Golden Harvest®

AGRONOMY IN ACTION

2020 RESEARCH REVIEW

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INTRODUCTION

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

David Schlake
Golden Harvest West Agronomy Manager

2019 was an unprecedented year for growers and producers in the Golden Harvest West Agronomy territory. We ended the fall of 2018 with many areas experiencing weather-related harvest challenges that resulted in little or no field work being completed prior to winter. This, in turn, lead to a hectic spring of 2019.

While planting followed normal pace in some areas, many growers were significantly delayed in planting. Corn was planted well into June. Additionally, some areas of the western geography were unable to plant at all, leading to record-breaking levels of prevent plant from extreme amounts of spring rainfall in South Dakota, parts of North Dakota and Nebraska.

Outside of weather challenges, we continued to see newly emerging insect pests. Corn rootworm pressure was also ever-present, showing the need for implementing a comprehensive corn rootworm management plan. 2019 was a minor year for corn and soybean disease pressure, even though growers continued to see a strong return on investment by utilizing foliar-applied fungicides. We do need to stay vigilant, as the past few years have shown increased activity of several pathogens in both crops. Weather disruptions persisted into the fall, contributing to harvest delays in some areas. Most agree, 2019 was a year for the record books, and one we hope not to repeat any time soon.

Regardless of the challenges of the season, the Golden Harvest agronomy team is committed to standing by our customers with our genetics, agronomy and service. As we enter the 2020 growing season, management plans from pests to disease will need to be reevaluated. To help growers with management decisions, we've compiled our most recent research, ranging on topics from seeding rate to soil nitrogen management, into this comprehensive, yet accessible summary. We look forward to helping growers succeed in 2020, with agronomic recommendations, new digital agronomy tools, and, as always, a commitment to the best-in-class agronomy and service, matched with industry-leading corn and soybean genetics.

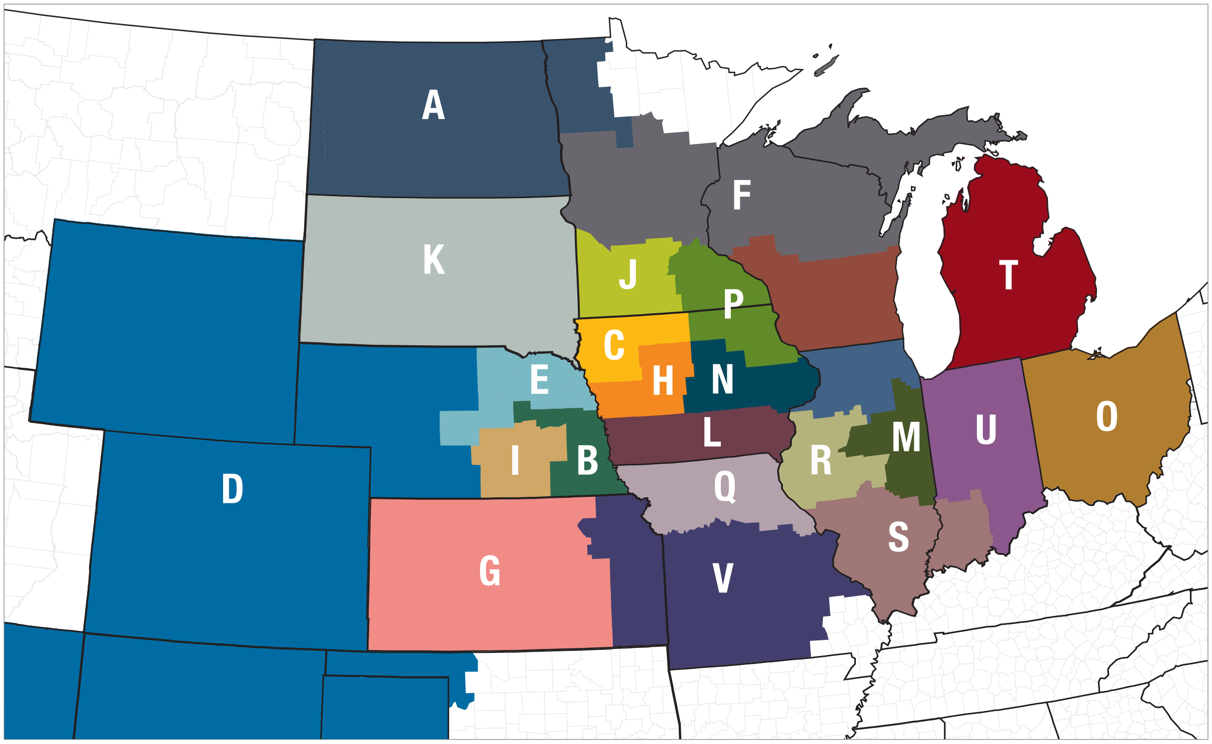
Steve Wilkens, M.S.
Golden Harvest East Agronomy Manager

In agriculture, we've come to expect the unexpected. 2019 did not disappoint. It's hard to imagine a year that could test the resolve and resilience of the American farmer more than this past growing season. Due to historic precipitation across the eastern Midwest, many farmers were unable to get their crops planted, or planting was delayed beyond anything experienced for a generation or longer.

While farmers struggled across the Midwest, those in the central and eastern Corn Belt and Great Lakes region were hit especially hard. There were more than 7 million unplanted acres across Illinois, Indiana, Michigan, Missouri, Ohio and Wisconsin. The delayed and drawn out planting season also created challenges for managing crop growth and development, weed, disease and insect control.

Mother Nature didn't stop delivering challenges with spring planting conditions, either. Pockets of Illinois, Iowa and Minnesota went 40 days without measurable rainfall during the growing season, followed by the return of heavy rains in the fall, just in time to deliver the slowest harvest on record. Despite all of these challenges, yields in many areas exceeded grower expectations. Golden Harvest® corn and soybean products performed very well. Golden Harvest had three, top three finishes in the National Corn Growers Contest in 2019, and multiple areas where corn and soybean yields exceeded 300 bu/acre and 80 bu/acre, respectively.

While we look to the 2020 growing season with optimism, we also know many growers will want to learn from the challenges presented by 2019 and re-think or adjust their management practices. To help with this process, we've compiled our most recent and applicable research studies to help you plan for and navigate the upcoming season. From everyone in Golden Harvest East, we look forward to partnering with you in 2020 to take crop performance on your operation to the next level.



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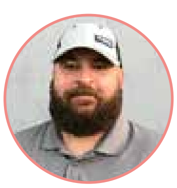
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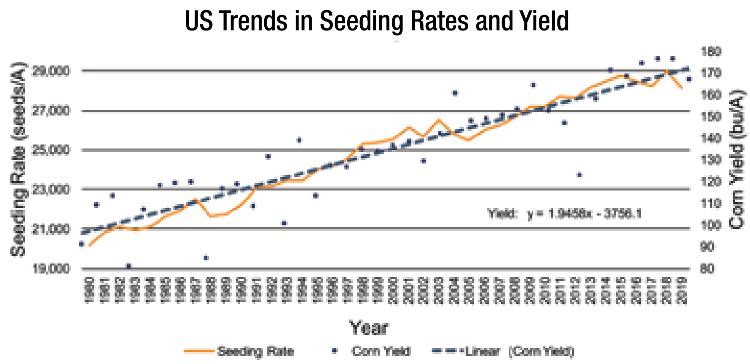
SEEDING RATE MANAGEMENT TO OPTIMIZE CORN YIELDS

Yield potential of corn hybrids continues 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 as seen in Graph 1. 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 (Figure 1), the Golden Harvest® Agronomy in Action research team has conducted trials since 1992 to provide hybrid specific guidance on seeding rates. 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.



Graph 1. National Agricultural Statistics Service (NASS)-reported trends of corn seeding rates and yield

POPULATION RESPONSE FACTORS

1. Yield environment

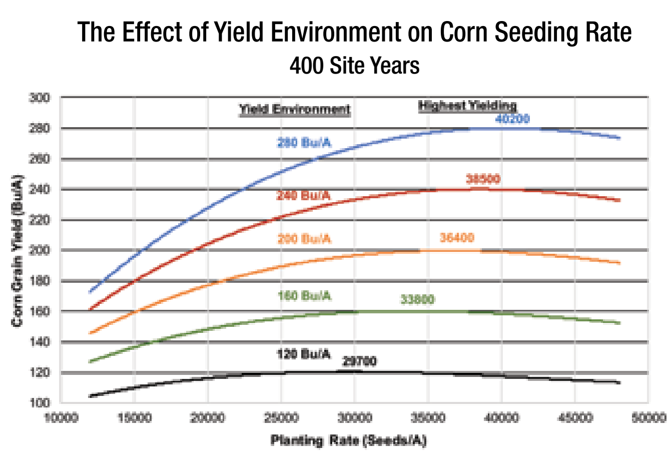
Optimum seeding rate increases as overall field yield potential increases. Penalty associated with incorrect seeding rate selection increases with yield environments (Graph 2).

2. Hybrid response

Yield response to increasing or decreasing seeding rates differs considerably among hybrids. Golden Harvest Agronomy In Action Research provides seeding rate response scores specific to every hybrid to help fine tune field recommendations (see Table 2, Hybrid Seeding Rate Adaptability Chart).

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



Graph 2. Yield environment influence on seeding rate

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

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. Adjust seeding rate up or down from optimum found in Table 1 to customize specific hybrid recommendations based on ratings in Hybrid Seeding Rate Adaptability Chart (Table 2).

   Example: If planting Golden Harvest corn G09A86, consider adjusting previously determined 32,300 seeds/A seeding rate up to 20% greater based on hybrid score. Ideal rates can fall from 32,300 to 38,760 for that specific hybrid in 200 bu/A yield environments.

Figure 1. Hybrid response to seeding rate; Ears per 5 row feet at each seeding rate

3. Root and stalk strength scores listed next to seeding rate suggestions in Table 2 can be used to help determine if the hybrid will have suitable agronomic characteristics for increasing seeding rates (lower scores indicate more suitable).

   Example: G09A86 agronomic root strength and stalk strength is good (less than 3) which allows more confidence to increase 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 also available to help create zone prescriptions such as: fertility, drainage, topography, NDVI imagery, soil type, and yield maps. Multiple years of yield data prove to be one of the most accurate resources. Using more than one year of data allows growers 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.

TIPS FOR DEVELOPING A FIELD PRESCRIPTION

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

Golden Harvest Hybrid Seeding Rate Adaptability Chart

Golden Harvest Hybrid Series	Relative Maturity (RM)	% Adjustment -20%	-10%	0	+10%	+20%	Root Strength	Stalk Strength
G80Q01	80			●	●		2	3
G84B99	84			●	●		2	2
G84J92	84			●	●		3	2
G85Z56	85			●			4	3
G88F37	88			●	●		3	4
G90Y04	90		●	—	●		4	2
G91V51	91			●			5	4
G92T43	92			●	●		5	4
G94P48	94			●			2	3
G95D32	95		●	●			3	2
G95M41	95			●			2	3
G96R61	96			●			3	2
G97N86	97			●	●		4	2
G99E68	99			●			2	3
G00H12	100			●	●		3	3
G01P52	101			●	—	●	4	2
G02K39	102			●	●		2	2
G02W74	102			●	—	●	2	2
G03C84	103		●	●			3	5
G03R40	103			●	●		2	2
G04G36	104			●			2	3
G04S19	104	●	—	●			4	3
G05K08	105		●	●			4	3
G05T82	105			●	—	●	5	2
G06K93	106			●	●		3	3
G06Q68	106			●	●		3	3
G07B39	109		●	●			5	4
G07F23	107			●			3	2
G07V88	107		●	●			5	3
G08D29	108			●			3	3
G08M20	108	●	—	●			3	3
G08R52	108			●			2	2

Golden Harvest Hybrid Series	Relative Maturity (RM)	% Adjustment -20%	-10%	0	+10%	+20%	Root Strength	Stalk Strength
G09A86	109			●	—	●	3	2
G09E98	109			●	—	●	5	2
G09Y24	109		●	●			4	4
G10D21	110			●			3	3
G10K03	110		●	●			4	4
G10L16	110			●			4	4
G10S30	110	●	—	●			4	3
G10T63	110		●	●			4	4
G11A33	111			●			2	2
G11B63	111		●	●			3	4
G11F16	111			●	●		2	2
G11V76	111			●			3	4
G12J11	112			●			4	4
G12S75	112			●			3	2
G12U17	112			●			3	2
G12W66	112			●			3	2
G13E90	113			●			4	4
G13H15	113			●			4	2
G13M88	113			●			2	3
G13N18	113		●	●			5	4
G13T41	113			●			2	2
G13Z50	113			●	—	●	2	4
G14H66	114		●	●			4	5
G14K50	114		●	●			5	2
G14N11	114		●	●			2	4
G14R38	114			●	—	●	2	3
G14V04	114			●			4	3
G15J91	115		●	●			2	4
G15L32	115			●			4	4
G16K01	116		●	●			5	3
G18D87	118			●	●		4	3

Table 2

Note: Seeding rate responses are based on yield response to seeding rate. Stalk and root strength also influence performance at high seeding rates. Root and stalk strength ratings based on 1-9 scale with 1 being best. Drought and disease tolerance and plant and ear height are also important characteristics to consider when choosing a seeding rate for a hybrid. Ratings apply to all hybrids with similar genetics.

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.

NARROW CORN ROWS MAY BE BENEFICIAL IN NORTHERN LATITUDES

INSIGHTS

- Narrow row corn has shown increased yields consistently in northern latitudes but less consistently when moving south.
- Response to 20-inch rows was inconsistent across locations as well as between hybrids in 2019 trials.
- Individual hybrid response to seeding rates in 20-inch rows was similar to 30-inch rows.
- Previous 30-inch hybrid seeding rate characterization data is still relevant for creating 20-inch seeding prescriptions.

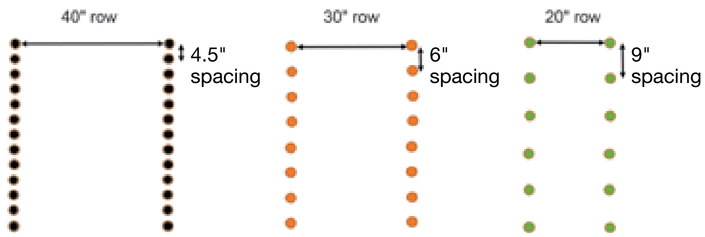


Figure 1. Row width influence on seed spacing within rows at 35,000 seeds per acre

Corn row spacing has evolved over time in response to equipment innovations that have slowly enabled narrowing rows. Early corn fields were planted in 40-inch rows to accommodate the width of a horse, not because 40-inch rows resulted in the greatest yield. With the introduction of the tractor, corn row spacing slowly began to evolve from 40-inch to present day standard 30-inch rows. Each transition to slightly narrower rows by equipment manufacturers simultaneously increased in-row seed spacing as illustrated in Figure 1. Greater distances between plants helps reduce interplant competition for resources and achieves a more complete canopy across rows. Improved canopy closure helps conserve soil moisture, but also makes the corn plant more efficient at capturing and utilizing light for photosynthesis.[1] Increased seed spacing also provides an opportunity for corn breeders to develop hybrids that can better withstand the interplant competition of increased seeding rates. The ability to plant and harvest more ears per acre combined with improved stress tolerant genetics has enabled continuous yield gains year after year.

IS THERE OPPORTUNITY TO REDUCE CORN ROW SPACING MORE?

The physiological principles of these yield gains continue to test the possibility of further increasing yields with narrower rows. Soybeans have consistently yielded higher in 15- to 20-inch rows, posing the question of the overall value of switching an entire farm operation to narrower rows.

Advantages will likely only occur if a yield limiting factor is minimized due to narrowing rows. Sunlight is not often considered a yield limiting factor in most geographies. Northern latitudes have shorter growing seasons, but also receive sunlight at a lower angle throughout the summer and this sunlight is spread over a greater surface area. Minnesota, North Dakota, and Michigan geographies are more limited in sunlight, making light interception a yield limiting factor in these latitudes.[2]

PREVIOUS FINDINGS

Previous studies examining row spacing have shown that while narrower rows do not always yield higher than standard rows, they often result in a small advantage in northern latitudes. Widdicombe and Thelan (2002) found that 15-inch rows yielded 6% better than 30-inch rows at several sites in Michigan. Similarly, Porter and colleagues (1996) observed a 7-8% yield increase with narrow rows at several sites in Minnesota. Results from Iowa have been less consistent with a 2% yield reduction in narrow rows[4] although sometimes narrow row advantages in higher yielding environments (greater than 235 bu/A) have been observed.[5]

Previous row-spacing studies using multiple hybrids, found them all to respond similarly across row spacings. However, Farnham et al. found two of six hybrids that performed better in 30-inch rows and one better in 20-inch rows.

