+Band P-S-Zn, +Broad K-B, +P-S-Zn and K-B, +N Sidedress, +Population, and +Fungicide) were

FACTOR	STANDARD		ENHANCED	
	Yield	Δ	Yield	Δ
	------------------------- bu/A-------------------------			
None or All	216		250	
Banded P-S-Zn	226	+10*	241	-9*
Broadcast K-B	216	0	244	-6
Band P-S-Zn & Broad K-B	227	+11*	234	-16*
Sidedress Nitrogen	223	+7*	241	-9*
Population: 32 or 44k	207	-8*	247	-3
Fungicide @ VT/R1	220	4	241	-9*

*Significant difference from the standard or enhanced control at $P \leq 0.10$.

Table 4. Combined results from six omission/addition plot trials evaluated in Illinois from 2014-2018 and averaged across both 30- and 20- inch row spacings. Data are the mean grain yields of standard and enhanced agronomic systems and the yields resulting by adding individual factors to the standard system or by subtracting individual factors from the enhanced system.

implemented by individually substituting the enhanced level of each management factor while all other management factors were maintained at the standard level (Table 3). Similarly, six omission treatments (-Band P-S-Zn, -Broad K-B, -P-S-Zn & K-B, -N Sidedress, -Population, and -Fungicide) were implemented by individually substituting the standard level of the factor while maintaining all other factors at the enhanced level. In this way, the value of each management factor was tested at the standard level of agronomic management in an enhanced management system.

While the Crop Physiology Laboratory has demonstrated positive yield responses to narrower row spacing in this study, responses to narrow rows can be mixed in commercial settings and are especially dependent on the hybrid used. Thus, the addition/omission results from this study have been averaged over both row spacings (Table 4).

The management factor that had the greatest impact on yield in both the standard and enhanced systems was fertility (Table 4). The addition of banded P-S-Zn and broadcast K-B in the standard system increased yield by 11 bu/A (+5%) while its omission from the enhanced system decreased yield by 16 bu/A (-6%). Most of the impact on yield was from the P-S-Zn, as K-B had no effect on yield when added to the standard system alone (Table 4). The influence of added fertility was most notable in the high-population, high-input system, which required the greatest availability of nutrients to maximize yields.

Averaged over the six environments, the supplemental 60 lbs N/A sidedressed over the base rate of 180 lbs/A increased yield by 7 bu/A (+3%) when added to the standard system and decreased yield by 9 bu/A (-4%) when omitted from the enhanced system (Table 4). As N availability is highly influenced by the weather, supplemental N had a greater impact on yield in environments with weather conducive to N loss (data not shown). Like other nutrients, N fertilization was more important in the enhanced system.

Significant yield increases with the enhanced system over the standard system indicate that the environments tested in this study could support plant populations greater than 32,000 plants/A (Table 2). However, increasing plant population from 32,000 to 44,000 plants/A decreased yield by 8 bu/A (-4%) in the standard system. Decreasing from the high density to the lower density in the enhanced system had a minimal, but negative, impact on yield (Table 4). Therefore, increasing plant population without adequate plant nutrition and fungicide (i.e. standard system) can decrease yield.

Response to fungicide is like nitrogen. It is highly influenced by the environment, especially by weather conditions conducive to disease development. Thus, when averaged across environments, the addition of fungicide to the standard system did not significantly affect yield (Table 4). However, removing fungicide from the enhanced system reduced yield by 9 bu/A (-4%).

MANAGEMENT FACTORS WORK TOGETHER

If combinations of agronomic factors acted additively, all of the individual yield values for the added factors over the standard control would amount to a yield increase of 14 bu/A. This is the sum (in bu/A) of +11 from fertility, +7 from sidedress N, -8 from increased plant population, and +4 from fungicide (Table 4). However, the actual yield response of all factors combined averaged across environments and row spacing was 34 bu /A (difference between the enhanced and standard control treatments), which is substantially greater than the summation of all individual added factor contributions (Table 4). Therefore, combining these enhanced management factors synergistically led to a 20 bu/A yield boost.

Notably, the impact on yield from one management factor is dependent on the other factors present in the system. Generally, yield reduction resulting from omitting a factor from the enhanced system was greater than the yield increase from adding that factor to the standard control (Table 4). When considering managing corn for greater yields, a comprehensive systems approach will often increase yield more than the increase from enhancing any one management factor alone.

MANAGEMENT CONSIDERATIONS FOR CORN SILAGE PRODUCTION

Golden Harvest is committed to sharing agronomic knowledge with livestock-producing customers to help them grow more corn silage and benefit their livestock operation. To help growers choose the best silage hybrids to meet the nutritional needs of dairy and beef operations, our Agronomy In Action Research team provides silage hybrid ratings. These ratings are supported by analysis of approximately 790 company and third-party trial locations across nine years of research and by our knowledge and understanding of each hybrid's silage characteristics.

HYBRID RATINGS EXPLANATION

Silage samples collected at harvest undergo NIR (near-infrared spectroscopy) analysis by independent labs to derive the silage quality and digestibility data results. This data is then reviewed, along with our agronomic field knowledge of each hybrid, to assign each a silage quality rating within four categories: BEST=best silage quality or yield content, relative to other hybrids; GOOD=good silage quality or yield content, relative to other hybrids; FAIR=fair silage quality or yield content, relative to other hybrids; and POOR=poor silage quality or yield content, relative to other hybrids.

SILAGE HYBRID MANAGEMENT CONSIDERATIONS

- Select hybrids well-adapted for the geographic region using local performance data whenever possible.
- Understand that hybrid characteristics such as stay-green and increased starch digestibility are important for silage production.
- Select hybrids best fitting specific needs for yield and quality. When comparing hybrid ratings, it is recommended to compare ratings within a maturity group.
- Plant early to optimize crop utilization of water, nutrients and sunlight.
- Plant at populations equal to or up to 10% greater than corn for grain.
- Acknowledge soil nutrient removal for potassium and phosphorus will be higher for silage than grain production, due to the increased removal of crop residue.
- Target a whole-plant moisture content of 60-70% at harvest, depending on ensiling method, with higher moistures best suited for storage in a bunker or pile.