AGRONOMY IN ACTION TRIALS

Before adopting narrow row spacing, it is important to address the following three questions:

1. Are there advantages or shortcomings to growing corn in less than a 30-inch row spacing?
2. Do seeding rates need to increase for 20-inch rows?
3. Do some hybrids respond differently or require different management in 20-inch rows?

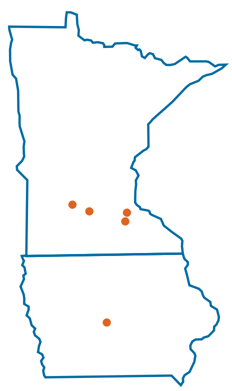


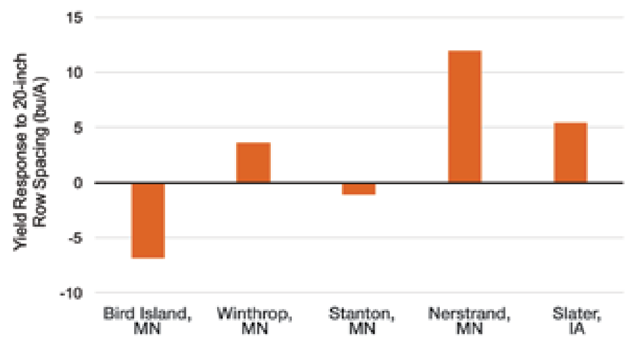
Figure 2. 2019 20-inch row spacing trials

Golden Harvest® Agronomy In Action research implemented trials to test how hybrids respond to changing row spacing and seeding rates. Over 46 different hybrids were evaluated in 20-inch and 30-inch row spacings at five different seeding rates ranging from 26,000 to 50,000 seeds/A across five locations. Locations shown in Figure 2 ranged in latitude from Slater, IA (latitude of 41.88) north to Bird Island, MN (latitude of 44.7). Trials were well-fertilized and received sufficient rainfall, limiting any potential differences to be contributed to amount of sunlight intercepted.

TRIAL RESULTS

Yield response to row spacing was inconsistent across locations. Response to 20-inch rows ranged from -7 bu/A to +12 bu/A, averaging a 2 bu/A increase across all sites. When yield was averaged across corn populations, Bird Island had greater yields with 30-inch rows, Nerstrand had higher yields with 20-inch rows as shown in Graph 1. The three other sites only found row spacing differences at specific populations.

Corn Yield Response When Shifting to 20-inch Row Spacing
(averaged across 5 seeding rates and multiple hybrids)

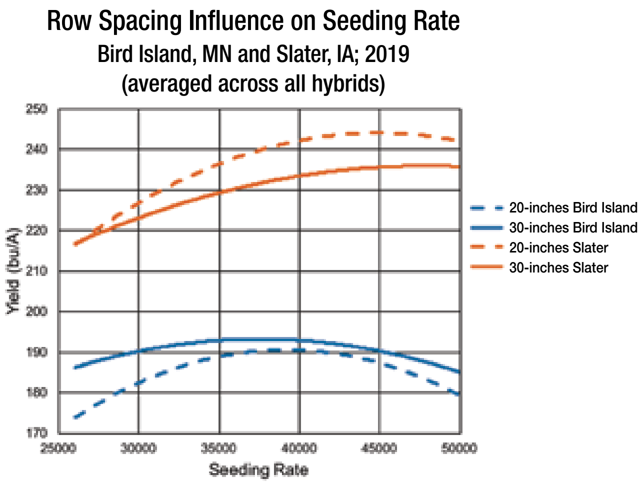


Graph 1. Rowspacing response by location

Yield response to row spacing varied by population at every location. Graph 2 illustrates how the optimum seeding rate and narrow row advantage changed dramatically across two locations. Lower planting rates with narrow rows increased in-row seed spacing resulting in a loss of narrow row efficiency for capturing solar radiation. On the other hand, populations at 50,000 plants/A likely experienced enough in-row competition that changes in the between-row environment were not meaningful.

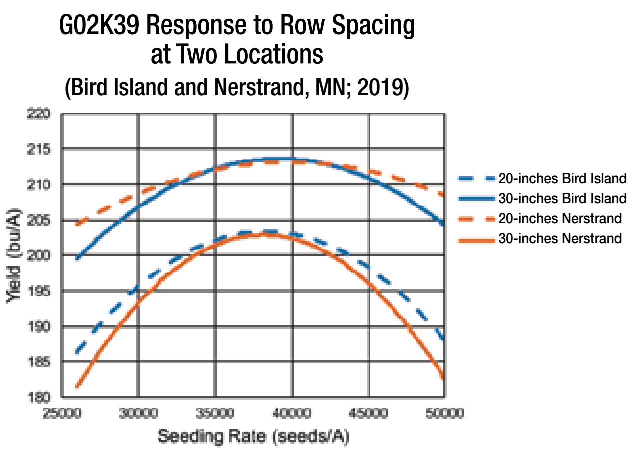
Individual hybrid response to narrow rows was also extremely inconsistent across testing locations.

Many times, there was little difference in yield within each hybrid when comparing the



Graph 2. Row spacing response change across two locations

two row spacings at optimum seeding rates. Golden Harvest corn G02K39 provides a good example of inconsistent hybrid response to narrow rows (Graph 3). Twenty-inch row spacing improved yields at Bird Island while 30-inch rows maximized yields at Nerstrand. In both situations, the optimum seeding rate remained unchanged at both locations no matter what the row spacing, implying that increasing seeding rates with narrow rows may not be necessary with all hybrids.



Graph 3. Example of inconsistent hybrid response to narrrow rows

It is difficult to test the interaction of row spacing and row orientation with a limited number of sites, but it is interesting to note that the three sites planted with east-west orientation (Bird Island, Winthrop, and Stanton) ranged from mostly favoring 30-inch rows to one small advantage for 20-inch rows, while sites planted in a north-south orientation (Nerstrand and Slater) both favored 20-inch rows, sometimes with a significant advantage.

SHOULD YOU MAKE THE SWITCH?

Narrower corn rows have been shown to increase yields more times than not in northern latitudes but making the switch to narrower rows in these latitudes should still be considered in context of the entire farming operation. If you are planting other crops that respond consistently to narrow rows, such as soybeans or sugar beets, there can be significant yield gains for those crops and very little risk of losing corn yield.

Net yield gains for narrowing row spacing of these crops may be sufficient for switching even without corn yield gains, no matter the latitude. The opportunity to increase corn seeding rates in 30-inch rows will eventually be capped due to in-row seed spacing limitations, leaving narrow rows and focused breeding of genetics that tolerate crowding as the only chance for continued seeding rate increases in future years.

When switching to narrow rows, individual hybrid seeding rates can be managed similarly in narrow and wide rows and should not require significant increases over current practices. Utilizing narrow row corn as part of an overall intensive management system that includes increasing seeding rates, fungicide application, irrigation and high soil fertility levels has merit for increasing yield potential. Utilizing narrow rows and increased seeding rates in lower yield potential fields or fields at high risk of stress such as drought or disease may not be a good combination. Planting in narrow rows in a north-south orientation may also increase solar capture and potentially yield, but this decision should be weighed with other row orientation factors, such as wind vulnerability.

EARLY SEASON DROUGHT STRESS ON CORN

Compared to stress during pollination and grain fill, drought stress during the vegetative growth stages is generally less detrimental to yield. However, early drought stress can reduce yield because of its impact on plant growth and nutrient uptake.

PLANT GROWTH

Leaf rolling from drought stress occurs when turgor (water) pressure is lost in the leaf's cells due to a lack of water as shown in Figure 1. Leaf rolling is the plants way to conserve water by decreasing the surface area of the leaf exposed to sunlight and reducing transpiration.[1] However, it also reduces photosynthesis, which can decrease plant growth and development, and as a result, limit yield potential.

ROOT GROWTH

Soil moisture is essential for proper root growth. Early season drought can cause root tips to dry out and stop growing. Dry soils also cause brace roots to grow along the surface

Figure 1. Corn leaf rolling as result of early drought stress

rather than penetrate the soil, which can lead to standability issues later in the season. The decrease in root growth limits the surface area available to collect nutrients and water from the soil. If moisture availability doesn't improve, overall plant growth can also be compromised.

NUTRIENT UPTAKE

Dry soils may temporarily reduce available nutrients in the soil solution. Potassium (K) is vital to several plant functions, including water and nutrient uptake and stalk health. Dry soils can exacerbate the plant's inability to uptake potassium due to reduced physical mobility and root interception of K. Deficiency symptoms start on the plant's older leaves and can be identified by yellowing or firing on the leaf margins. Generally, drought will have less of an impact where K availability is adequate in the soil. Adequate K levels within the plant will also help to increase drought tolerance by supporting water uptake.

EFFECT ON YIELD

Extended early season drought can limit yield potential because of its impact on the plant's development processes. The number of kernel rows on the ear are determined around the V6 growth stage, while potential number of kernels are determined from approximately the V7 growth stage up until one week before silk emergence.[2] As a result, extended periods of early drought can reduce the maximum number of potential kernel formation leading to potential yield reduction. Corn leaves that are rolled up for a couple of days likely won't see significant yield loss, but corn that's rolled up for the majority of a two-week period may see yield losses up to 20%.[3] Extended early season drought under extremely dry conditions can even lead to plant death. Yield reduction varies greatly depending on the severity and duration of the stress.

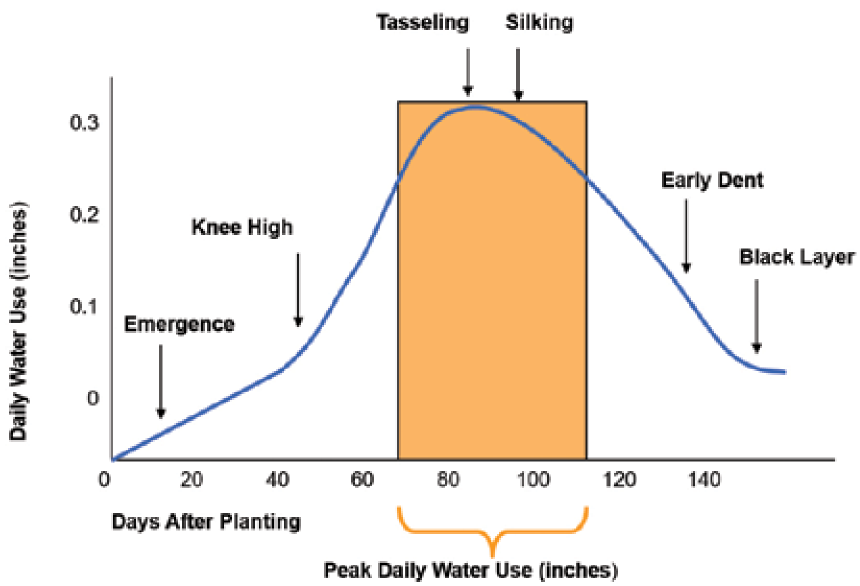


Figure 2. Corn water demand by growth stage

Overall, yield loss from early season stress can occur, although as Figure 2 illustrates, the highest demand for water doesn't occur until the plant begins to shift from vegetative growth stages to reproductive growth stages. Drought stress at or near pollination will result in the most severe losses from lack of water availability.

SOIL COMPACTION AND ITS EFFECT ON CORN GROWTH

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.

Figure 1. Compaction layer from tillage on wet soils

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 reduces 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 worsen 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.

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.

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

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.

Figure 2. Sidewall compaction from wet planting conditions

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 and increasing the risk of late season lodging because the roots cannot fully develop enough to anchor the plant.

DETERMINING WHEN SOIL IS READY FOR FIELDWORK

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 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.

VOLUNTEER CORN MANAGEMENT

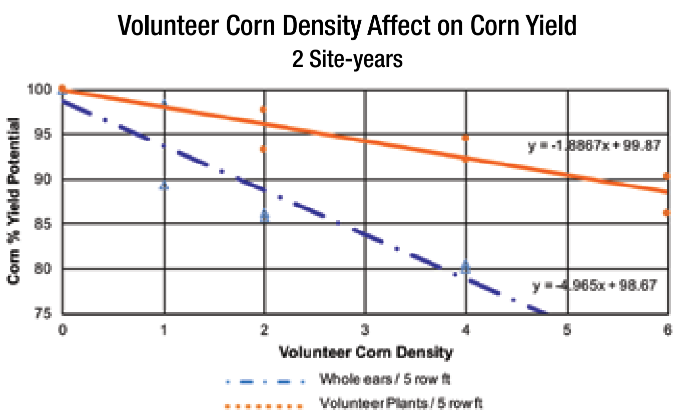
Volunteer corn is a competitive weed. It deprives corn and soybeans of water, nutrients, light and space which consequently reduce yield. Management of volunteer corn plants in crop production has traditionally involved a combination of cultural and mechanical practices. Herbicide tolerant crops now 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.

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.

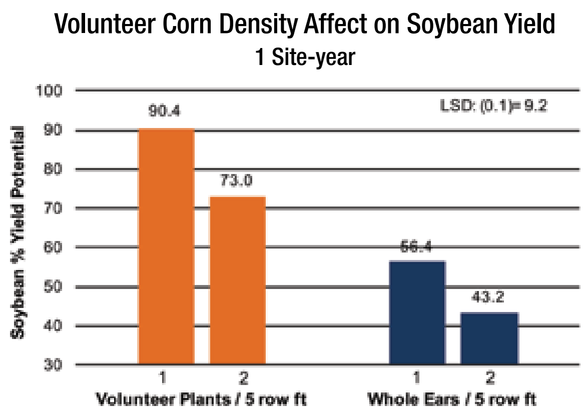
Figure 1. Four whole ears of volunteer corn per 5 feet

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)
- Volunteers became more competitive in both corn and soybeans as the density increased



Graph 1



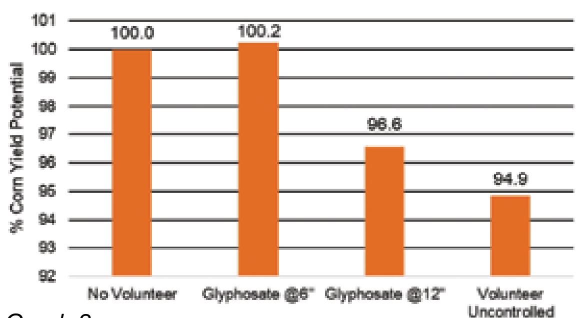
Graph 2

- Low densities of < 2 individual volunteer plants did not economically affect corn yield while all densities reduced soybean yield significantly

APPLICATION TIMING IS CRITICAL

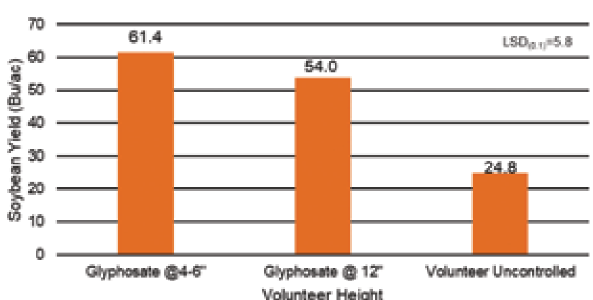
Like any other weed, volunteer corn starts competing with crops at early growth stages, so it is imperative to control volunteers early in the season to maintain corn and soybean yield.

Effect of Volunteer Management Timing on Corn Yield
(Average over 6 Volunteer Corn Densities) 2 Site-years



Graph 3

Effect of Volunteer Management Timing on Soybean Yield
(Average over 4 Volunteer Corn Densities) 1 Site-year



Graph 4

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® insecticide 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
- 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 within 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 in 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. The following Bayer Genuity® trait stacks: VT Double PRO® RIB Complete® Corn Blend, Genuity® VT Triple PRO® RIB Complete® Corn Blend and Trecepta® corn hybrids DO NOT provide tolerance to glufosinate. A solution for fields where these Genuity® traits were planted in the prior year is to plant an Agrisure® traited hybrid containing tolerance to both glyphosate and glufosinate and timely apply a glufosinate based herbicide to manage small volunteer corn plants (Figure 2). Important: 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.

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

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 tank mix with an auxin herbicide[1] (Figures 3 & 4). 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. Fusilade®DX herbicide is available for use as tank mix partner with XtendiMax® with VaporGrip® Technology (requires drift reducing adjuvant) or Engenia®. Fusilade® DX herbicide offers superior control of volunteer corn with less risk of antagonism over Clethodim 2EC herbicide.

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

CORN RESPONSE TO WESTERN CORN BELT HIGH PH SOILS

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.