Yield Calculated on a per acre basis and adjusted to standard moisture.
Crude Protein (CP) Indicates the percent content of this important feed component relative to other hybrids.
Neutral Detergent Fiber Digestibility 48 Hour Estimates the ruminant digestibility of the NDF fraction.
Fat Indicates the percent content of this important feed component relative to other hybrids.
Starch Indicates the percent content of this important feed component.
Total Digestible Nutrients (TDN) Describes the energy content of feeds as the sum of the digestibility of different nutrients.
Net Energy Lactation (NEL) Feed effect on net energy for lactating cows based on acid detergent fiber (ADF).
Milk/Ton An estimate of forage quality driven by starch content, starch digestibility and NDF; **Milk/A** Combines the estimate of forage quality (Milk/Ton) and yield (Tons/A) into a single term.**
Beef/Ton A proprietary estimate of forage quality driven by TDN; **Beef/A** Combines the estimate of forage quality (Beef/Ton) and yield(Tons/A) into a single term.
*** Milk: Combining Yield and Quality into a Single Term, https://fyi.uwex.edu/forage/files/2016/11/Milk-2016-Combining-Yield-and-Quality-into-a-Single-Term-2.pdf*

Golden Harvest Corn Silage Hybrid Ratings

Golden Harvest Hybrid Series	Relative Maturity (RM)	Yield (tons/Acre)	Protein	NDF	NDFD	Starch	Fat	TDN	Feed Effect On: NEL	Milk/Ton	Milk/Acre	Beef/Ton	Beef/Acre
G78C29	78	Good	Good	Best	Best	Best		Best	Best	Best	Best	Best	Good
G80Q01	80	Good	Good	Good	Good	Best		Good		Good	Good	Good	Good
G82M47	82	Fair	Fair	Fair	Good	Fair	Fair	Good	Fair	Good	Fair	Good	Fair
G84J92	84	Good	Fair	Fair	Good	Good	Best	Fair	Fair	Fair	Good	Fair	Good
G85Z56	85	Best	Good	Fair	Good	Fair	Good	Best		Best	Best	Best	Best
G88F37	88	Good	Good	Good	Good	Best		Good		Good	Fair	Good	Fair
G89A09	89	Good	Good	Poor	Good	Fair	Good	Good	Fair	Good	Fair	Good	Fair
G90S99	90	Fair	Good	Good	Fair	Good	Good	Good	Good	Fair	Fair	Good	Fair
G90Y04	90	Best	Best	Fair	Good	Good	Good	Good	Good	Good	Best	Good	Best
G91V51	91	Best	Fair	Best	Good	Best	Good	Good	Best	Best	Best	Best	Best
G94P48	94	Fair	Best	Best	Good	Best	Best	Best	Best	Good	Fair	Best	Fair
G95D32	95	Good	Fair	Best	Fair	Best	Best	Good	Good	Good	Best	Good	Best
G95M41	95	Good	Good	Fair	Good	Best	Best	Good	Good	Good	Fair	Good	Fair
G96R61	96	Best	Good	Good	Good	Fair	Good	Good	Good	Good	Best	Good	Best
G97N86	97	Good	Good	Good	Fair	Good	Best	Good	Good	Good	Good	Good	Good
G98L17	98	Best	Good	Fair	Fair	Good	Fair	Good	Good	Good	Best	Good	Best
G98M44	98	Good	Good	Best	Fair	Best	Best	Good		Good	Best	Good	Best
G99E68	99	Fair	Good	Good	Fair	Good	Poor	Good	Good	Good	Fair	Good	Fair
G00H12	100	Good	Best	Poor	Good	Fair	Best	Fair	Good	Fair	Fair	Fair	Fair
G01P52	101	Good	Good	Best	Good	Good	Fair	Good	Good	Good	Good	Good	Good
G02K39	102	Good	Good	Best	Good	Good	Best	Best	Best	Best	Good	Best	Good
G02W74	102	Fair	Good	Best	Best	Good	Good	Good	Good	Good	Fair	Good	Fair
G03B96	103	Good	Good	Fair	Fair	Poor	Fair	Good	Good	Good	Fair	Fair	Fair
G03C84	103	Good	Good	Good	Good	Best	Best	Good	Good	Fair	Good	Good	Good
G03J49	103	Good	Fair	Good	Good	Best	Fair	Good	Good	Good	Good	Good	Best
G03R40	103	Good	Good	Poor	Good	Fair	Best	Fair	Fair	Fair	Fair	Fair	Fair
G04G36	104	Fair	Good	Best	Best	Best	Best	Best	Best	Best	Fair	Best	Good
G04S19	104	Best	Fair	Good	Good	Good	Good	Good	Good	Good	Best	Good	Best
G05K08	105	Good	Good	Good	Fair	Best	Best	Fair	Good	Fair	Fair	Good	Fair
G06K93	106	Good	Fair	Good	Good	Best	Best	Best	Good	Best	Good	Best	Good
G06Q68	106	Fair	Good	Good	Best	Good	Best	Good	Good	Good	Fair	Good	Fair
G07B39	107	Best	Good	Good	Best	Good	Best	Best	Best	Best	Best	Best	Best
G07F23	107	Best	Good	Good	Good	Good	Fair	Good	Good	Good	Best	Best	Best
G07V88	107	Good	Fair	Good	Good	Best	Good	Good	Best	Best	Best	Best	Good
G08D29	108	Good	Good	Poor	Fair	Fair	Good	Good	Fair	Fair	Fair	Fair	Fair
G08M20	108	Good	Best	Good	Good	Best	Best	Fair	Good	Fair	Fair	Fair	Fair
G08R52	108	Best	Good	Best	Fair	Best	Poor	Fair	Fair	Fair	Best	Fair	Best
G09A86	109	Best	Best	Good	Fair	Good	Good	Good	Good	Good	Good	Good	Best
G09Y24	109	Good	Good	Good	Best	Good	Good	Good	Good	Good	Good	Best	Good
G10C45	110	Good	Good	Good	Good	Best	Best	Best	Best	Good	Best	Good	Good
G10D21	110	Good	Good	Fair	Fair	Good	Good	Good	Good	Good	Fair	Fair	Good
G10K03	110	Fair	Good	Good	Good	Good	Best	Good	Good	Good	Fair	Good	Fair
G10L16	110	Good	Good	Best	Good	Best	Best	Good	Best	Good	Good	Good	Good
G10S30	110	Fair	Good	Fair	Good	Good	Best	Good	Good	Good	Fair	Good	Fair
G10T63	110	Best	Fair	Fair	Fair	Fair	Good	Good	Good	Good	Best	Good	Best
G11A33	111	Poor	Good	Best	Good	Best	Best	Good	Best	Good	Fair	Good	Fair
G11B63	111	Best	Good	Fair	Good	Fair	Fair	Good	Good	Fair	Best	Good	Best
G11F16	111	Fair	Good	Good	Good	Best	Fair	Fair	Good	Good	Fair	Good	Fair
G11V76	111	Good	Good	Good	Good	Good	Fair	Good	Good	Good	Good	Good	Good
G12S75	112	Best	Fair	Poor	Fair	Fair	Good	Good	Good	Good	Best	Fair	Best
G12U17	112	Good	Good	Best	Best	Best	Fair	Good	Good	Good	Good	Good	Good
G12W66	112	Good	Fair	Good	Good	Good	Good	Good	Good	Good	Best	Good	Best
G13E90	113	Good	Best	Good	Good	Fair	Good	Good	Good	Good	Best	Good	Good
G13H15	113	Best	Fair	Good	Fair	Best	Poor	Good	Good	Good	Best	Good	Best
G13M88	113	Fair	Fair	Good	Fair	Best	Good	Good	Fair	Fair	Fair	Good	Fair
G13N18	113	Good	Good	Fair	Good	Good	Good	Best	Good	Best	Good	Best	Fair
G13Z50	113	Good	Fair	Good	Best	Good	Poor	Good	Good	Good	Fair	Good	Fair
G14K50	114	Best	Fair	Best	Good	Best	Best	Good	Best	Good	Best	Good	Best
G14N11	114	Good	Good	Best	Good	Best	Fair	Good	Good	Good	Fair	Good	Good
G14R38	114	Good	Fair	Best	Good	Best	Best	Best	Best	Best	Best	Best	Best
G14V04	114	Good	Good	Good	Fair	Good	Fair	Good	Good	Good	Good	Good	Good
G15J91	115	Good	Good	Fair	Good	Good	Poor	Good	Good	Good	Fair	Good	Good
G15L32	115	Best	Good	Good	Good	Best	Best	Good	Good	Good	Good	Good	Good
G16K01	116	Good	Fair	Good	Good	Good	Good	Good	Best	Good	Good	Best	Good
G17E95	117	Good	Good	Fair	Good	Fair		Good		Good	Best	Good	Good
G18D87	118	Best	Best	Fair	Good	Fair	Fair	Good	Good	Good	Best	Good	Best
G18H82	118	Fair	Good	Best	Best	Best	Good	Good	Good	Good	Good	Good	Good