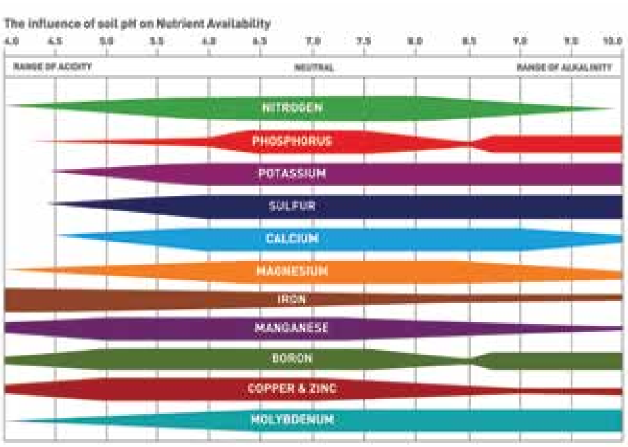


Figure 1. Soil pH effects on nutrient availability

WHY IS SOIL PH IMPORTANT?

In agriculture, soil pH plays a major role in crop production. Plants obtain fourteen of their seventeen 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 making them less available to the plant.

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

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, basic soils 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.

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

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
G77H21	77	5	4	1	Good	G01D24	101	2	2	2	Good
G78C29	78	4	3	2	Good	G02K39	102	5	5	1	Fair
G80Q01	80	5	4	1	Good	G03R40	103	4	4	2	Good
G82M47	82	4	4	3	Fair	G03C84	103	3	3	1	Fair
G84B99	84	6	6	1	Fair	G05B91	105	6	6	2	Fair
G85A33	85	3	5	2	Fair	G05K08	105	5	6	1	Fair
G85Z56	85	3	4	1	Good	G07A24	107	5	6	4	Good
G84J92	86	3	5	1	Fair	G08D29	108	4	5	1	Fair
G88F37	88	3	5	1	Fair	G08M20	108	5	5	2	Good
G89A09	89	3	5	3	Fair	G08R52	108	5	5	1	Fair
G91V51	91	3	4	1	Poor	G10L16	110	5	6	1	Fair
G90Y04	92	2	2	1	Good	G10K03	110	3	3	2	Good
G94P48	94	3	2	1	Good	G11B63	111	3	3	1	Good
G95M41	95	3	4	3	Good	G12U17	112	3	3	3	Good
G95D32	95	3	4	1	Good	G13H15	113	3	3	2	Fair
G96V99	96	4	4	3	Good	G13Z50	113	4	4	2	Good
G97N86	97	3	2	4	Fair	G14V04	114	3	3	1	Best
G98L17	98	2	2	2	Best	G14N11	114	3	2	2	Good
G00H12	100	5	5	2	Best	G15L32	115	4	5	2	Best

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

[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.

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

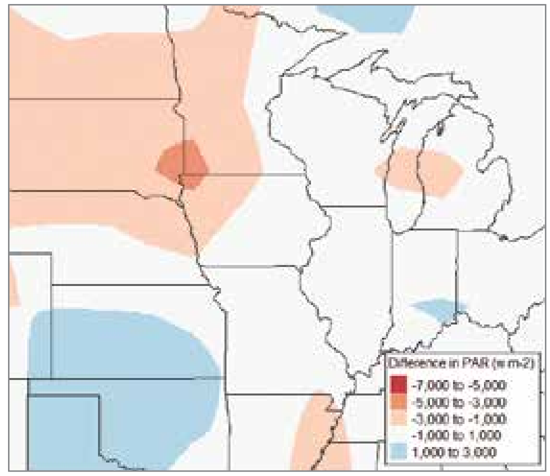
SOLAR RADIATION: EFFECT ON CORN YIELD AND STANDABILITY

2019 was a unique year in many ways. Record rainfall and unprecedented planting delays occurred broadly. There were many obvious factors influencing final yield, such as planting date and drought. Lodging or reduced yields in fields with no apparent stress can be more challenging to understand. Available solar radiation from sunlight (in addition to temperature and precipitation) is one of those factors that plays a strong role in corn growth and development. Tracking temperature and precipitation deficits in-season are often easier to visualize than seasonal sunlight accumulation. Sunlight is an essential component in photosynthesis that results in production of carbohydrates used for plant development and grain production. The maps included here show how much photosynthetically active radiation (PAR) differed in 2019 to the prior six years (2013-2018) average. PAR designates the solar radiation wave band plants can use in photosynthesis.

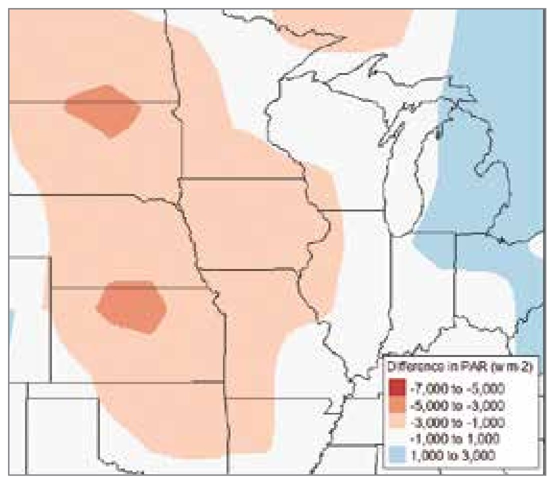
Reductions of plant available light at key growth stages can have negative impacts on yield and possibly put plants at higher risk for stalk lodging. Low solar radiation has the biggest effect on yield during silking and grain fill periods. Experiments that intentionally shaded corn to approximately 50% solar radiation reduced yield by 12-20% when shaded during silking and by 19-21% when shaded during grain fill.[1,2] Shading during silking results in ear tip-back or fewer kernels per row, whereas shading during grain fill results in decreased kernel weight from shallower kernels.

Flowering commonly occurs mid to late July followed by grain fill throughout August in most geographies with normal planting dates. July and

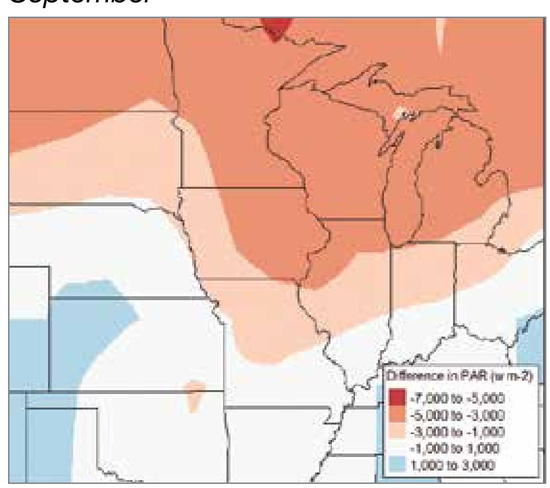
July



August



September



August are therefore the most critical months when evaluating seasonal sunlight deficiencies impact on yield and stalk strength. If planting was delayed into late May/early June, it may be more applicable to consider August and September solar radiation impact on corn since flowering and grain fill dates are later than normal.

Corn can become even more susceptible to lodging if sunlight is limited during the grain fill period. Limited photosynthesis during grain fill signals the plant to remobilize carbohydrates from the stalk to the ear, weakening the stalk. This problem can be further exacerbated when near perfect growing conditions during ear size determination (at V6-V12 for rows/ear and at V18 for kernels/row) and pollination are followed with below normal solar radiation during grain fill.

Favorable growing conditions throughout flowering will set plants up for higher yield potentials and create a greater demand for carbohydrates during grain fill than the plant may be able to supply with limited light availability.

Solar radiation maps illustrate areas receiving both higher and lower than normal daylight accumulation for each month. Below-normal July accumulations in northern Nebraska, northwest Iowa, western Minnesota and most all of the Dakotas in 2019 may explain unexpected ear tip back and reduced yields for these areas. August continued to encounter below-normal light accumulation in most of the same areas while also expanding across a larger geography into remaining parts of Iowa, Nebraska, Kansas and sections of Missouri, western Illinois and northern Oklahoma. Lower light availability in these areas for August could add increased demand for carbohydrate relocation from stalks to support grain fill, resulting in higher potential for stalk lodging, reduced yields or a combination. Areas forced to delay planting into June should also consider light limited geographies within the September map that could be at higher risks due to stress during grain fill. Continue to scout fields for stalk integrity throughout harvest and adjust harvest schedules accordingly to help minimize losses.

MANAGEMENT CONSIDERATIONS FOR SILAGE PRODUCTION

Golden Harvest is committed to sharing agronomic knowledge with livestock producing customers to help them grow more corn silage. To help growers choose the best silage hybrids to meet the nutritional needs of their 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 eight 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 potential and quality. When comparing hybrid ratings, it is recommended that you 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.

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
G80Q01	80	Good	Good	Good	Good	Best		Good		Good	Good	Good	Good
G84B99	84	Good	Good	Good	Good	Best		Best		Best	Good	Best	Good
G84J92	86	Best	Good	Good	Good	Best	Best	Fair	Good	Fair	Good	Fair	Good
G85Z56	85	Best	Good	Fair	Good	Fair		Best		Best	Best	Best	Best
G88F37	88	Good	Best	Good	Fair	Best		Good		Good	Fair	Good	Fair
G89A09	89	Best	Good	Fair	Good	Fair		Good		Good	Good	Good	Good
G90Y04	92	Best	Best	Fair	Good	Good	Best	Good	Good	Good	Best	Good	Best
G90G13	90	Good	Fair	Fair	Fair	Good	Best	Fair	Fair	Fair	Fair	Fair	Fair
G91V51	91	Best	Good	Good	Good	Good		Good		Best	Best	Best	Best
G92T43	92	Good	Fair	Good	Fair	Best	Good	Fair	Good	Fair	Fair	Fair	Good
G94P48	94	Best	Good	Good	Good	Fair		Best		Good	Good	Good	Good
G95D32	95	Best	Fair	Good	Good	Best	Best	Good	Good	Best	Best	Best	Best
G95M41	95	Fair	Fair	Good	Fair	Best		Fair		Fair	Fair	Fair	Fair
G97N86	97	Best	Best	Good	Fair	Good	Best	Good	Good	Best	Best	Best	Best
G00H12	100	Best	Best	Fair	Fair	Good	Best	Fair	Fair	Fair	Good	Fair	Good
G01P52	101	Good	Good	Best	Good	Good	Fair	Good	Good	Good	Good	Good	Good
G02K39	102	Best	Good	Good	Good	Best	Best	Best	Best	Best	Best	Best	Best
G02W74	102	Fair	Good	Best	Best	Good	Good	Good	Good	Good	Fair	Good	Fair
G03R40	103	Fair	Best	Poor	Fair	Poor	Best	Fair	Fair	Fair	Fair	Fair	Fair
G03C84	103	Good	Good	Good	Good	Best	Best	Good	Good	Fair	Good	Good	Good
G04S19	104	Best	Good	Good	Good	Good	Good	Good	Best	Good	Best	Good	Best
G05T82	105	Best	Fair	Good	Good	Good	Good	Good	Good	Best	Best	Good	Best
G05K08	105	Good	Best	Best	Good	Best	Best	Good	Good	Good	Good	Good	Good
G06Q68	106	Fair	Good	Good	Good	Best	Best	Good	Best	Good	Fair	Good	Fair
G06K93	106	Good	Fair	Good	Good	Best	Best	Best	Good	Best	Good	Best	Good
G07F23	107	Best	Good	Good	Good	Good	Good	Best	Best	Best	Best	Best	Best
G07V88	107	Good	Fair	Good	Good	Best	Good	Good	Best	Best	Best	Best	Good
G07B39	109	Best	Good	Best	Best	Good	Best	Best	Best	Best	Best	Best	Best
G08D29	108	Good	Good	Fair	Good	Good	Best	Good	Good	Good	Fair	Good	Fair
G08M20	108	Good	Best	Best	Good	Best	Best	Fair	Good	Fair	Fair	Fair	Fair
G09A86	109	Best	Best	Good	Fair	Best	Good	Good	Good	Good	Good	Good	Best
G09Y24	109	Good	Good	Good	Best	Good	Good	Best	Best	Best	Good	Best	Good
G09E98	109	Best	Fair	Best	Best	Good	Good	Best	Best	Best	Best	Best	Best
G10L16	110	Fair	Good	Best	Good	Best	Best	Good	Good	Good	Fair	Good	Fair
G10T63	110	Best	Fair	Fair	Fair	Fair	Best	Good	Good	Good	Best	Good	Best
G10K03	110	Fair	Good	Good	Good	Good	Best	Good	Good	Good	Fair	Good	Fair
G10S30	110	Fair	Good	Fair	Good	Good	Best	Good	Good	Good	Fair	Good	Fair
G11B63	111	Best	Good	Good	Good	Good	Fair	Fair	Good	Fair	Best	Fair	Best
G11A33	111	Poor	Good	Best	Best	Best	Best	Good	Best	Good	Fair	Good	Fair
G11F16	111	Fair	Good	Good	Good	Best	Fair	Fair	Good	Good	Fair	Good	Fair
G12U17	112	Good	Good	Best	Best	Best	Fair	Good	Good	Good	Good	Good	Good
G12W66	112	Good	Fair	Good	Fair	Good	Best	Good	Good	Good	Good	Good	Good
G12J11	112	Good	Good	Fair	Fair	Good	Good	Good	Good	Good	Good	Good	Good
G13N18	113	Fair	Good	Good	Good	Good	Fair	Best	Best	Best	Good	Best	Fair
G13Z50	113	Fair	Fair	Good	Good	Good	Fair	Good	Good	Good	Fair	Good	Fair
G13H15	113	Best	Fair	Good	Fair	Good	Fair	Good	Good	Good	Best	Good	Best
G13E90	113	Good	Best	Good	Good	Fair	Good	Good	Good	Good	Good	Good	Good
G13M88	113	Fair	Fair	Best	Good	Best	Good	Good	Fair	Fair	Fair	Good	Fair
G13T41	113	Fair	Good	Good	Good	Good		Good	Good	Good	Fair	Good	Fair
G14R38	114	Good	Fair	Best	Good	Best	Best	Best	Best	Best	Best	Best	Best
G14N11	114	Best	Fair	Best	Good	Best	Good	Good	Good	Good	Best	Good	Best
G14K50	114	Best	Fair	Best	Good	Best	Best	Good	Best	Good	Best	Good	Best
G14H66	114	Good	Good	Good	Good	Fair	Fair	Good	Good	Good	Good	Good	Good
G14V04	114	Good	Good	Good	Fair	Good	Fair	Good	Good	Good	Good	Good	Good
G15L32	115	Best	Good	Good	Good	Best	Good	Good	Good	Good	Good	Good	Good
G16K01	116	Good	Fair	Good	Good	Good	Good	Best	Best	Best	Good	Best	Good
G18D87	118	Best	Best	Good	Best	Good	Good	Best	Best	Best	Best	Best	Best

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.*

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*

WESTERN BEAN CUTWORM

Western bean cutworm (WBC) is native to North America and appears as a severe pest in several areas of the Corn Belt. Traditionally a pest of the western Great Plains, WBC has moved east into much of the Corn Belt.[1] While populations may vary from year to year, this corn pest is a consistent threat in some corn growing regions. Egg masses of up to 200 eggs can be laid in the upper plant leaves and mature quickly over a few days. It is common to find multiple western bean cutworm larvae feeding per ear, because they are not cannibalistic (unlike corn earworm).

Figure 1. WBC egg mass with eggs at different stages before hatching

SCOUTING AND TREATMENT

Infestations of western bean cutworm are often patchy and may occur over a span of several weeks, requiring multiple scouting visits and creating challenging treatment decisions. There are multiple options for scouting which include pheromone traps, using degree days to predict moth emergence, black light traps and actual scouting of corn plants.[2] When scouting corn plants check twenty plants in a minimum of five areas in each field for egg masses. Inspect the upper surface of leaves within upper 1/3 of plant for eggs. Eggs will be grouped into 15 to 50 individual eggs, laid in flat, irregularly shaped masses. Each egg will be about the size of a pin head. Eggs darken as they mature, changing from white with a thin red ring to brown, purple and eventually turning black before hatching. Egg color can help predict egg hatch and proper timing of foliar insecticides. This is important as timing of insecticide treatments can be difficult due to moth flights and egg laying spread over time, resulting in multiple hatch timings. Proper timing of insecticide application is also critical as larvae will quickly migrate to developing kernels within the husks after hatch. After larvae enter the ear, they are protected from insecticides making delayed applications ineffective.

Figure 2. WBC larvae


Figure 3. Ear damage from heavy western bean cutworm populations

PLANT DAMAGE

Upon egg hatch, young larvae feed mainly on pollen within tassels and eventually move down into developing silks. Once pollination is complete, WBC will quickly move inside the ear husk and feed on developing kernels. Holes in husks are often visible from entering and exiting of ears. Larval feeding affects corn yield and reduces grain quality through damaged kernels and resulting mold and mycotoxin development. Kernel quality degradation can negatively affect the price of grain and can be potentially harmful to livestock.