Corn Silage Hybrid Ratings Chart Key: Best | Good | Fair | Poor | Insufficient Data

** NOTE: These ratings should not be used to estimate actual production per animal, but instead they should be used to determine relative overall silage quality and yield of each hybrid.*

TIMING HARVEST DECISIONS BASED ON CORN DRYING METHOD

INSIGHTS

- Mature corn crops can lose up to ¾ to 1 percentage point of moisture per day in September; whereas in November, it is typical for percentage moisture loss per day to max out at about ¼ of a point.
- Associated costs of field drying, such as lodging, dropped ears, header losses, etc., are often not thought of but should be heavily considered in decision-making.
- Dryer efficiency and energy costs should also be key in deciding when to terminate field drying.

FIELD DRYING COMPARED TO MECHANICAL DRYING

The statement "the crop is not made until it is in the bin" is true every year. At what point does field drying stop and mechanical drying start? This answer depends on many factors, such as the time of year, crop health, energy prices and dryer capacity and efficiency. To help make harvest decisions, test and monitor moisture in individual fields to understand variability in how different corn hybrids dry.

A mature corn crop may lose as much as ¾ to 1 percentage point of moisture per day during September, depending on weather conditions.[1] By November, air temperatures will decrease, and natural drying may drop to as little as ¼ of a percentage point of moisture or less per day. Slower drydown rates require more time to field dry and result in higher potential field losses. Although field drying may appear less costly, costs associated with lodging, dropped ears and header losses also need to be considered. Just two kernels on the ground per square foot equals a 1 bu/A yield loss. Depending on the corn hybrid, pest pressures and environmental factors, letting the crop field dry could be risky. Mechanically drying full-season hybrids or late-planted fields where corn will mature later in the season may be a better option to consider.

When determining whether to field or mechanically dry the crop, take dryer efficiency and energy costs into account. Drying costs can differ significantly based on the type of drying method, starting grain moisture, desired end moisture and energy costs.

DECIDING HOW SOON TO HARVEST

- Field drying below 20% significantly increases the risk of in-field yield loss.
- Starting harvest at 25% moisture minimizes grain damage and yield loss.
- Balance possible increased drying costs associated with high moisture corn against potential field loss.

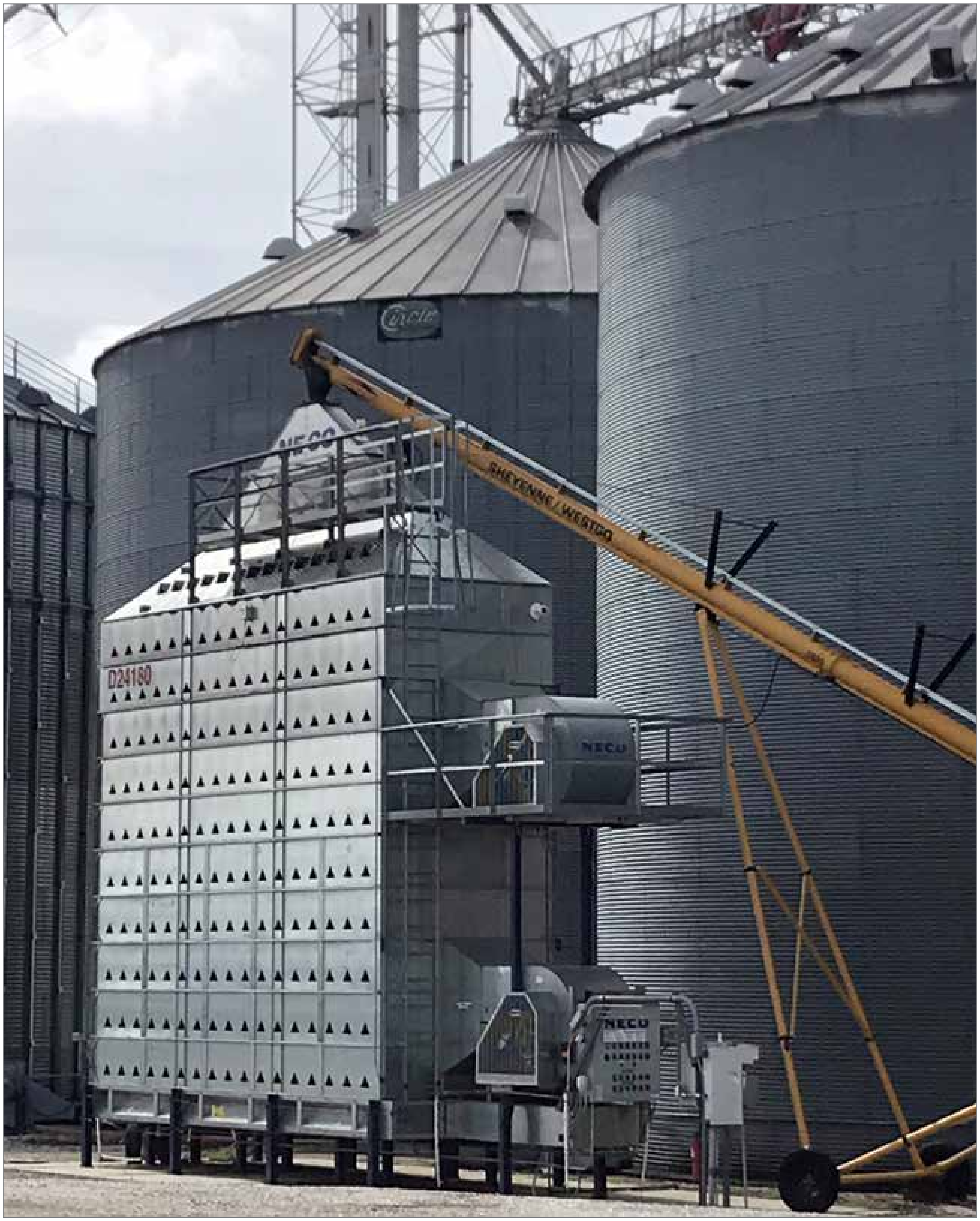
YIELD ENVIRONMENT (BU/A)	ADDITIONAL POINTS OF MOISTURE TO REMOVE DUE TO HARVESTING EARLY				
	1	3	5	7	9
100	0.8	2.4	4.0	5.6	7.2
130	1.0	3.1	5.2	7.3	9.4
160	1.3	3.8	6.4	9.0	11.5
190	1.5	4.6	7.6	10.6	13.7
220	1.8	5.3	8.8	12.3	15.8
250	2.0	6.0	10.0	14.0	18.0
280	2.2	6.7	11.2	15.7	20.2
310	2.5	7.4	12.4	17.4	22.3