PROTECT YOUR HYBRIDS

Agrisure Viptera® is the only trait available today that effectively controls western bean cutworm. It is the best option on the market to consistently limit western bean cutworm damage and protect grain quality.

By controlling major leaf-, stalk- and ear-feeding corn insects, including western bean cutworm, Agrisure Viptera trait offers better crop stand and lower levels of disease, resulting in increased yield and profit potential.


Figure 4. Agrisure Viptera (left) compared to ears without Agrisure Viptera (center and right) under WBC pressure

MANAGING CORN ROOTWORM

Corn rootworm (CRW) 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 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.

Figure 1. Various levels of corn rootworm feeding

Corn rootworm is a difficult pest to manage and no single product will consistently provide bulletproof protection. There is no silver bullet for corn rootworm, but smart planning and a robust Golden Harvest® portfolio 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.

Growers concerned about CRW should have a multi-year management plan in place for each field that incorporates multiple control strategies, including:

- Crop Rotation – rotating to non-host crops like Golden Harvest soybeans is the most effective option in most areas. In geographies where CRW have adapted their lifecycle (western CRW variant or northern CRW extended diapause) to overcome single year rotation, the benefits of rotation may be reduced. (Figure 2)
- Transgenic traits – use of different CRW traits like Agrisure Duracade® and Agrisure® 3122 trait stacks
- 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

Geographic Distribution of Northern and Western Corn Rootworm and Variants

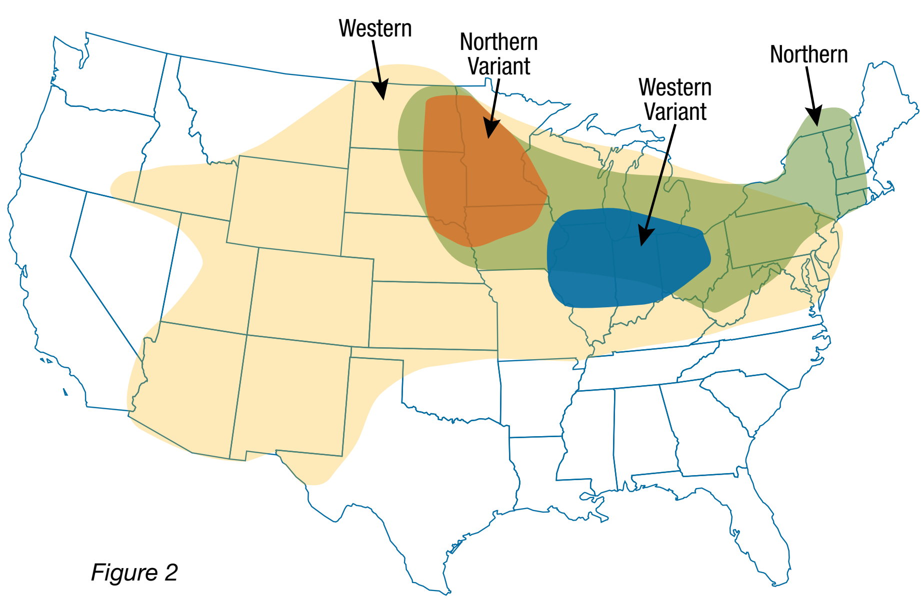


Figure 2

Syngenta is the leader in corn insect control and serves as a valuable partner in the development of insect control strategies that integrate multiple control technologies. By sitting down with their Golden Harvest Seed Advisors, growers can collaboratively design a plan for this year and beyond. Projecting the CRW pressure in each field will be used to develop a multi-year field-by-field corn rootworm management plan. That plan 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.

Agrisure Duracade offers a new tool against CRW larvae. The Agrisure Duracade 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 (Figure 3). Utilizing corn trait stacks like Agrisure Duracade 5222 is like having multiple players working together to protect the field from 16 above- and below-ground insects.

Long-term corn rootworm management again will require a multi-year, field-by-field approach that utilizes various control methods. There's an important balance between CRW control, yield protection and resistance management. It's not one-size-fits all: effective CRW management will require the integration of multiple control measures, 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)

MANAGING LOW PRESSURE CORN ROOTWORM

Under low pressure, consider if you have experienced low larval feeding damage, low adult beetle population and no rootworm-caused corn lodging issues in the prior year.

- If so and you plan to plant continuous corn: consider using a single CRW trait, multiple CRW traits, or a non-CRW traited hybrid with Force soil insecticide.
- If so and you plan to plant first-year corn in areas with western CRW variant or northern CRW extended diapause, consider using a single CRW trait, multiple CRW traits, or a non-CRW traited hybrid with Force soil insecticide.
- If so and you plan to plant first-year corn in areas without western CRW variant or northern CRW extended diapause, consider using a non-CRW traited hybrid with the added yield protection of Force soil insecticide if secondary pest pressure is likely.

MANAGING HEAVY PRESSURE CORN ROOTWORM

1. ***Rotation:*** Under heavy pressure, rotate to a non-host crop if possible, such as soybeans, which provides the best opportunity to break the reproductive cycle of CRW.
2. ***Rotation alternatives:*** If crop rotation is not an option, consider whether you have used CRW trait(s) and experienced unexpected damage, excessive root feeding or lodged corn not explained by environmental factors:
   a. No history of problems using traits: Use multiple CRW traits or scout and consider beetle control with a foliar insecticide.
      - Agrisure trait stacks with the Agrisure Duracade trait offer excellent CRW control and are available with a simple, in-bag E-Z Refuge seed blend for convenience.

- Warrior II with Zeon Technology insecticide minimizes egg laying from adult CRW females and facilities proper pollination by preventing silk clipping.

b. Prior year(s) damage with CRW trait: Rotate CRW traits, use multiple CRW traits plus a soil-applied insecticide, or scout and consider beetle control with a foliar insecticide.
   - Force soil insecticide drives yield when used in combination with hybrids that contain single or multiple CRW trait combinations.
   - Secondary insects or other agronomic reasons may influence the decision to use a soil insecticide.

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

The Agrisure traits portfolio offers the broadest above- and below-ground insect control in the industry.

- Agrisure trait stacks with two CRW modes of action include: Agrisure Duracade 5222 E-Z Refuge®, Agrisure Duracade 5122 E-Z Refuge, and Agrisure 3122 E-Z Refuge.
- Agrisure Duracade 5222 E-Z Refuge combines the Agrisure Duracade CRW control trait and the Agrisure Viptera insect control trait, to create the most advanced trait stack on the market.

EXAMPLE OF A MULTI-YEAR CORN ROOTWORM MANAGEMENT PLAN

Year 1: Consider rotating to a non-host crop, such as soybeans.

Year 2: Bring back corn and use an above-ground trait stack, such as Agrisure Viptera 3220 E-Z Refuge. If the field is in an area under pressure from Western corn rootworm variant or Northern corn rootworm extended diapause, use an above-ground stack with a soil-applied insecticide, such as Force. Scout for beetles to provide an indication of rootworm pressure in the following year. Any year with corn planted, if beetle pressure is heavy, treat for adult CRW beetles. If beetle pressures indicate the potential for high pressure, consider crop rotation or carefully plan corn rootworm control methods.

Year 3: Plant Agrisure Duracade trait stack. The Agrisure Duracade trait is available in the Agrisure Duracade 5222 E-Z Refuge and Agrisure Duracade 5122 E-Z Refuge trait stacks, offering growers industry leading corn rootworm control, and producing noticeably healthier plants with stronger roots and thicker stalks.

Year 4: Consider repeating with Agrisure Duracade. This is an option if the previous year's adult CRW beetle count was below threshold. However, if the adult CRW beetle population is high, consider rotating to a non-host crop or rotating to a different dual mode of action trait stack, such as Agrisure 3122 E-Z Refuge. Another option is to rotate to a different dual mode-of-action trait stack and add a soil-applied insecticide.

Year 5: Based on previous year CRW pressure, a grower could plant an Agrisure Duracade or Agrisure 3122 stack again, provided the annual CRW beetle count is below threshold. If CRW pressure remains high, consider returning to crop rotation. Avoid using the same CRW control method in a field for more than 3 years in a row and return to crop rotation when possible.

TAR SPOT OF MIDWESTERN CORN

Tar spot of corn is a relatively new disease to the U.S. It was first reported in northwest Indiana and north-central Illinois in 2015 by plant pathologists at Purdue University. Since 2015, this disease has spread and can now be found in several states (Figure 1). Prior to 2015, tar spot only occurred in Mexico, Central America and northern parts of South America in cooler high elevation environments.

Figure 1. Counties confirmed with Tar Spot incidence in 2019 (Corn ipmPIPE 10/21/19)

FUNGAL PATHOGEN RESPONSIBLE

Tar spot observed in the United States is caused by a fungus referred to as *Phyllachora maydis*.[1] In Latin America where P. maydis was first observed, it has been known to form a complex with a secondary fungal pathogen, Monographella maydis. The combination of the two fungus are referred to as tar spot complex and known to cause more severe yield loss when both pathogens are present.[2] In Latin America where M. maydis has been observed, it appears as a secondary "fisheye" shaped lesion surrounding the original P. Maydis tar spot. Although similar lesions surrounding the tar spot lesion have been observed in the U.S., to date M. Maydis has not been formally identified.[1]

IDENTIFICATION

- Tar spot can be identified by raised black, circular fugal structures (Figure 2 stromata) which appear as specks of tar splattered onto the leaf surface.
- Lesions have a bumpy feel that is not easily rubbed off.
- Spots can also be surrounded by a small, tan halo giving a "fish-eye" appearance.
- The disease begins on the lower corn leaves and moves to the upper plant and ear husks.
- Tar spot is found on both healthy and dead plant tissue on upper and lower surface of leaves.
- It can be confused with common and southern rust late in season as they switch from producing orange-red spores (urediniospores) to black spores (teliospores), but rust pustules differ in that they may easily be scraped from the leaf.
- Tar spot may also be confused with saprophytic organisms that break down dead plant tissue late in season, however they will not exhibit a bumpy texture.

Figure 2. Phyllachora maydis, the fungus causing tar spot with and without lesions forming around stromata.

- Laboratory diagnosis may be required to correctly diagnose the disease.

DEVELOPMENT

Much about how this fungal pathogen behaves in the U.S. is still unknown, although it has been well studied in Latin America. Tar spot can move limited ranges by wind and plant residue. It appears to be capable of overwintering in soil and residue due to its reoccurrence in years following its first introduction. This disease thrives in cool (60-70 F) and humid conditions with prolonged periods of wet leaves. Visual symptoms of tar spot generally start on the lower leaves and rapidly move up the plant. Infection can occur at any crop stage, although it is most commonly observed throughout the grain fill period.

MANAGEMENT PRACTICES

- ***Hybrid Selection:*** Hybrids differ in susceptibility to tar spot infection. Opportunistic field evaluations were collected at multiple fields in 2018 and 2019. Hybrid differences observed in Table 1 can be used in hybrid placement decisions for fields with known history of tar spot.
- ***Crop Rotation and Tillage:*** Rotating to crops other than corn and utilizing tillage to bury residue could help reduce fungus inoculum levels in fields. Due to newness of tar spot, much is still unknown of the magnitude of the reduction that comes from increased residue management practices.
- ***Fungicide Application:*** Early fungicide applications at or before first signs of development have been effective against tar spot in previous trials[3]. Early fungicide programs applied prior to the onset of disease can be effective, however late season curative applications of fungicides are not recommended.
- If conditions are favorable for tar spot development early in the season, an application at V4-V8 corn growth stage and/or the VT/R1 growth stage with a registered product could reduce infection within fields previously confirmed with tar spot in prior years.
- Fully registered Syngenta fungicide options include Trivapro® along with EPA Section 2 (ee) special labels for use of Miravis® Neo and Quilt Xcel® to manage tar spot.
- It is important to consider all potential disease issues you could be facing when making fungicide decisions for your corn crop. Other diseases like gray leaf spot, Northern corn leaf blight, Northern corn leaf spot and rust may also be present, further improving chances of economic response.

RM	GOLDEN HARVEST HYBRID SERIES	TARSPOT (1-9)	RM	GOLDEN HARVEST HYBRID SERIES	TARSPOT (1-9)
86	G84J92	2	106	G06Z97	5
89	G89A09	2	107	G07F23	4
90	G90Y04	3	108	G08D29	4
91	G91V51	2	108	G08M20	7
94	G94P48	1	109	G09A86	4
95	G95D32	3	109	G09Y24	4
95	G95M41	5	110	G10D21	3
96	G96R61	2	110	G10L16	4
96	G96V99	3	110	G10T63	4
97	G97N86	3	111	G11A33	3
98	G98L17	3	111	G11V76	4
98	G98B71	4	111	G11F16	5
99	G99E68	5	112	G12S75	2
100	G00H12	2	112	G12J11	3
101	G01P52	3	112	G12W66	4
102	G02W74	3	113	G13M88	4
102	G02K39	4	113	G1350	5
103	G03R40	3	114	G14N11	3
103	G03C84	3	114	G14R38	3
104	C04S19	4	115	G15J91	2
105	G05T82	3	115	G15L32	7
105	G05B91	4	116	G16K01	3
106	G06Q68	5	118	G18D87	3

Table 1. Golden Harvest hybrid tar spot 1-9 rating 1= best 9= worst

PHYSODERMA BROWN SPOT AND STALK ROT IN CORN

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 73-86° 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.
- 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.

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

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

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

- 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, making the plant more susceptible to pathogens such as PSR, allowing stalk rot diseases to thrive.
- Over time, stalk strength weakens, increasing 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 if you have fields with known history of the disease.
- Crop rotation and tillage may help reduce disease developmentand pressure.
- A fungicide application at R1 such as Trivapro® may reduce disease severity and improve overall plant health.

CORN HYBRID RESPONSE TO FOLIAR FUNGICIDES

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 with an R1 foliar fungicide response with low disease presence are provided as a decision making tool for high and low disease risk fields.

ESTIMATING RESPONSE WITH LOW DISEASE PRESENCE

Over 187 trials, where Quilt Xcel® fungicide at 10.5 fl oz/A (Pre 2016) or Trivapro® fungicide at 13.7 fl.oz/A (2016-2019 testing) were applied at the R1 growth stage (Figure 3), were used to evaluate consistency of response in low disease presence fields. Yield response varied greatly across 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, and Poor

Response to R1 Fungicide Averaged Across Hybrids Within Location
29 Site Years, 2019

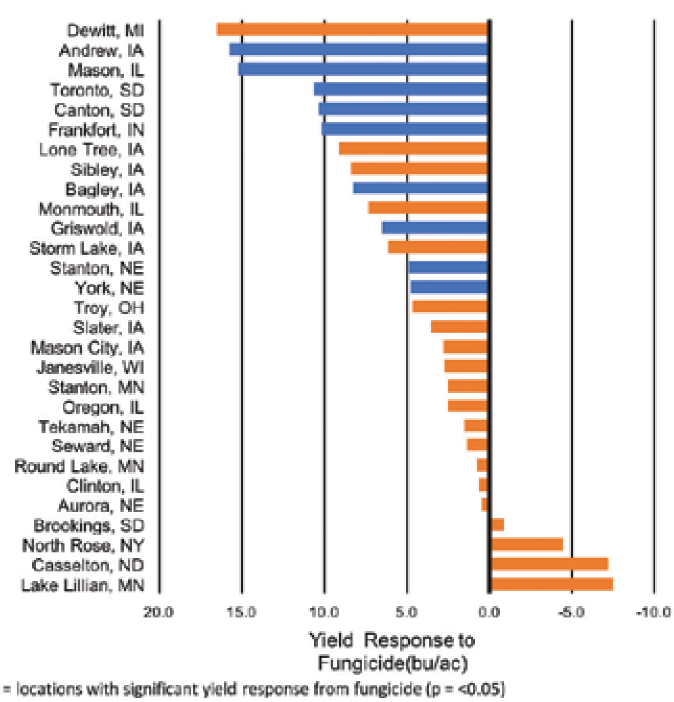


Figure 2. Differences in fungicide response across 2019 trialing locations

Figure 1. Fungicide being applied at R1, rows being driven across are borders and not harvested for yield.

PREDICTING DISEASE RISK FOR EACH FIELD

Predicting disease development is challenging, however timely fungicide applications prior to disease establishment almost always pays off. If disease risk is high, it is important to plant hybrids with good disease tolerance to the specific disease risk of the field. Beyond hybrid selection, consider the following factors which put fields at more risk for 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.

In a separate Golden Harvest Agronomy In Action trial, 2,000 stalks were evaluated for stalk strength by comparing an untreated check and a Quilt Xcel application (Figure 3). Stalks that either completely or partially collapsed when pinched at the first internode above the brace roots were classified as "weak," indicating potential for future standability issues.

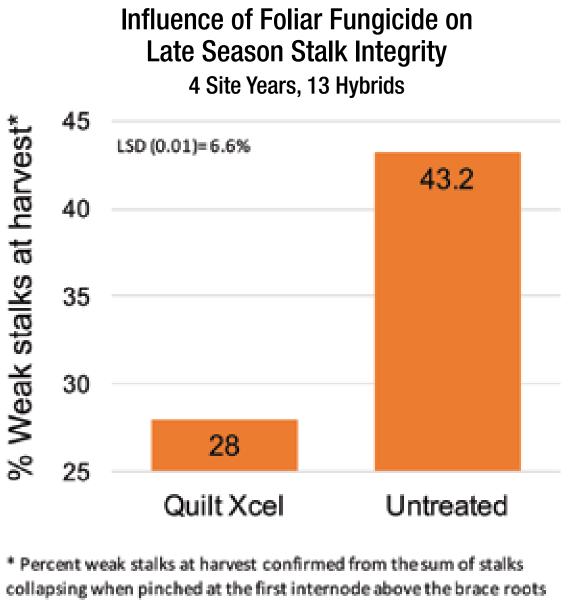


Figure 3.Improved stalk quality due to fungicide application

The graph indicates that utilizing Quilt Xcel can:

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

An additional benefit observed with Trivapro 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.

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 RISK

- 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 RISK

- 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 Risk Fungicide Response	High Disease Risk			
			GLS	NCLB	SCLB	ES
G80Q01	80	Best	-	4	-	3
G84B99	84	Good	-	4	-	3
G85Z56	85	Good	-	3	-	4
G84J92	86	Good	-	3	-	3
G88F37	88	Best	-	3	-	3
G89A09	89	Fair	-	4	-	3
G90G13	90	Good	-	4	-	5
G91V51	91	Good	-	3	-	3
G92T43	92	Best	5	3	-	3
G90Y04	92	Fair	-	3	-	-
G94P48	94	Good	-	3	-	3
G95M41	95	Good	-	4	-	3
G95D32	95	Good	4	5	-	2
G96R61	96	Good	-	2	-	3
G97N86	97	Good	4	4	-	-
G99E68	99	Good	2	2	-	3
G00H12	100	Fair	3	5	-	3
G01P52	101	Best	4	5	-	3
G02W74	102	Good	3	2	-	4
G02K39	102	Good	3	4	-	3
G03C84	103	Best	4	3	3	3
G03R40	103	Best	4	5	5	3
G04S19	104	Good	4	4	4	2
G04G36	104	Good	3	3	3	4
G05K08	105	Good	4	3	4	2
G05T82	105	Good	4	5	4	4
G06K93	106	Fair	5	4	3	4
G06Q68	106	Fair	5	2	3	5
G07V88	107	Fair	5	3	3	5
G07F23	107	Fair	3	2	5	2
G08R52	108	Good	5	3	5	-
G08M20	108	Good	3	3	4	4

Golden Harvest Hybrid Series	RM	Low Disease Risk Fungicide Response	High Disease Risk			
			GLS	NCLB	SCLB	ES
G08D29	108	Best	4	2	6	4
G09E98	109	Fair	3	3	4	6
G07B39	109	Best	5	4	5	3
G09Y24	109	Good	5	2	4	3
G09A86	109	Fair	2	5	4	5
G10S30	110	Best	6	2	4	2
G10K03	110	Best	5	3	5	-
G10T63	110	Good	3	4	3	5
G10D21	110	Fair	2	2	-	-
G10L16	110	Good	4	6	4	3
G11F16	111	Fair	4	3	4	2
G11A33	111	Good	3	3	4	2
G11V76	111	Good	4	3	6	-
G11B63	111	Fair	4	4	5	-
G12J11	112	Good	3	4	3	4
G12W66	112	Good	4	4	4	4
G12S75	112	Fair	3	3	6	-
G12U17	112	Best	4	3	5	-
G13M88	113	Fair	3	3	3	5
G13E90	113	Best	6	3	3	-
G13T41	113	Good	4	2	3	2
G13H15	113	Fair	3	4	5	-
G13Z50	113	Good	4	3	4	4
G13N18	113	Best	6	4	2	6
G14V04	114	Good	5	3	4	4
G14H66	114	Good	3	2	5	4
G14K50	114	Best	6	3	3	5
G14N11	114	Best	5	5	4	3
G14R38	114	Fair	5	4	4	3
G15J91	115	Best	4	2	3	-
G15L32	115	Best	3	4	3	3
G16K01	116	Fair	5	4	3	5
G18D87	118	Fair	3	3	3	5

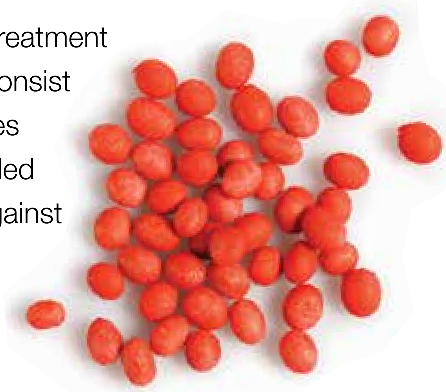
Hybrid Response Ratings: Best Good Fair Poor

Disease Resistance Rating Scale: 1-2 - Highly Resistant; 3-4 = Resistant; 5-6 Moderately Resistant; 7-8 = Moderately Susceptible; 9 = Susceptible; – = No data available; ES = Eyespot; NCLB = Northern Leaf Blight; SCLB = Southern Leaf Blight; GLS = Gray Leaf Spot

SOYBEAN SEED TREATMENT, WHAT'S ON YOUR SEED?

Many growers have witnessed the value and return on investment of a seed treatment on soybeans, especially when protecting seed to optimize yield with early planting dates. Research has shown that seed treatment can help reduce seeding rates and reduce seed costs. The problem we face today, is that the color of the seed doesn't mean it's fully protected. With tight operating margins, you have to understand what you're purchasing and if it was applied properly. This requires knowing what active ingredients, additives, and rates were used. Otherwise you 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 soil-borne pathogens. Some of these active ingredients also give flexibility to manage seed-borne disease, such as *Phomopsis* sp, that might not even be present in your 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 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 soil-borne pathogens to enter roots, reducing the risk of diseases such as *Fusarium virguliforme*, commonly known as sudden death syndrome. 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 a 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 your 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 additional 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 you may have seen value in previous years. Multi-year analysis at the University of

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

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]

Golden Harvest Preferred Seed Treatment *Untreated*

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 your beans, be sure to consult your seed supplier. When planting early, or late, foregoing a seed treatment increases your 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

FACTORS INFLUENCING SOYBEAN PLANTING DATE RESPONSE

INSIGHTS

- Mid-May or earlier planting dates will usually maximize yield potential.
- Yield reductions of ½ percentage point per day may occur each day planting is delayed after mid-May.
- Planting fullest relative maturity (RM) possible for geography will enhance yield potential.
- Seeding rates resulting in final stands greater than 100,000 will maximize yield potential and/or prospective economic return.

BACKGROUND

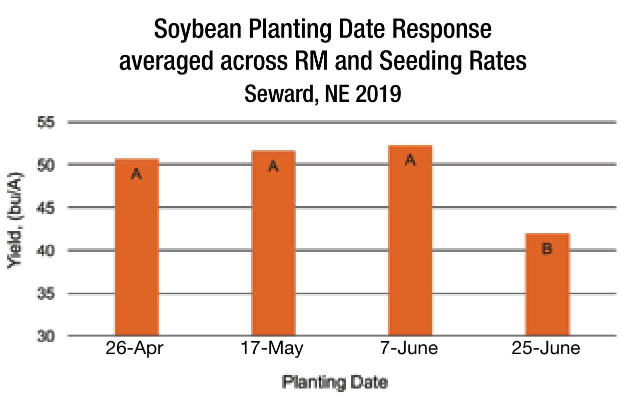
Earlier planting may help maximize soybean's photoperiod as well as help avoid excessive heat and moisture stress during critical flowering stages. This is done by utilizing early season precipitation and temperatures.[1] Though planting too early can also result in poor stands or delayed emergence from cool, wet soils or higher than average bean leaf beetle pressure.[2] Significant delays in planting of soybeans often results in reduced yields. Optimizing the soybean growth between vegetative and reproductive stages may result in better yield potential. Balancing the time spent accumulating nodes during vegetative growth and length of time in reproductive stages to fill pods is crucial to ensuring high yield.[3] Planting fuller season varieties adapted for your region is typically one of the best ways to maximize yields and returns.[4] Trials were conducted in 2019 to demonstrate how planting date, RM and seeding rate interact with each other.

2019 PLANTING DATE TRIALS

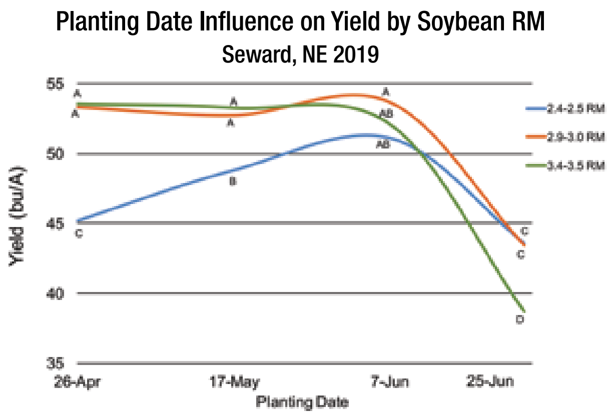
Studies were conducted at Seward, NE, Slater, IA, and Clinton, IL in 2019. Due to excessive precipitation and soil crusting, targeted planting dates and seeding rates were not achieved at Slater, IA and Clinton, IL locations. Results from these locations were excluded for this reason. Four planting dates were established at Seward on April 26th, May 17th, June 7th and June 25th. Two varieties were selected within 3 sets of RMs to represent early (2.4-2.5), mid (2.9-3.0) and full (3.4-3.5) season varieties normally adapted for the area. Each of the 6 varieties were planted at 100,000, 140,000, and 180,000 seeds per acre. These studies were then combined with historic seeding rate and planting date datasets to look at broader trends across multiple growing conditions.

RM SELECTION WITH DELAYED PLANTING

Results illustrate three important concepts: timely planting of the right maturity at the right rate. While interactions between seeding date, seeding rate and maturity were present, generally, yields were not reduced with delayed planting at Seward, NE until late June (Graph 1). Previous planting date trials have shown yield decreases from delayed planting to occur much earlier.



Graph 1. Planting date main effect at Seward, NE



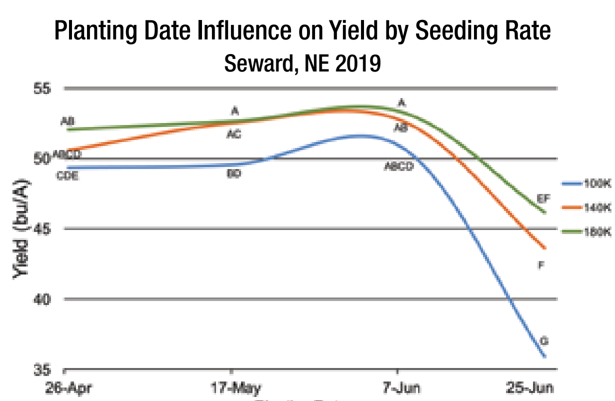
Graph 2. Yield comparison of planting date for three relative maturity groups at Seward, NE

Mid and full season varieties (2.9-3.5) performed better than early season varieties except for June planting dates (Graph 2). Early RM varieties (2.4-2.5 RM) were more competitive with full and mid RM varieties at the June 7th planting date, although this date still did not warrant adjusting to an earlier RM. Planting delayed into late June was the only time when full season varieties did not perform as well as early or mid RMs. This is largely due to an early killing frost that impacted all RMs, however fuller season varieties were impacted more. Figure 1 shows differences in maturation of three planting dates on September 13, 2019. Maturation differences due to soybean RM can also be observed within each planting date. Even with an early frost, there were no yield benefits to switching from a 2.9 to a 2.4 RM variety in June.

Figure 1. Maturation differences from planting date and RM on September 13. From left to right planting dates are April 26, May 17 and June 7.

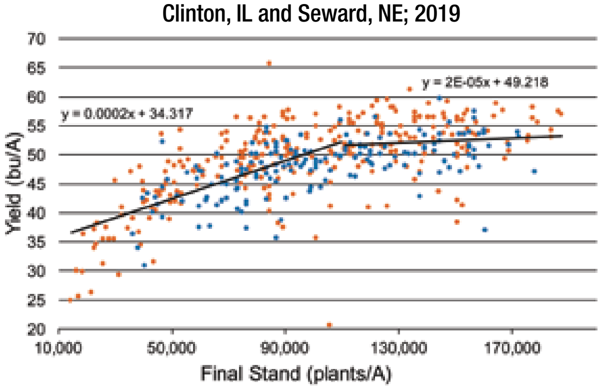
PLANTING DATE INFLUENCE ON SEEDING RATE

Relative maturity of soybeans had no bearing on determining the best seeding rate in our trials. There was little to no difference in yields when comparing 140,000 and 180,000 seeds/A seeding rates across all planting dates (Graph 3). Although not statistically different, increasing seeding rates to 180,000 in late June showed more benefit over 140,000 than at earlier planting dates. This agrees with previous planting date trials showing similar responses due to a shortened flowering and pod-fill period from delayed planting. Soybeans are less able to increase the number of seeds per plant due to reduced stands at late planting dates, which makes increasing seeding rates more important in these situations. Seeding rates of 100,000 seeds/A always yielded less than higher seeding rates, however differences were even greater with June 26th planting dates. Greater yield differences between seeding rates at the June 25th planting date is largely due to poor stand establishment as the result of 2019 weather. Final stand establishment ranged from 71-90% of seeding rates across the first three planting dates, with more severe stand losses in the final planting date due to soil crusting. Final stands with June 25th



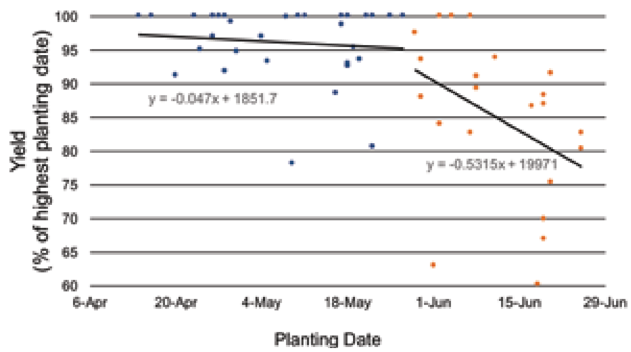
Graph 3. Yield comparison of planting date for three seeding rates at Seward, NE

planting for the 100,000 seeding rate ranged from 70-80,000 plants per acre, whereas the 140,000 seeding rate still established 114,000 plants per acre. Final stand establishment is more important than actual seeding rates in assessing yields. When looking at 2019 trials, final stands greater than 100,000 plants per acre yielded similarly (Graph 4). As stand establishment decreased to less than 100,000 plants/A, there was a 2 bu/A loss for every 10,000 fewer plants established. It is important to note that the 2019 growing season had many challenges. Wet, cool conditions prevailed during optimal planting dates, leading to poor stand establishment. Environmental conditions biased the data towards favoring an early June planting date instead of a mid-May date as historic data suggests.



Graph 4. Effect of harvest population on soybean yield

Results from historic planting date research show that yields are most likely to reach their maximum if planted by mid to late May (Graph 5). If planting is delayed after this



Graph 5. Multi-year planting date influence on soybean yield

cutoff, yield losses average 0.5% per day. Planting by mid-May will usually maximize light exposure for full-season soybeans, whereas delaying will put full-season beans at risk of frost damage.

This study shows the importance of planting date and seeding rate on soybean management. It also illustrates the challenging environmental conditions of 2019. Even so, data from this season still suggest planting prior to late-May will maximize yield potential. Seeding rates from 2019 suggest seeding at 140,000 seeds/A will likely yield as well as higher seeding rates. Seeding at 100,000 seeds/A is not recommended due to uncertainty of achieving good stand establishment, resulting in yield losses.

Delays in corn planting are likely to cause greater economic losses than delayed soybean planting. Therefore, it is recommended to ensure timely planting of corn before switching to soybeans.

SOYBEAN TOLERANCE TO HERBICIDES

SULFENTRAZONE HERBICIDE INJURY

Crop response to sulfentrazone, and most other PPO herbicides (flumioxazin, saflufenacil, etc.), often occurs when the herbicide is splashed on the 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]

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

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.