Table 1. Bu/A required to offset additional drying costs due to early harvest

Assumptions used for calculations: Corn price $3.50/bu; Bin drying with stirrer; Propane $1.50/gal; Electricity $0.10 per KW-h

Table 1 illustrates bushels per acre required to offset additional drying costs due to harvesting earlier.

- For example, if harvesting at 25% moisture, rather than the standard 20% moisture level, an additional 5 points of moisture would need to be removed with mechanical drying. For a 190 bu/A crop, drying could be warranted if anticipated field losses while field drying could exceed 7.6 bu/A.
- Field drying losses can easily range from 0–10 bu/A per moisture point removed.



HARVESTING SOYBEAN AT HIGHER MOISTURE TO MAXIMIZE YIELD

INSIGHTS

- Timing is everything when it comes to maximizing soybean harvest because optimum moisture is key to combining the best yields.
- Check each field closely as soybeans with green stems or a few remaining leaves may be drier than perceived.
- Avoid harvesting when beans are at their driest for the day, such as on hot afternoons, to reduce pod shatter; 4–5 seeds per square foot found on the ground is the equivalent of 1 bushel per acre yield loss.
- Soybean harvest losses can be managed by timely harvest and proper combine adjustments, which may be needed multiple times throughout the day, depending on changing moisture and weather.

Soybean harvest can be delayed for many reasons, from uncooperative weather to equipment downtime. Other times, a lack of adequate harvest planning and scheduling may be the holdup. Delayed harvest can increase the risk of yield loss. This article will review key considerations that can help minimize yield and economic losses during harvest.

TWO WAYS SOYBEAN YIELD LOSS HAPPENS

1. Field loss – Field loss ranging from 5–12% of total yield potential can occur before and during harvest.[1] Over half of this field loss is typically attributed to header, or threshing losses, related to combine efficiency. Delaying harvest until soybeans are below 11% moisture can increase the likelihood of pod shattering. Repeated drying and wetting cycles can further increase yield losses while waiting to harvest. Harvesting early and properly adjusting your combine are two of the best ways to minimize these types of losses. Harvesting at moisture content of 13–13.5% is optimal for minimizing mechanical damage. If bins are equipped to air dry soybeans, harvest can start as early as 16–18% moisture and easily aerate to 13% to help minimize field loss

2. Soybean moisture loss and influence on yield calculations – A standard bushel of soybeans weighs 60 lbs. at a standard 13% moisture. Soybeans delivered at moisture levels greater than 13% are usually discounted by the buyer using a calculated discount rate. Weight loss from soybeans with moisture levels less than 13% is not taken into consideration for calculating total bushels sold. The moisture loss results in reduced harvest weights and fewer bushels sold.

Table 1 illustrates the percent of total yield loss incurred at time of delivery for every point of moisture below 13%. As a result, soybeans discounted for being wetter than 13% can sometimes be more profitable than delivering drier beans. The following example calculates soybeans delivered at 14% moisture with a 3% price discount, compared to the same soybeans delivered at 8% moisture. The calculation doesn't account for incremental field loss that likely also occurred from harvest delays.

MOISTURE LEVEL	POTENTIAL YIELD REDUCTION
8%	5.4%
9%	4.4%
10%	3.3%
11%	2.25%
12%	1.14%

Table 1. Impact of harvesting soybeans at moisture levels less than 13%[2]

Example:

- **14% moisture = 3% dock**
  3% price dock of original price ($8.50/bu) = $8.25 x 80 bu/A = $660 gross per acre
- **8% moisture = 0% dock**
  5.4% yield reduction x 80 bu/A = 4.3 bu less - 80 bu/A = 75.7 bu x $8.50/bu = $643 gross per acre

UNDERSTANDING SEED QUALITY TESTING DIFFERENCES

INSIGHTS

- Germination testing is required by law and is a good indication of the plant-producing potential of a seed lot under normal conditions.
- The seed vigor test represents the seed's ability to develop a normal seedling under stressful environmental conditions.
- There is not a standardized test across the seed industry for seed vigor. Inconsistent lab vigor testing procedures make it difficult to compare results across labs.

The agronomic value of a perfect corn stand emerging evenly over a 24- to 48-hour window is well understood. Having the confidence that your seed is of the highest possible quality to achieve this goal is equally important. This article will review current industry as well as Golden Harvest® seed quality testing standards. Interpretation of independent seed lab test results will also be explored.

Seed testing is important to ensure that only the best quality seed lots are allowed into the marketplace. Testing provides assurance to the farmers using the products. Golden Harvest has seed testing protocols and product specifications to ensure the products shipped to customers meet or exceed these expectations.