RESPONSE TO SULFENTRAZONE AND METRIBUZIN HERBICIDES

Numerous university studies have documented differing level 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 ratings categorized into three groups:

- **Best** – None, to slight visual herbicide injury risk
- **Average** – Slight to moderate visual herbicide injury risk
- **Poor** – Moderate to high visual herbicide injury risk

Figure 2. Soybean crop response to metribuzin

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 potential.

Golden Harvest Variety	Trait Stack	Relative Maturity	Herbicide Tolerance		Golden Harvest Variety	Trait Stack	Relative Maturity	Herbicide Tolerance	
			Sulfentrazone	Metribuzin				Sulfentrazone	Metribuzin
GH00629X	RR2X	0.06	Best	Best	GH2818E3	E3	2.8	Average	Best
GH00833E3	E3	0.08	Best	Average	GH2808X	RR2X	2.8	Average	Best
GH00866	GENRR2Y	0.08	Best	Average	GH2981X	RR2X	2.9	Average	Best
GH00934E3	E3	0.09	Average	Average	GH3042E3	E3	3.0	Best	Best
GH0145X	RR2X	0.1	Best	Best	GH3027LG	LL GT27	3.0	Best	Average
GH0294E3	E3	0.2	Average	Best	GH3088X	RR2X	3.0	Best	Best
GH0227LG	LL GT27	0.2	Best	Best	GH3152E3S	E3/STS	3.1	Best	NR
GH0325E3	E3	0.3	Average	Best	GH3195X	RR2X	3.1	Average	Average
GH0391	GENRR2Y	0.3	Best	Average	GH3227LG	LL GT27	3.2	Best	Average
GH0308X	RR2X	0.3	Best	Best	GH3347X	RR2X	3.3	Best	Best
GH0443X	RR2X	0.4	Best	Average	GH3319E3	E3	3.3	Best	Average
GH0593E3	E3	0.5	Average	Average	GH3324X	RR2X	3.3	Average	Average
GH0543X	RR2X	0.5	Best	Best	GH3427LG	LL GT27	3.4	Best	Best
GH0674X	RR2X	0.6	Best	Best	GH3475X	RR2X	3.4	Best	Average
GH0627LG	LL GT27	0.6	Best	Average	GH3582E3	E3	3.5	Best	Best
GH0670L	LL	0.6	NR	Average	GH3546X	RR2X	3.5	Best	Best
GH0715E3	E3	0.7	Best	Best	GH3527LG	LL GT27	3.5	Best	Average
GH0749X	RR2X	0.7	Best	Best	GH3624E3	E3	3.6	Average	Best
GH0944E3	E3	0.9	Best	Best	GH3759E3S	E3/STS	3.7	Best	Best
GH0936X	RR2X	0.9	Best	Best	GH3727LG	LL GT27	3.7	Best	Average
GH0927LG	LL GT27	0.9	Best	Average	GH3728X	RR2X	3.7	Average	Best
GH1024X	RR2X	1.0	Best	Best	GH3827LG	LL GT27	3.8	Average	Average
GH1184E3	E3	1.1	Best	NR	GH3922E3	E3	3.9	Average	Average
GH1225X	RR2X	1.2	Best	Best	GH3934X	RR2X	3.9	Average	Best
GH1362E3	E3	1.3	Best	Best	GH3927LG	LL GT27	3.9	Best	Best
GH1327LG	LL GT27	1.3	Best	Best	GH3982X	RR2X	3.9	Best	Average
GH1317X	RR2X	1.3	Average	Average	GH4155E3	E3	4.1	Average	Average
GH1486X	RR2X	1.4	Best	Average	GH4240XS	RR2X/STS	4.2	Average	Best
GH1414X	RR2X	1.4	Best	Best	GH4227LGS	LL GT27/STS	4.2	Average	Average
GH1541E3	E3	1.5	Best	Best	GH4314E3	E3	4.3	Average	Average
GH1538X	RR2X	1.5	Best	Best	GH4307X	RR2X	4.3	Average	Average
GH1638X	RR2X	1.6	Best	Best	GH4438E3	E3	4.4	Average	Best
GH1627LG	LL GT27	1.6	Best	Best	GH4589X	RR2X	4.5	Average	Best
GH1619X	RR2X	1.6	Average	Best	GH4527LGS	LL GT27/STS	4.5	Average	Average
GH1763E3	E3	1.7	Best	Best	GH4531XS	RR2X/STS	4.5	Average	Average
GH1852X	RR2X	1.8	Best	Best	GH4612E3S	E3/STS	4.6	Average	Best
GH1827LG	LL GT27	1.8	Best	Average	GH4628X	RR2X	4.6	Poor	Best
GH1915X	RR2X	1.9	Best	Average	GH4768E3	E3	4.7	Average	Average
GH2011E3	E3	2.0	Average	Best	GH4863L	LL	4.7	NR	Average
GH2041X	RR2X	2.0	Best	Best	GH4727LG	LL GT27	4.7	Average	Average
GH2230X	RR2X	2.2	Best	Best	GH4741X	RR2X	4.7	Poor	Best
GH2420E3	E3	2.4	Best	Best	GH4877E3S	E3/STS	4.8	Best	Best
GH2427LG	LL GT27	2.4	Best	Best	GH4823XS	RR2X/STS	4.8	Average	Average
GH2537X	RR2X	2.5	Best	Average	GH4955E3	E3	4.9	Poor	Best
GH2552X	RR2X	2.5	Best	Best	GH4908LS	LL/STS	4.9	NR	Average
GH2610E3	E3	2.6	Average	Best	GH4917XS	RR2X/STS	4.9	Average	Average
GH2727LG	LL GT27	2.7	Average	Average	GH5175XS	RR2X/STS	5.1	Average	Average
GH2788X	RR2X	2.7	Average	Average	GH5270X	RR2X	5.2	Average	Best

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

SOYBEAN YIELD RESPONSE TO MANAGEMENT STRATEGIES

INSIGHTS

- Seeding rates greater than 140,000 seeds per acre does not increase potential yield enough to warrant incremental seed cost.
- Fungicide response is similar across all seeding rates.

INTRODUCTION

With volatile grain markets, farmers are continually looking for information and practices to economically increase potential grain yield in addition to minimizing on-farm inputs. Besides environment (which has numerous uncontrollable factors) yield is derived by properly selecting and placing the right genetics and implementing the appropriate management tactics.

Ensuring input decisions will have a positive economic return can be difficult and brings an uncertainty to in-season management choices. Optimum product placement can be achieved through a conversation with your local Golden Harvest® Seed Advisor and utilizing the proprietary product placement algorithm within E-Luminate® seed placement tool. Management decisions rely on knowledge of the field, local climate conditions, active crop scouting and understanding the potential influence applied treatments may have on yield and crop development.

Studies are abundant showing the positive benefits to the application of fungicide on soybean grain yield. Within these studies the positive response is attributed to two primary rationale; improved disease control and its interaction with physiological plant processes.

The following study examined the response and interaction of fungicide in relation to soybean variety and plant population. This work was conducted to provide improved recommendations to farmers related to fungicide applications in soybeans and any potential interaction with variety selection and seeding rate.

YIELD MANAGEMENT

Numerous management practices can be employed to benefit soybean yields. Some of these include earlier planting dates with late maturing soybeans to maximize vegetative development and length of growing season. In addition, properly managing soil pH and fertility, a multi-layered herbicide program and

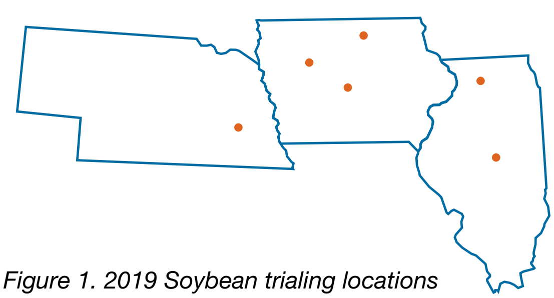
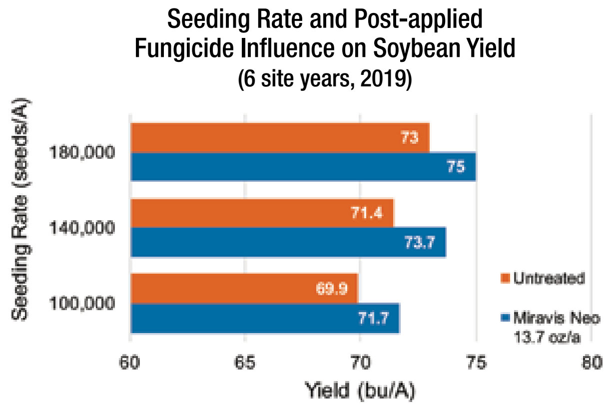


Figure 1. 2019 Soybean trialing locations

proper integrated pest management strategies are extremely important. It should be emphasized that earlier planting dates tend to be most effective if a later maturing soybean is selected to capitalize on length of growing season. Minimizing the stress placed on a soybean crop is critical in helping to maximize yield and potential return on investment (ROI). Stress during the soybean reproductive stages can result in increased abortion of flowers and pods, lower seed count, and/or lower seed weight. Soybean plants will naturally abort flowers and pods to manage environmental stress during seed development. Keep in mind over half of all soybean flowers produced abort and never contribute to yield.[1] Reducing the impact of environmental stressors can help reduce
pod abortion.

2019 SOYBEAN SEEDING RATE AND FUNGICIDE TRIALS

Golden Harvest Agronomy In Action Research conducted trials across Illinois, Iowa, and Nebraska in 2019 to understand the effects of seeding rate and foliar fungicide application on soybeans (Figure 1). Six Golden Harvest soybean varieties were replicated in blocks that would later either receive a fungicide application or remain untreated. Within each block three seeding rates (100,000, 140,000 and 180,000 seeds per acre (seeds/A) were established. Miravis® Neo fungicide was applied at 13.7 oz/A at the R3 (beginning pod) growth stage to designated blocks. Disease ratings were taken 21 days after treatment. Stand counts were taken every two weeks after emergence to monitor in-season stand loss throughout the season. Grain yield and moisture were collected at harvest.



Graph 1. Seeding rate and foliar fungicide influence on soybean yield

SEEDING RATE AND FUNGICIDE INFLUENCE ON YIELD

Fungicide response varied across locations from 0.1- 4.2 bu/A averaging 2.4 bushels per acre (bu/A) across all locations, regardless of variety or seeding rate (Graph 1). Sac City, IA, the only location with measurable disease presence, resulted in a 4.2 bu/A yield increase from fungicide application. To better understand changes in soybean yield, multiple yield determining factors were looked at on a per plant basis to see how soybean plants adjust. A single variety was selected at each location and yield component counts were taken from all three seeding rates. Per plant counts of branching, nodes, seeds, seeds per pound, and pods were collected across all seeding rates both with and without fungicide (Table 1 and 2). The yield increase observed from Miravis Neo

YIELD COMPONENTS ADJUSTMENT FROM FUNGICIDE
(Averaged across 6 locations, 2019)

TREATMENT	BRANCHES/ PLANT	NODES/ PLANT	PODS/ PLANT	SEEDS/ PLANT	SEEDS/ LB
Miravis Neo (13.7 oz/a)	2.3	15.4	40.5	104.4	2,349
Untreated	2.4	15.3	37.4	97.9	2,419
Difference	-0.1	0.1	3.1	6.5	70

Table 1. Influence of fungicide on yield components

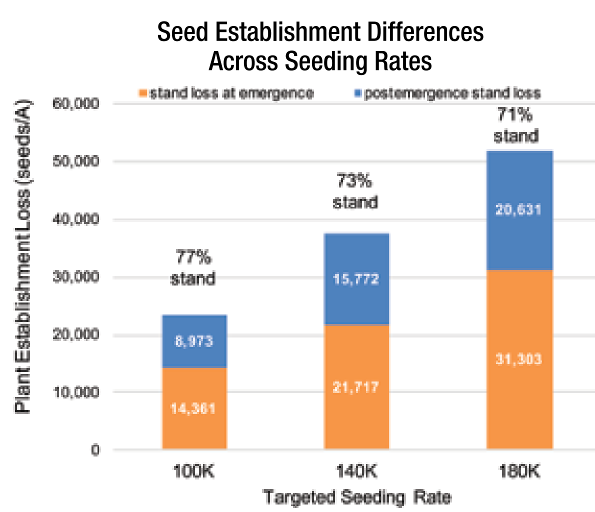
was also seen within individual yield components as both a slight increase in seeds per plant (6.6%) and seed size (2.8% fewer seeds per pound). The increase in seeds per plant was likely a result of producing 8.3% more pods/plant compared to the untreated check (Table 1). The combination of small physiological plant adjustments such as pods per plant and seed size can result in a significant yield increase. Individual yield component analysis supports previous claims that improved plant health can reduce plant stress and minimize seed abortion to improve yield potential.[2] Other yield parameters, such as branching and nodes per plant, were not influenced by fungicide as both were determined by the plant earlier in the growing season prior to fungicide applications. Although, other management practices, such as seeding rate, can have an influence on both branching and nodes per plant.[2] As seeding rates decreased, soybean plants compensated by increasing their total number of seeds per plant using multiple methods such as increased branching, nodes and pods per plant (Table 2). Similar effects have been observed when narrowing row spacing to less than 30-inches. Additionally, canopy closure is critical to ensuring soybean grain yield is maximized.[3] Row closure as early as possible allows soybean plants to harvest more sunlight to help maximize energy production for yield allocation and aid in late season weed control.

SEEDING RATE	BRANCH/ PLANT	NODES/ PLANT	PODS/ PLANT	SEEDS/ PLANT
100,000	2.9	16.5	49.0	123.2
140,000	2.3	15.4	37.3	99.1
180,000	1.8	14.7	30.3	80.5

Table 2. Soybean yield component difference resulting from adjusting soybean seeding rates

THE IMPACT OF STAND LOSS

Soybean stand establishment ranged from 82-85% emergence across seeding rates. Minor early season stand losses occurred across all seeding rates, although several established plants began to die closer to the R2-R3 growth stages. Final stands remaining at harvest ranged from 71-77% of seeding rate, roughly 10% less than at emergence. Stand loss was more severe at higher seeding rates (Graph 2). Increasing the total number of plants within a row creates greater plant-to-plant competition for water, nutrients, and sunlight. The increased competition for light, due to more plants per acre, also leads to taller plants and makes the plant more susceptible to potential lodging. Lodging within 2019 trials were similar at 100,000 and 140,000 seeds/A seeding rates but increased at the 180,000 seeds/A seeding rate. Limiting plant-to-plant competition within the row through use of lower populations or narrower row spacing may help reduce stress between plants and help minimize stand loss.



Graph 2. Stand loss associated with three soybean seeding rates

ECONOMICS OF SEED RATE DECISIONS

SEEDING RATE	SEED COST ($/AC)	YIELD (BU/AC)	NET REVENUE* ($/AC)	NET REVENUE OVER/UNDER 140K SEEDING RATE ($/AC)
100,000	$39.28	70.7	$596.97	-$1.07
140,000	$55.00	72.6	$598.04	-
180,000	$70.71	74.0	$595.35	-$2.69

Commodity price = $9.00 / bu
*Net Revenue = (yield x commodity price) - seed cost

Table 3. Economic comparison of seeding cost changes due to seeding rate and its influence on net revenue, compared to a 140,000 seeds/A seeding rate

Although yield was greatest at 180,000 seeds/A for both treatments in our trials, economics suggest lower seeding rates could maximize ROI potential. While increasing seed rates also increases final stands, the percent of seed developing into viable plants decreased in our trials (Graph 2). The difference between early season and harvest plant stand populations illustrates that money spent on initial seed cost may not be fully realized at higher seeding rates. Using $55/unit seed cost and $9/bushel commodity price, the 1.4 bu/A advantage of increasing from 140,000 to 180,000 seeds per acre still resulted in $2.69 per acre loss (Table 3). Yield and net revenue from 100,000 seeds/A were both less than from 140,000 seeds/A, although not by much. Using the assumptions in Table 2, it would have required a minimum of 1.76 bu/A increase to cover the cost of 40,000 additional seed needed to plant 180,000 seeds per acre.

CONCLUSIONS

The results of this work indicate that there is a high likelihood that soybeans will respond to fungicide regardless of variety. Fungicide applications should always be based on scouting for early signs of disease presence and using proper integrated pest management practices. Results indicated the highest yielding population treatment was 180,000 seeds/A. However, economic analysis illustrated the yield advantage was just shy of covering the increase in seed cost. As new soybean traits are introduced, resulting in increased cost per unit of seed, growers will need to carefully consider seeding rates greater than 140,000 seeds/A to maximize their return on investments. Furthermore, the 2019 growing season was "abnormal" which may have attributed some of the advantage that was observed within the 180,000 seeds/A seeding rates. On-farm testing can be very helpful when trying to decide on soybean seeding rates. Optimum seeding rates will vary based on individual management practices including tillage, planting equipment and row spacing. Keep in mind that seeding rates should always be based on percent pure live seed printed on seed bag tags prior to finalizing seeding rate decisions.

SOYBEAN CYST NEMATODE AND ACTIONS TO REDUCE DAMAGE

HOW SERIOUS IS SOYBEAN CYST NEMATODE?

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 yield loss[3], are not obvious enough to be visible from above-ground symptoms.[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 which is what transports moisture and nutrients throughout the plant. The juveniles modify plant cells and begin to feed, robbing nutrients and damaging their host. SCN continue to feed inside the root but eventually grow large enough to burst outside the root. They continue to feed, with the largest portion of the developing body exposed on the root exterior (See Figure 2).[6]

Figure 2. Cysts and cysts on roots

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

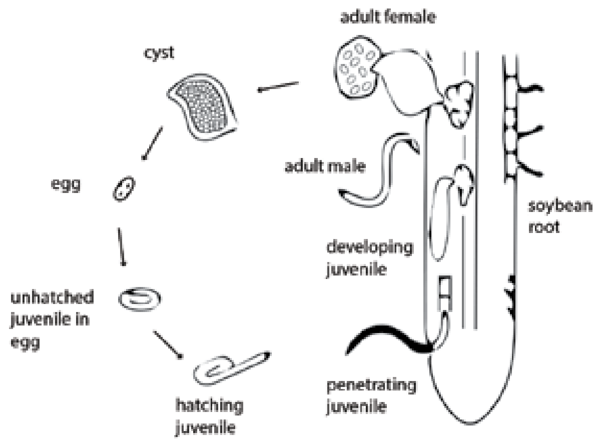


Figure 3. Soybean cyst nematode life cycle

- 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 field-wide 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.

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

Table 1. Common SCN non-host crops

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. 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 over 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. In the absence of new introductions of alternative sources of resistance that offer yield and agronomic traits necessary for breeders, SCN populations will likely slowly increase due to continued adaptation to PI 88788. 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 newly registered Saltro® Seed treatment which as available to add on to existing fungicide/ insecticide seed treatment options. Saltro® provides protection against sudden death syndrome as well as providing robust activity against SCN, root knot, reniform, lesion and lance nematodes.

SUMMARY

SCN presents a complex challenge to U.S. soybean growers. As outlined above, soybean yields may be silently reduced by 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.

BEAN LEAF BEETLE ON SOYBEANS

The bean leaf beetle (BLB) can be found in almost any soybean field. This pest feeds on a range of legumes such as alfalfa, green beans and clover, although soybeans are the primary host.

BLB usually doesn't occur enough in soybean fields to warrant management, but economic populations can develop within a couple years if environmental conditions and cultural practices are right. Significant BLB populations have been reported in several fields, and it is very likely many more economic infestations have gone undetected due to lack of awareness.

IDENTIFICATION AND LIFE CYCLE

Bean leaf beetle goes through multiple development stages beginning as an egg, larvae and pupa, but it is mostly visible and damaging in its adult beetle stage. BLB are similar in appearance and size to an adult corn rootworm beetle, with a length near 1/5-inch long. It can appear as many colors such as yellow, orange or red, and can include 2-4 black rectangular spots on its back although spots can sometimes be absent. A black triangle near the back of its neck is a consistent identifier distinguishing it from other beetles.[1] (Figure 1)

Figure 1. BLB adult beetle feeding on soybean unifoliate leaf

Adults lay eggs in the soil near the base of the soybean plant. Larvae emerge from these eggs, live underground and feed on soybean roots. They resemble corn rootworm larvae and rarely cause economic injury. Larvae pupate in the soil, from which adults later emerge and start another round of above-ground feeding. The bean leaf beetle has 2 generations per year throughout most of the Corn Belt. The number of generations can be as short as 1 in northern areas and up to 3 generations in southern states.

Adults overwinter locally in wooded or grassy areas and emerge from overwintering in early spring to feed on available plant hosts, such as alfalfa or clover. They immediately move to soybean fields once plants emerge, a preferred host, and feed on cotyledons, stems and leaves. Though early soybean planting often results in a yield advantage, first fields planted are the most likely to encounter BLB feeding and potentially large populations later in the season.

Overwintering adults will migrate into newly emerging soybean fields and feed before females begin to lay eggs in mid- to late-May. Larvae hatch from May through mid-June and pupate underground. First generation (F1) adults emerge during late June through July to feed primarily on soybean leaves. F1 feeding appears as round holes eaten through the leaf and rarely causes economic injury.

In the north, F1 beetles are present late enough in the season to move to pod feeding and increase risk of economic injury. In central and southern areas, a second generation (F2) of adults will emerge during August and early September (Figure 2). As leaves mature, the adults move to the pods and feed on the outer green tissue, exposing the seeds to the weather and disease. F2 adults will overwinter locally in central regions. In the south, a third generation of beetles (F3) will often develop and overwinter.

AREA DISPERSAL

When significant BLB populations establish in a field, they typically persist for future generations. If BLB populations are high in the spring, there's a good chance later generations will be significantly present later in the season. BLB can fly short distances, so neighboring fields may also experience economic damage later in the season.

Figure 3. BLB feeding damage to seedling soybeans

IMPACT ON SOYBEANS

BLB may cause economic damage throughout the season, but typically impact young seedlings or soybean pods forming late in season.[2] Along with yield loss, BLB adults are known to transmit bean pod mottle virus, which may also result in economic injury.[1] This virus may cause spotting or mottling and puckering in soybean leaves, and mottling of pods and discoloration of seeds.[3] Bean pod mottle causes "green stem" or the delayed dry down of stems and leaves, potentially causing yield loss from reduced seed size and pod set. Virus pressure is often correlated to BLB population size.

BEAN LEAF BEETLE MANAGEMENT

Areas where BLB populations have been historically moderate to high are at greatest risk for future yield loss. Prioritize monitoring these fields for BLB adults in the season ahead, especially if your field is one of the first locally planted. Scout for BLB adults twice during the soybean growing season: once at the seedling stage and again at the first appearance of F1 beetles in early July (Figure 2).

SEEDLING STAGE MONITORING

Controlling the initial overwintering BLB generation with foliar or seed insecticides in the spring may greatly reduce yield loss if populations are high. Fields where seed applied insecticides were not used are especially vulnerable and should be scouted first and most frequently. Apply a foliar insecticide if there is an average of 3 or more beetles per plant. Managing BLB populations early helps avoid economic injury to seedlings and reduces the risk of late season beetle feeding.

F1 GENERATION MONITORING

Economic injury from F1 BLB populations is rare, but it's still a good idea to scout for F1 beetles in July. High counts at this time can be an indicator you will be at a greater risk for an economic F2 population in late summer. Start sampling for BLB with an insect sweep net at the first appearance of F1 adults in July. Sample on 3 different dates, approximately each week after the first occurrence of F1 beetles. Economic thresholds for late season BLB populations is dependent on density of beetles in field and the typical cost associated with an unplanned foliar insecticide. Refer to local university extension established thresholds to determine if late season beetle populations warrant treating with a foliar insecticide.

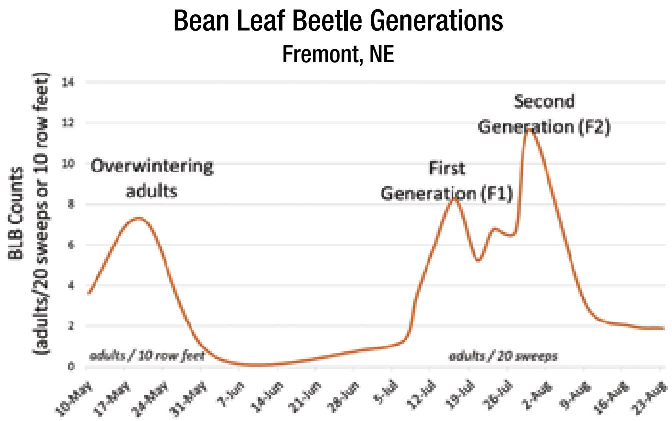
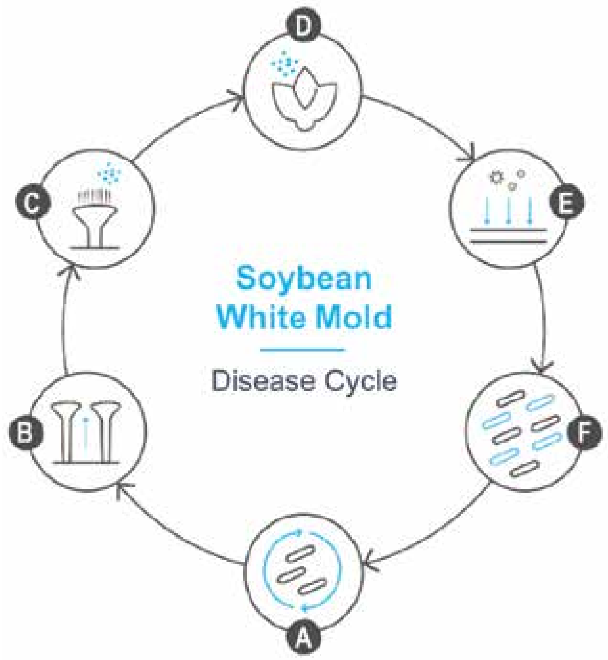


Figure 2. BLB adult beetle numbers throughout the year at an Agronomy in Action site

WHITE MOLD IN SOYBEANS

White mold is a potentially devastating soybean disease that kills stems from the point of infection up, impacting yield. It is caused by the soilborne fungal pathogen *Sclerotinia sclerotiorum*, which can survive in soil for years. Because white mold symptoms do not appear until late in the season, it is important to know the factors that encourage growth so the disease can be managed.



- **A** The fungus overwinters as sclerotia
- **B** Sclerotia germinate to produce trumpet-shaped apothecia
- **C** Apothecia contain numerous asci containing ascospores
- **D** Ascospores are forcibly discharged and travel to young susceptible flowers
- **E** Flower infections allow the fungus to enter the stem and kill plant tissues above
- **F** More sclerotia develop (white are young sclerotia and black mature) to allow the fungus to survive over the winter

WHITE MOLD DEVELOPMENT

The fungus overwinters as thick, walled structures known as sclerotia (A) either in or on the soil or in infected plant tissue (F). Sclerotia that are within the top five centimeters of the soil surface can germinate to produce trumpet shaped apothecia (B), or the fruiting bodies that contain asci and ascospores.[1]

Asci are filled with ascospores (C), which are forcibly released into the air. Some airborne spores land on susceptible soybean flowers, germinate and infect the plant (D). Flower infections extend into the stem and kill the tissues above the infections (E). Typical symptoms of white mold are flagging or dead plant tops. The fungus will grow on and/or in the plant and develop more sclerotia for survival over the winter (F).

WHITE MOLD IDENTIFICATION

White mold first appears on soybeans stems as lesions, gray to white in color, at the nodes. Foliar symptoms (yellow or brown leaves) appear later after the fungus has progressed enough to kill the plant. It then develops into fluffy or cottony, white growth on the stems and eventually dark black sclerotia along the stem or bean pods. As soybeans become dry or die, the stems will seem bleached, or light in color.

FAVORABLE CONDITIONS FOR WHITE MOLD DEVELOPMENT

- Rain during soybean bloom, along with cool temperatures (less than 86 degrees Fahrenheit)
- High relative humidity and moist soil
- Prolonged periods of low soil temperatures (41 to 59 degrees Fahrenheit)
- Moderate air temperatures and frequent rain just prior to flowering
- To help determine if conditions are favorable for development, consider downloading the University of Wisconsin Sporecaster app: ipcm.wisc.edu/apps/sporecaster/

BEST PRACTICES FOR WHITE MOLD MANAGEMENT

- Variety selection: There are no varieties with complete resistance, but some have partial resistance.
- Crop rotation: A minimum of two to three years of a non-host crop, such as corn or small grains, can reduce sclerotia in the soil.
- Tillage: Inconclusive
- Canopy management: Early planting, narrow rows, high plant populations and high soil fertility all accelerate canopy closure and favor disease development.
- Weed control: Many common broadleaf weeds, such as henbit, velvetleaf, and common lambsquarters are also hosts of S. sclerotiorum[1].
- Irrigation: Avoid excessive irrigation until after flowering.
- Fungicides: Can help suppress white mold with proper application timing

Manage white mold with a fungicide when disease is present and conditions are favorable for disease development. Apply Miravis® Neo fungicide at 20.8 oz/A at early bloom (R1) to full bloom (R2). If favorable conditions for white mold development continue, apply a second application of Miravis Neo at 13.7 to 20.8 oz/A 10 to 14 days after first application. Adjust the rate based on severity of the disease pressure and conditions. If the disease is present but conditions are not favorable for white mold development, apply 13.7 oz/A of Miravis Neo at early bloom (R1) to full bloom (R2). An adjuvant may be added at recommended rates. To obtain thorough coverage, apply in sufficient volume.

JAPANESE BEETLE IDENTIFICATION AND MANAGEMENT IN SOYBEANS

The Japanese beetle is a notable pest with an increasing distribution across the United States. While it causes defoliation in soybeans, the Japanese beetle is also known to feed on other crops.

LIFE CYCLE AND PEST IDENTIFICATION

Japanese beetles have one generation per year and overwinter in the soil as larvae. As soil temperatures warm, larvae move closer to the surface and pupate into the next development stage. Adults then begin to emerge in mid-June, females lay eggs in July and August, and as eggs hatch in the soil, larvae feed on roots and decaying plant material. Since larvae are about ½ to 1 inch long and cream-colored with a brown head, they can be confused with other common soil grubs. Adult Japanese beetles are about ½ inch long and are shiny metallic green with metallic bronze wings. Adult Japanese beetles also have 6 white tufts of hair along each side of their abdomen.[1]

INJURY TO SOYBEAN FIELDS

Japanese beetles feed on more than 300 types of plants, including field crops and ornamental plants.[2] Adult beetles feed on leaf tissue between the veins, resulting in a distinctly "skeletonized" look, with leaf veins remaining and the leaf tissue removed. When Japanese beetles continue feeding on leaves, they remove more leaf tissue and reduce the leaf surface area needed for photosynthesis, potentially leading to reduced grain fill and lower yields.

Japanese beetle feeding on soybean leaves

SCOUTING TIPS

Japanese beetles provide the greatest risk of injury during crop reproductive stages. Scout entire fields for signs of Japanese beetle damage.

- Japanese beetles tend to feed in clusters. Some areas of the field may have low populations, while other areas are heavily infested. If only a small area is scouted, beetle populations may be over- or under-estimated. Scouting the entire field will give you a better view of just how much pressure is present.
- Because of how mobile Japanese beetles are, feeding damage is generally higher along the borders, as they move into the field from other host plants.
- Japanese beetles have several look-alikes, including the false Japanese beetle, or sand chafer, so be careful when scouting.

TREATMENT THRESHOLDS

To prevent yield loss, consider an insecticide treatment if defoliation is 30% or greater during vegetation, and more than 20% during the reproductive stages.[3] If your soybean fields hit these thresholds, apply an insecticide like Endigo® ZC, which combines 3 industry-leading technologies for quick knockdown and extended residual control. Keep in mind that because of their mobility, Japanese beetles may repopulate an area that was recently treated. If that's the case, retreatment may be necessary to protect leaf tissue during pod fill.

SEED TREATMENT OPTIONS FOR SOYBEAN SUDDEN DEATH SYNDROME

INSIGHTS

- Syngenta's Saltro® seed treatment provided consistent protection across varying levels of sudden death syndrome pressure, often resulting in significant yield benefits.
- Saltro also provided improved performance over ILEVO® in both yield and crop safety.

Soybean sudden death syndrome (SDS) can be an economically devastating disease. It is distributed throughout major soybean growing regions of the United States and Ontario, Canada. The pathogen responsible for SDS is *Fusarium virguliforme*.[1,2,3] It overwinters on crop residue or in the soil.