INDUSTRY SEED VIGOR TESTING TECHNIQUES

- Field Emergence
- Accelerated Aging
- Conductivity
- Protein
- Respiration
- Seedling Growth Rates
- Cold Test
- Rapid Germination
- Saturated Cold Test

Figure 1. Low and high seed vigor lab testing samples

STANDARD INDUSTRY SEED QUALITY TESTING

Multiple seed quality tests are required by the Federal Seed Act and individual state seed laws to be carried out and reported on seed bag tags. Germination and physical purity are both required to be visible on bag tags. Genetic purity testing ensures genetic purity and trait purity expression are meeting product specifications. Genetic purity results of less than 95% require bag tag labeling to be referred to as a blend. Germination is measured using a warm germination test, which is a standardized process adopted across the seed industry. Germination determines the plant producing potential of a seed lot. The germination capacity of a seed lot is expressed as the percentage of normal seedlings developed under favorable laboratory conditions. Germination test results are highly consistent across certified seed testing labs. The Association of Official Seed Analysts (AOSA) Rules for Testing Seed define the procedure that all seed providers are required to follow for completing germination testing. Warm germination results are an essential measure of seed quality, however they do not predict how seeds will emerge under stressful field conditions.

GOLDEN HARVEST PROPRIETARY SEED VIGOR TESTING

Seed vigor tests are commonly used by seed providers and 3rd party seed testing labs to better understand the seed's ability to germinate and grow normally under stressful soil conditions. Vigor testing is not required by federal or state laws, although is routinely used across the seed industry to ensure the best quality seed for customers. Due to lack of legal requirements, vigor testing procedures are at the discretion of the seed supplier. The importance of predicting consistent emerging products to ensure a good customer experience has led seed providers to develop proprietary testing methods to deliver the highest quality seed possible. Multiple vigor tests are utilized across the seed industry. However, due to lack of a universal testing procedure, it is difficult to compare results across labs.

In addition to warm germination, Golden Harvest utilizes proprietary vigor tests to quantify seed vigor. In 2019, Golden Harvest introduced a new and novel approach to seed vigor testing. Although a vigor test cannot mimic every potential combination of environmental factors affecting field emergence, this new method is designed to mimic the imbibitional chilling stress seeds face in less than ideal field situations (Figure 2). This test is helping differentiate at a genetic, as well as physiological, level and will help provide customers with seed at or above industry and independent lab seed quality standards. As the Golden Harvest Vigor test was developed, it was validated in actual field emergence trials, and compared with 3rd party vigor tests before finalizing the protocol. The Golden Harvest Vigor test continues to be validated yearly against field emergence and through lab testing to ensure the most current and relevant testing procedures are being used.

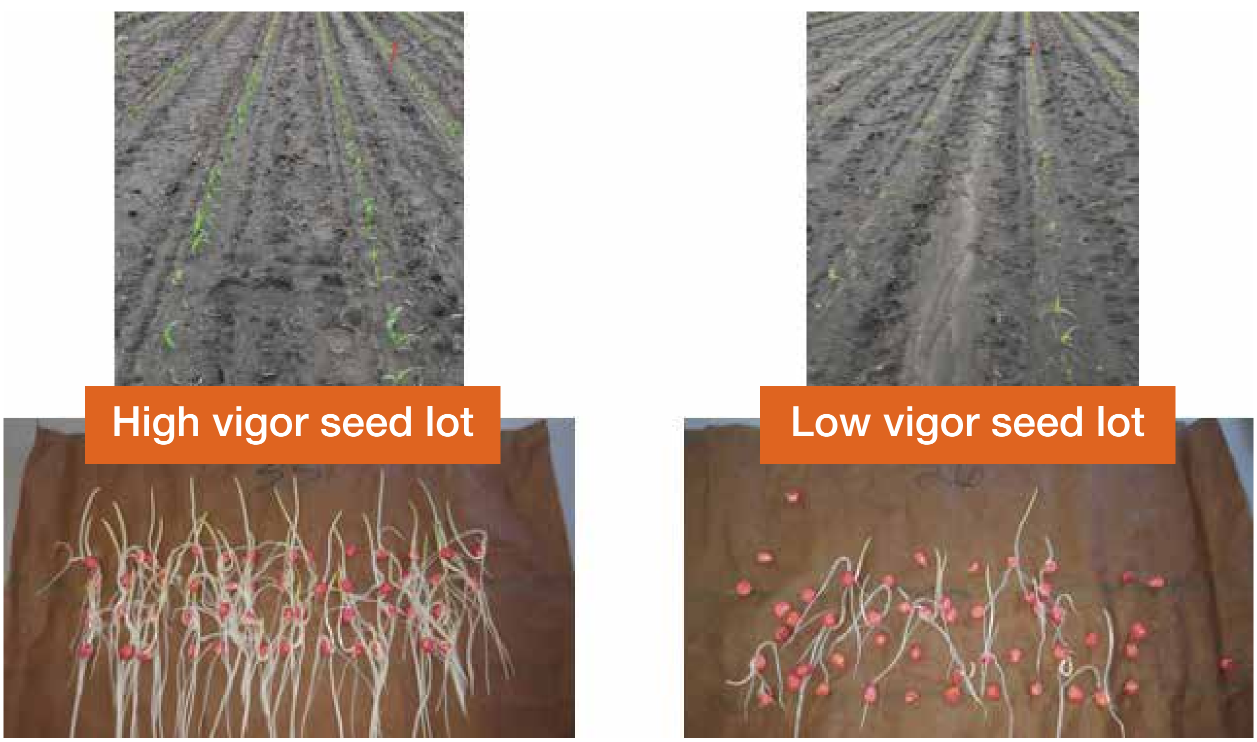


Figure 2. Example of Golden Harvest's vigor testing in the field and lab

TIPS FOR MANAGING VIGOR DIFFERENCES AMONG HYBRIDS

- Be as patient as possible and plant into optimum soil conditions to minimize environmental stress. Differences in hybrids may only be seen in extreme environmental conditions.
- Plant hybrids with better early season vigor first and save other seed for the back side of the planting window.
- Avoid comparing results across labs. Different testing procedures make it difficult to compare fairly.
- Keep in mind achieving a good stand is still realistic with seed having a lower vigor test result. The lack of 3rd party testing calibration for specific germplasm behavior has to be considered.

The warm germination test and Golden Harvest Vigor Test are just two examples of the many tools Golden Harvest utilizes in its quality assurance program to evaluate seed quality. Golden Harvest conducts seed quality testing continuously and endeavors to provide its customers with quality seed. Development of the Golden Harvest Vigor Test is one of various technological improvements that Golden Harvest is implementing into the new state of the art Quality Control Laboratory located in Slater, Iowa. Ultimately, Golden Harvest stands behind every unit of seed to be of the best quality.

COMMON REASONS FOR LAB VIGOR RESULT DISCREPANCY

1. *Improper seed sampling procedure.* Seed tests are only as good as the sample submitted. It is critical to pull a representative seed core sample from throughout the entire shipping container.
2. *Comparing results across different 3rd party labs.* Not all vigor tests are equal.
3. *Vigor testing procedure not calibrated for genetic families.* Not all genetics react the same to all vigor tests. Some genetics will always score lower or higher than if a different vigor test were used. Most major companies use proprietary tests they have validated against their genetics and field data to correct for this, whereas most 3rd party labs do not have this capability.
4. *Non-accredited seed lab performing test.* Labs not following AOSA Rules for Testing Seed or operating without oversight of an accredited analyst (Registered Seed Technologist or Certified Seed Analyst) are less likely to deliver consistent results.

EVALUATING YIELD DATA TO SELECT HYBRIDS FOR YOUR FARM

INSIGHTS

- Local test plots are only as useful as they are relevant to the operation, deeming it very important to consider soil type, management practices, population, row spacing, pH and more.
- Comparing similar RMs and trait packages will help streamline and narrow down the product decision process.
- E-Luminate® is a data-driven digital tool available to Golden Harvest® Seed Advisors that allows them to quickly and easily use multiple sources of data to best understand product performance in their area as an aid in hybrid selection.

INTERPRETING HARVEST YIELD DATA

Yield data can be one of the most valuable assets for selecting the best hybrids, however it can also be one of the most difficult things to interpret correctly. Local corn or soybean test plots provide valuable insight for predicting how hybrids may perform on similar soils, management practices and weather patterns. This article will focus on a few key approaches and considerations to keep in mind while interpreting yield results.

THINGS TO CONSIDER BEFORE COMPARING PRODUCTS

Accessing data from as many sources as possible will help build confidence in final selections, as long as the data are relevant. Sort yield trial data into categories that best match environments and management practices that coincide with the fields where hybrids will be placed. Soil type, soil pH, irrigation, seeding rates and fertility levels are all examples of items to consider. Once trial data have been paired down to locations relevant to the farming operation, there are a few other items to keep in consideration to ensure making fair comparisons that will best indicate performance in the field.

- **Trait package:** Only compare products with similar insect, drought and herbicide traits. For example, hybrids lacking corn rootworm protection may not perform as well as hybrids with traits that protect against feeding due to excessive feeding. The lack of performance may not have been related to the hybrid genetics and, if offered in a traited version, may be the best choice.

- **Relative maturity (RM):** Yield is often maximized by planting the fullest-season hybrid or variety RM adaptable to a specific growing region. Most farm operations plant multiple RMs for multiple reasons, such as need for early grain delivery or just to hedge against weather volatility. Only comparing hybrids with similar RM (+/- 3 RM for corn) will be the best way to find products for those end needs. Due to differences among seed company RM rating scales, an alternative approach is to limit comparison to hybrids with similar harvest moisture.
  - Corn: plus or minus a moisture difference of 3%
  - Soybeans: plus or minus a moisture difference of 2%

GOLDEN HARVEST AND COMPETITOR YIELD RESULTS EXAMPLE			
	G08D29-3120A Brand (bu/A)	Pioneer P0825AMXT Brand (bu/A)	%Wins
1-Location Ave	176.6	180.4	0%
Location #1	176.6	180.4	–
Location #2	209.1	203.1	–
2-Location Ave	192.9	191.8	50%
Location #1	176.6	180.4	–
Location #2	209.1	203.1	–
Location #3	116.6	124.5	–
Location #4	230.1	203.7	–
Location #5	225.3	213.9	–
Location #6	249.2	240.6	–
6-Location Ave	201.2	194.4	67%

Table 1. Example of the need for multiple comparisons to interpret performance

HOW MUCH DATA DO YOU NEED?

The more data available will only increase confidence in choosing the best hybrid. Table 1 summarizes actual data used to compare two hybrids across 6 locations. This illustrates how a single location comparison could misdirect decision making. The overall win percentage of the Golden Harvest® hybrid continuously increased with additional location comparisons. Data combined across years and locations can help get to the needed level of comparisons to feel confident. Knowing that hybrid entries will not be consistent across trials, it's important to have a way to compare a hybrid of interest against other hybrids in a fair fashion. The best way to accomplish this is by using paired comparisons as illustrated in Table 1. The exact number of comparisons needed is dependent upon on how confident

PROBABILITY TO DETECT HYBRID DIFFERENCE AT VARIOUS NUMBER OF LOCATIONS AND YIELD DIFFERENCE LEVELS							
Number of Locations	**Hybrid Yield Difference Level (bu/A)**						
	2	**5**	**10**	**15**	**20**	**25**	**30**
2	54%	59%	67%	73%	78%	81%	84%
5	56%	65%	77%	85%	91%	94%	96%
10	58%	70%	84%	93%	97%	**99%**	**99%**
15	60%	73%	89%	96%	**99%**	**100%**	**100%**
20	61%	76%	92%	98%	**100%**	**100%**	**100%**
25	62%	79%	94%	**99%**	**100%**	**100%**	**100%**
30	64%	81%	96%	**99%**	**100%**	**100%**	**100%**

Table 2. This chart represents the probability percentage of detecting a yield difference by: 1) Number of locations; 2) Desired detection level (bu/A).

you need to be in the final decision. Table 2 uses statistics to illustrate how additional locations increase ability to predict the best product. It also illustrates how the need to detect small versus large differences between hybrids can change the number of locations needed. As an example, in Table 2, when comparing two hybrids across 25 trials, there is a 79% probability that the hybrid yielding 5 bushels more than the other is indeed better. Yield differences less than 5 bushels likely weren't repeatable.

SIMPLIFYING HYBRID COMPARISONS

Fairly and accurately comparing hybrids can be challenging and require a lot of time if not equipped with the right tools. E-Luminate® is a data-driven digital tool available to Golden Harvest® Seed Advisors that allows them to quickly and easily use multiple sources of data to best understand product performance in a specific area. For more support and information, contact a local Golden Harvest Seed Advisor to discuss hybrid selection.

E-luminate®

Performance assessments are based upon results or analysis of public information, field observations and/or internal Syngenta evaluations.

PHYSICAL CORN KERNEL ATTRIBUTES INFLUENCE ON BEEF CATTLE PERFORMANCE

INSIGHTS

- Physical corn kernel characteristics can be used to predict feed efficiency.
- High test weight was not a good indicator of beef feed-to-gain, although kernel size and softness were highly correlated.
- In a dry-rolled, corn-based diet, cattle fed corn with a higher proportion of soft endosperm gain more efficiently than cattle fed corn with a hard endosperm.

INTRODUCTION

Kernel characteristics such as test weight, density and hardness can vary significantly between corn hybrids. Test weight, expressed as pounds per bushel, can often become part of seed selection discussions even though grain market prices are typically not discounted until test weight falls below No. 2 yellow corn standards of 54 lbs/bu. There is a belief by many that high test weight grain is associated with high grain yields and feeding performance, however there is little evidence in research literature to support this. Golden Harvest®, in collaboration with the University of Nebraska-Lincoln (UNL), designed trials to evaluate the role that physical corn kernel characteristics have on influencing beef cattle feed performance.[1] Trials were designed in a way to address two main objectives:

1. Is cattle feed performance affected by physical attributes of corn hybrid grain utilized in feed rations?
2. What kernel characteristics of the hybrid most influence feed performance?

BEEF FEEDLOT STUDY DESIGN

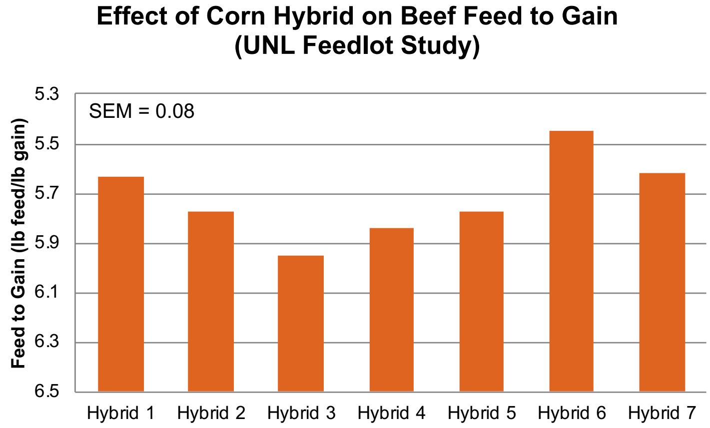
- Eight crossbred steer calves were randomly assigned to pens.
- Seven hybrids with differing kernel characteristics were grown, characterized for kernel attributes and assigned to an individual pen as part of the feed ration.
- Rations consisted of 66% dry-rolled corn of each selected hybrid with 20% wet gluten, 10% corn silage and 4% supplement.
- Each hybrid was replicated in four pens.
- Cattle were fed for 167 days and processed at a commercial packing plant.
- Carcass data was collected to calculate multiple beef performance and quality variables.

KERNEL CHARACTERISTICS MEASURED

1) Test weight
2) 1,000 kernel weight
3) Kernel size and shape
4) Feed constituent content (% protein, oil, starch, etc.)
5) Starch type
6) In-vitro starch disappearance
7) In-situ rate and extent of disappearance
8) Kernel hardness – as determined by various methods

FEEDLOT STUDY RESULTS

Of all animal performance variables measured, “feed-to-gain ratio” was the only feed performance characteristic influenced by hybrid grain characteristics (Graph 1). Feed-to-gain is the average pounds of feed needed for each pound of animal gain. Low feed-to-gain values indicate that less feed is needed to produce similar weight gain. Other animal performance variables such as dry matter intake, average daily gain, hot carcass weight, marble score and 12th rib fat were not influenced by hybrid differences. In a dry-rolled, corn-based diet, cattle fed corn hybrids with a higher proportion of soft endosperm tended to gain more efficiently than cattle fed corn hybrids with a harder endosperm.



Graph 1. Feed-to-gain ratio of each hybrid

Kernel Test	Hybrid Used in Feedlot Trials							SEM	P
	1	2	3	4	5	6	7		
1,000 K wt.	318^{c}	317^{c}	315^{cd}	311^{d}	326^{b}	344^{a}	341^{a}	1.74	0.01
Stenvert Hardness									
% Soft	72^{a}	67^{b}	64^{c}	68^{b}	63^{c}	73^{a}	71^{a}	0.01	0.01
Time to grind (seconds)	7.6d^{e}	7.8^{cd}	9.7^{a}	8.1^{c}	8.7^{b}	7.3^{e}	7.9^{cd}	0.12	0.01

Table 1. Hybrid 1,000 kernel weight and Stenvert Hardness test results

GRAIN CHARACTERISTICS RELATED TO LOW FEED-TO-GAIN RATIO

Of the kernel characteristics measured across hybrids, 1,000 kernel weight, kernel hardness and in-situ rate of disappearance were strongly correlated with lower feed-to-gain ratios. More commonly recognized attributes such as high test weight were not as correlated to feed efficiency gains. Due to the high correlations and relative ease of being able to characterize hybrids for 1,000 kernel weight and hardness characteristics, Golden Harvest utilizes these findings to characterize commercial hybrid physical grain characteristics for determining which are more likely to have better feed performance.

1) 1,000 kernel weight
- Closely related to kernel size
- Different measurement than test weight
- Higher values correlated to better (lower) feed-to-gain ratios (r^2 = -0.8135; P = 0.026).

2) Kernel hardness
- The “Stenvert Hardness Test” provided the best predictors of feed-to-gain response.
- Softer kernels have better feed-to-gain ratios.
- Hybrids that required less time to grind in a micro-hammer mill (r^2 = 0.8275; P = 0.022) and produced a larger percentage of soft particles (r^2 = -0.83202; P = 0.021) resulted in improved feed performance (lower feed-to-gain ratio).

3) In-situ rate of disappearance
- Percent of grain digested within live animal rumen over designated time.

Golden Harvest® Corn Beef Feed-to-Gain Ratings *(Based on UNL study correlating 1000 kernel weight and hardness to feed)**					
Golden Harvest Hybrid Series	**Relative Maturity (RM)**	**Beef Feed-to-Gain Rating***	**Golden Harvest Hybrid Series**	**Relative Maturity (RM)**	**Beef Feed-to-Gain Rating***
G80Q01	80	Fair	G08M20	108	Best
G84J92	84	Good	G08R52	108	Good
G85Z56	85	Best	G09A86	109	Best
G88F37	88	Best	G09T26	109	Good
G90Y04	90	Good	G09Y24	109	Fair
G91V51	91	Best	G10D21	110	Good
G94P48	94	Good	G10K03	110	Good
G95D32	95	Good	G10L16	110	Good
G95M41	95	Good	G10S30	110	Good
G96R61	96	Fair	G11A33	111	Good
G97N86	97	Best	G11B63	111	Best
G98M44	98	Fair	G11F16	111	Good
G99E68	99	Fair	G11V76	111	Good
G00H12	100	Fair	G12S75	112	Good
G01P52	101	Best	G12U17	112	Good
G02K39	102	Best	G13E90	113	Good
G02W74	102	Fair	G13H15	113	Good
G03C84	103	Good	G13M88	113	Good
G03R40	103	Fair	G13N18	113	Best
G04G36	104	Best	G13T41	113	Good
G04S19	104	Best	G13Z50	113	Best
G05K08	105	Best	G14N11	114	Best
G06K93	106	Good	G14R38	114	Best
G06Q68	106	Good	G15J91	115	Good
G07B39	107	Good	G15L32	115	Best
G07F23	107	Best	G16K01	116	Good
G07G73	107	Good	G17E95	117	Fair
G07V88	107	Best	G18D87	118	Fair
G08D29	108	Good			

Beef Feed-to-Gain Ratings Key: Best | Good | Fair | Poor

** Ratings based on Jaeger, Stephanie L.; Macken, Casey N.; Erickson, Galen E.; Klopfenstein, Terry J.; Fithian, Wayne A.; and Jackson, David S., "The Influence of Corn Kernel Traits on Feedlot Cattle Performance" (2004). Nebraska Beef Cattle Reports. Paper 197.*

Chart 1. Feed-to-gain ratings

CORN HYBRID GRAIN END-USE CHARACTERISTICS

INSIGHTS

- Some hybrids produce higher levels of specific grain end-use characteristics.
- Higher grain end use characteristics could reduce need for feed supplements or be used to capture premiums on grain delivered.

Golden Harvest® is built on a commitment to sharing agronomic knowledge with customers to help them grow more corn. The Corn Hybrid Grain End-Use Ratings provide information that can help people produce corn for livestock, the ethanol industry or other grain end uses where grain quality is just as important as yield. These Corn Hybrid Grain End-Use Ratings are generated by collecting grain samples from internal company trials which are sent to an independent laboratory for protein, oil and starch analysis. The data from these analyses are then categorized for the end-use based on the level of each characteristic with four ratings: Best (highest level); Good (above-average level); Fair (average to below-average level); Poor (low level).

USES FOR HIGH QUALITY CORN GRAIN

- Greater feed value per unit of grain
- Can improve feed efficiency, reducing cost per pound of gain
- Reduces the need for feed supplements, and the storage and handling costs associated with those supplements
- Potential for premium on grain

UNDERSTANDING GRAIN QUALITY TRAITS

Protein: Represents the ability of a feed to supply the animal with amino acids and nitrogen, the basic building blocks needed for growth and maintenance of the body.

HARVEST–POST-HARVEST

Oil and Starch: Both traits are an indication of the ability of a feed to meet the animal's energy, fat deposition and heat production needs. Starch is the largest single component in corn grain and the primary source of most of the energy in corn. Oil is more energy dense than starch, thus a unit change in oil content affects the energy supplied by the feed more than a similar unit change in starch.

ETHANOL

- Specific hybrids can yield 2-5% more ethanol than bulk commodity corn.[1]
- Ideal hybrids for dry-grind ethanol production have a larger portion of high total fermentables (HTF), which is starch plus small amounts of free glucose, fructose, maltose and sucrose within kernels.
- Grain starch content alone is not a good indicator of ethanol yield.

FACTORS INFLUENCING GRAIN END-USE CHARACTERISTIC CONTENT

- Environment – Corn grown in the northern U.S. tends to be higher in protein and corn grown in the central and southern U.S. tends to be higher in starch.
- Genetics – Some hybrids will consistently produce higher levels of specific grain end-use characteristics, regardless of growing conditions and crop management.
- Soils – High fertility soils tend to produce higher levels of protein.
- Management – Proper nitrogen fertility correlates to increased protein levels.

Golden Harvest® Corn Hybrid Grain End-Use Ratings

Golden Harvest Hybrid Series	Relative Maturity (RM)	Protein	Oil	Starch	Ethanol	Golden Harvest Hybrid Series	Relative Maturity (RM)	Protein	Oil	Starch	Ethanol
G80Q01	80	Good	Good	Best	Good	G08D29	108	Fair	Best	Good	Good
G84J92	84	Fair	Fair	Best	Best	G08M20	108	Fair	Best	Best	Good
G85Z56	85	Good	Fair	Good	Good	G08R52	108	Good	Poor	Best	Best
G88F37	88	Good	Fair	Good	Good	G09A86	109	Good	Good	Good	Good
G90Y04	90	Good	Fair	Best	Good	G09T26	109	Good	Best	Good	Fair
G91V51	91	Fair	Good	Good	Best	G09Y24	109	Good	Best	Good	Good
G94P48	94	Good	Best	Good	Good	G10D21	110	Best	Best	Good	Good
G95D32	95	Fair	Fair	Best	Best	G10K03	110	Fair	Best	Good	Good
G95M41	95	Fair	Fair	Best	Best	G10L16	110	Fair	Fair	Best	Good
G96R61	96	Best	Poor	Good	Good	G10S30	110	Fair	Best	Fair	Best
G97N86	97	Best	Fair	Good	Good	G11A33	111	Fair	Best	Good	Good
G98M44	98	Good	Good	Good	Good	G11B63	111	Good	Fair	Best	Good
G99E68	99	Best	Poor	Best	Best	G11F16	111	Fair	Good	Good	Good
G00H12	100	Good	Best	Good	Good	G11V76	111	Good	Poor	Best	Best
G01P52	101	Best	Fair	Good	Good	G12S75	112	Fair	Fair	Best	Best
G02K39	102	Good	Best	Fair	Good	G12U17	112	Fair	Good	Best	Best
G02K39	102	Good	Best	Good	Fair	G13E90	113	Fair	Fair	Good	Good
G02W74	102	Good	Fair	Good	Best	G13H15	113	Good	Best	Good	Good
G03C84	103	Fair	Best	Good	Good	G13M88	113	Best	Best	Fair	Fair
G03R40	103	Good	Best	Good	Good	G13N18	113	Good	Fair	Fair	Good
G04G36	104	Fair	Best	Fair	Good	G13T41	113	Fair	Best	Good	Good
G04S19	104	Fair	Fair	Best	Best	G13Z50	113	Fair	Fair	Good	Best
G05K08	105	Good	Best	Good	Good	G14N11	114	Fair	Fair	Best	Best
G06K93	106	Fair	Best	Best	Good	G14R38	114	Fair	Good	Good	Best
G06Q68	106	Fair	Fair	Best	Good	G15J91	115	Best	Poor	Best	Best
G07B39	107	Fair	Best	Good	Fair	G15L32	115	Fair	Good	Best	Good
G07F23	107	Fair	Best	Good	Best	G16K01	116	Fair	Good	Good	Best
G07G73	107	Fair	Best	Good	Good	G17E95	117	Fair	Good	Good	Good
G07V88	107	Good	Best	Best	Best	G18D87	118	Best	Fair	Good	Good

Corn Hybrid Grain End-use Ratings Key: Best | Good | Fair | Poor

Using this chart:

Protein – A source of nitrogen and amino acids needed for animal growth
Oil – A secondary source of energy in corn grain and more energy dense than starch
Starch –The largest single component in corn grain and the primary source of energy

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HARVEST PREP

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HARVEST – POST HARVEST

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