Figure 2. (Right) Base seed treatment with SDS foliar symptoms (Left) Saltro seed treatment

The disease consists of an early season root rot stage followed by yellowing and lesion development between leaf veins in late July or August (Figures 1 and 2). Symptoms may resemble Brown Stem Rot (BSR), but some key differences can help differentiate these two diseases. BSR stem symptoms are limited to the pith (the inner most part of the stem) whereas SDS affects the cortex (the part of the stem surrounding the pith).[4] SDS can often be first diagnosed as a white or blue fungal growth on the roots, although BSR will not exhibit this type of symptomology. The discoloration and lesions developing between leaf veins is the result of a buildup of toxins produced during the root phase of the pathogen earlier in the growing season. Affected leaves will drop from the plant, leaving the petioles still attached to the stem. SDS can sometimes be exacerbated by the presence of soybean cyst nematode (Heterodera glycines) as a result of the nematode's point of entry creating a pathway for increased fusarium infection within soybean roots. When conducive conditions prevail, losses from SDS can be significant. Conditions that favor infestation are:

Figure 1. Leaf yellowing and lesions caused by SDS

- 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 SCN
- Cooler temperatures during flowering and pod fill stages

MANAGEMENT OPTIONS

Planting into warmer, drier soils can minimize early infection, although management is best achieved through genetic resistance. Discuss variety tolerance with your Golden Harvest® Seed Advisor to select the best options for high risk fields. There are many seed providers offering different seed treatment options for managing SDS. Two of the most common types of treatments offered are 1) biologicals 2) succinate dehydrogenase inhibitors (SDHI). SDHI class of products have proven to be most effective at managing SDS in previous trials.

SDS FIELD TRIALS

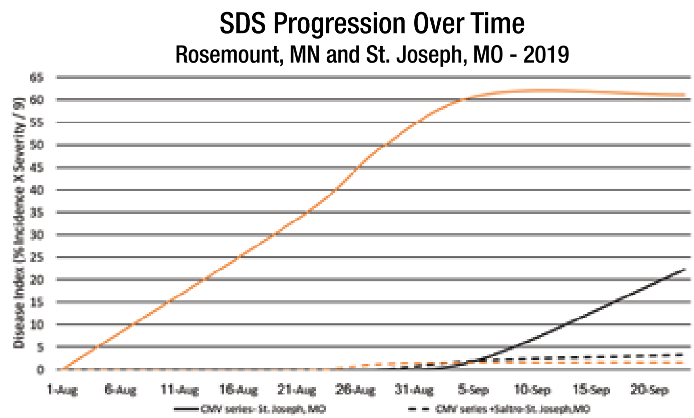
Trials were jointly conducted at 7 locations (Figure 3) with university, contract researchers and Syngenta teams in the 2019 growing season to evaluate performance of Saltro, a new SDHI seed treatment. ILEVO seed treatment, another SDHI, was included as an industry standard for baselining Saltro performance. Both SDS treatments were tested in various combinations with two base seed treatment packages which are outlined in Table 1.

Treatment #	Base Treatment	SDS Treatment
1	Golden Harvest Preferred Seed Treatment CMV Series (Fungicide/Insecticide)	None
2		Saltro (0.075 mg ai/seed)
3		ILEVO (0.15 mg ai/seed)
4	Golden Harvest Preferred Seed Treatment CCB Series (Fungicide/Insecticide/ Nematicide)	None
5		Saltro (0.075 mg ai/seed)

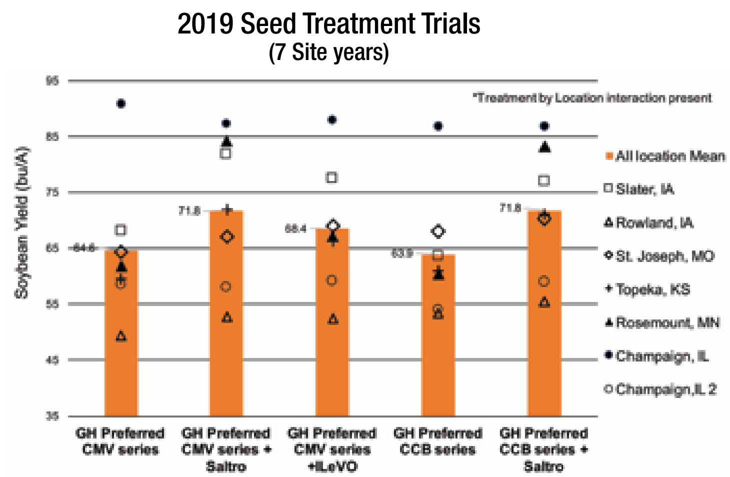
Table 1. Individual treatment combinations of two base treatments and two SDS seed treatments

RESULTS

Yield response from adding specific SDS seed treatments varied across trials in 2019 due to different levels of disease presence and the time in which foliar symptoms begin to appear.



Graph 1. SDS disease progression at Rosemount, MN and St. Joseph, MO in 2019



Graph 2. Individual locations and average yield response comparisons of SDS seed treatments

Graph 1 illustrates a much earlier progression and severity of SDS at Rosemount, MN in contrast to a much later progression at St. Joseph, MO. Graph 2 illustrates the average as well as individual trial location yield responses in 2019. On average, Saltro increased yield by 7.5 bushels across all trials, however individual location responses ranged from 0-22 bu/A depending on the location. Locations with low disease presence such as the two Illinois sites showed no yield response. Rowland, IA and St. Joseph, MO sites did see foliar symptoms, but progressed late in the growing season resulting in minimal increases of 2-3 bushels. Symptoms began to appear much earlier (mid- to late-August) at the Topeka, KS, Slater, IA and Rosemount, MN locations, resulting in 11, 13 and 22

Figure 3. SDS field trial locations

bushel responses to Saltro seed treatment respectively. ILEVO provided similar yield benefits across most locations with the exception of the Rosemount, MN location where severity of SDS was much higher. At the Rosemount, MN location, Saltro treatments yielded significantly more than ILEVO. Figure 4 illustrates the visual differences in severity observed between Saltro and ILEVO at the Rosemount, MN site.

Figure 4. Senescence differences due to SDS at Rosemount, MN trial. Left to right, each four rows are 1) Golden Harvest Preferred Seed treatment (GH PST), 2) GH PST + Saltro 3) GH PST + ILEVO.

SUMMARY

Results from this study show the benefits that seed treatments can provide for managing SDS in soybeans. When conditions are conducive for SDS development, adding Saltro to seed treatment mixtures will help preserve leaf area, maximizing photosynthesis throughout the season and leading to improved yields. Current industry standards such as ILEVO performed well at the majority of locations, although under high disease situations, it appears that Saltro may offer improved protection.

In addition to yield, a burned or scorched appearance was consistently visible on cotyledons of ILEVO treatments across all trial sites. Soybean canopy development was often slowed in response to ILEVO treatments as compared to all other treatments (Figure 5).

Saltro seed treatment provided consistent protection across varying levels of SDS pressure, often resulting in significant yield benefits. Saltro also appears to provide improved performance over ILEVO in both yield and crop safety.

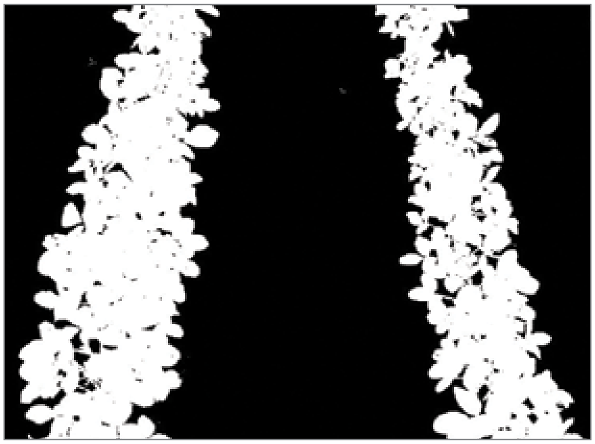


Figure 5. Early season canopy development differences. Left, Golden Harvest Preferred Seed treatment; Right, Golden Harvest Preferred Seed treatment with ILEVO

HARVESTING SOYBEAN AT HIGHER MOISTURE TO MAXIMIZE YIELD

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

KEY SUMMARY

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:

- 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.
- Soybeans that dried down and became wet again during rain and cool, cloudy weather will more easily split and shatter, so be extra careful harvesting in such situations.
- Timing is everything when it comes to soybean harvest because optimum moisture is key to combining the best yields.

TIMING HARVEST DECISIONS BASED ON CORN DRYING METHOD

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 do we stop field drying and utilize mechanical drying? 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 your 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.

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 you anticipate 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.

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


Circle
NECO
SHEYENNE / WESTGO
D24180
NECO
NECO

EVALUATING YIELD DATA TO SELECT HYBRIDS FOR YOUR FARM

INTERPRETING HARVEST YIELD DATA

Yield data can be one of your most valuable assets for selecting the best hybrids for your operation, 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 your 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 you are placing hybrids. 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 your farming operation, there are a few other items to keep in consideration to ensure you are making fair comparisons that will best indicate performance on your 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, be your 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%

HOW MUCH DATA DO YOU NEED?

The more data available will only increase your confidence in choosing the best hybrid. Table 1 summarizes actual data used to

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

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).

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 you need to be in your final decision.

Table 2 uses statistics to illustrate how additional locations increases your 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, we have 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 new 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 your area. For more support and information, contact your local Golden Harvest Seed Advisor to discuss hybrid selection for your farms.

E-luminate®

YIELD MONITOR PREPARATION FOR HARVEST

Yield monitor data can provide information to help make better decisions about seed selection, placement and management in fields. The data can also help identify yield-influencing factors not seen from other field observations. Yield monitor data are based on estimates, and the interpretation and decisions made are only as good as the quality of the data collected. Optimizing the use of yield monitor data requires knowledgeable set up and calibration.

HOW YIELD MONITORS ESTIMATE YIELD

Yield monitor systems are more than a monitor display in the cab – they include several sensors that collect data. There are multiple sources of information yield monitors use to accurately estimate yield[1]:

1. Rate of grain flow measured by the impact plate, or optical sensors
2. Distance traveled using GPS
3. Grain moisture as measured from sensor plate

In addition, there are three key pieces of data the operator needs to manually enter:

1. Lag time
2. Header position
3. Header width

Calibration of the yield monitor involves a series of steps to make sure that the estimation of each data factor is accurate. Depending on the type of yield monitor, there may be additional pieces of data used to determine the yield estimate displayed on the monitor.

KEY FACTORS FOR ACCURATELY ASSESSING YIELD

Yield monitors must be calibrated or "trained" to interpret signals to provide more accurate yield estimates. The first step toward properly capturing yield data is to become familiar with the combine monitor system being used and its components. The owner's manual should outline the specific calibration method for your equipment.

1. Mass flow: Impact sensor
    a. This is the most important calibration measurement, as it determines grain flow at pounds per second through the clean grain elevator in the combine.[2]
    b. Most yield monitor systems have the ability to add multipoint/load calibration points to allow estimates over different flow ranges.

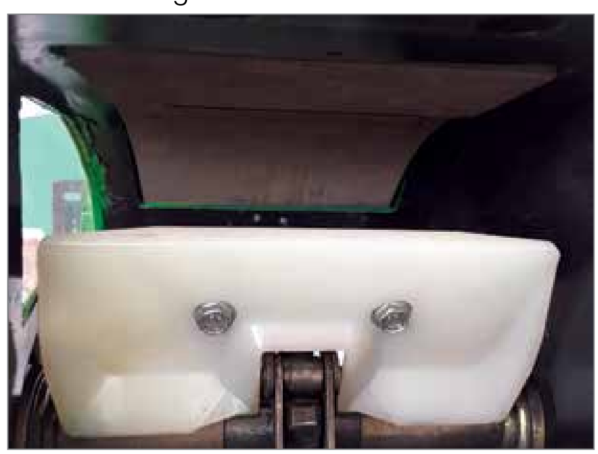


Figure 1. An example of a common impact plate sensor, which is located at the top of a combine's clean grain elevator.

2. Mass flow vibration calibration: Impact sensor plate
    a. This calibration is used to document the effect of vibration when the combine is running.[3]

   b. To ensure you're measuring correctly, check that the proper header is attached and in operating position, the combine is empty of grain, the separator and header are engaged, and the combine is running at full revolutions per minute (RPM).
3. Moisture sensor calibration: Performed prior to weight calibration
   a. Using a handheld moisture tester, calibrate sensor output from the grain tank to multiple in-field samples per calibration load.
   b. Moisture sensors will adequately measure grain moisture when in the 10 to 33% range.

Figure 2. An example of a moisture sensor, which is typically located on the combine's grain elevator for easy access to clean blades.

4. Temperature calibration: Performed before weight calibration
   a. Helps ensure mass flow sensor and moisture sensors are interpreting correctly.
5. Lag time settings
   a. Measurement of time it takes grain to travel from the header to the mass flow sensor.[4]
   b. Compensation for grain flow delay allows more accurate yield mapping.
   c. Total time typically ranges between 10 to 15 seconds: however subtracting 1 to 2 seconds from total measured time should remove the time grain travels from the mass flow sensor to entering the bin.
6. Header position setting: Controls when yield data should and shouldn't be recorded
   a. Proper settings ensure false yield data is not being recorded while no crop is being harvested such as when turning at the end of the row.
7. GPS measurements of harvest speed and distance
   a. Abrupt speed changes commonly cause yield estimate errors, which is difficult to fix with calibration, but can be corrected post-harvest with data analytics.
8. Header cut width setting: Number of rows by row spacing
   a. Another common problem is having an incorrect harvest width or partial header setting.
   b. If header width changes mid-season, weight calibrations should be performed again.

When calibrating yield monitors, it is important to pay extra attention to details. Combine and yield monitor user guides are great references to help create a yield monitor checklist of adjustments to make before harvest.

QUICK CALIBRATION TIPS

1. Harvest and calibrate using a wide range of hybrids with different grain moisture.
2. Harvest a minimum of 3,000 lbs. per calibration load.
3. Use minimum of 4 to 8 calibration loads to properly measure.
4. Harvest each calibration load at different load rates by using different combine harvest speeds of 3, 4, 5 and 6 mph per load.
5. Calibrate separately for each crop you plan to harvest.
6. Make sure the weigh wagon or grain catch cart scales used for calibration are accurate.
7. Do not unload on the go while calibrating.

CONSIDERATIONS FOR NITROGEN APPLICATION TIMING

INSIGHTS

- Initial nitrogen application delayed until V6 growth stage or later reduces corn yield potential.
- Single nitrogen applications made just prior to or shortly after planting will deliver optimal yield potential.
- When nitrogen rates are optimal, hybrid nitrogen use efficiency has minimal yield impact.
- Yield environment is not a good indicator for optimal nitrogen rate.

Nitrogen management is one of the most dynamic concepts growers face each year. Underapplying nitrogen can be costly from lack of yield response, whereas over-application can lead to poor return on investments as well as increasing environmental concerns from nitrates in surface and tile drainage runoff into water sources. Determining the best nitrogen rate to maximize crop productivity and profitability is dependent on balancing 1) weather, 2) economics and 3) capabilities of the farm operation (equipment, labor, time and form of nitrogen available).

SPLIT NITROGEN APPLICATION CONSIDERATIONS

Applying 100% of total nitrogen in a single application at or prior to planting is the most common management practice used, however split application practices are increasing in many areas. With split applications, growers are applying a portion of total nitrogen demand prior to or shortly after planting followed with the remaining nitrogen prior to peak demand at silking.

Nitrogen demand is minimal at early growth stages, which allows application to be delayed. However, this practice can be risky, limited by applicator crop clearance, acres/day capacity and wet soil conditions, potentially resulting in acres not receiving a nitrogen application. Split-application or “spoon-feeding” ensures that ample nitrogen is available to the crop at critical growth stages. Split applications also allow nitrogen rate adjustment based on the amount of nitrogen remaining in the soil. The economic and environmental benefit is applying only the amount of nitrogen needed to deliver yield potential.

The potential disadvantage of this approach is persistent wet soil after crop emergence may prevent timely, in-season nitrogen application. Success of in-season nitrogen application is also highly dependent upon moisture following application. Depending on the form of nitrogen and application method, a lack of moisture and dry conditions could result in significant volatilization (into the air) losses. Even with soil incorporated applications, moisture is still needed to disperse nitrogen throughout rooting zones to maximize uptake. Delayed nitrogen application or lack of availability due to dry conditions will limit nitrogen uptake by corn plants and potentially reduce corn yield or agronomics (such as plant standability, disease tolerance, etc.).

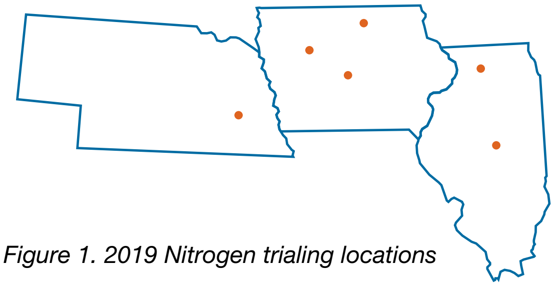


Figure 1. 2019 Nitrogen trialing locations

2019 NITROGEN FIELD TRIALS

As split application practices are increasing, the Golden Harvest® Agronomy In Action research team initiated trials in 2019 to better understand advantages and disadvantages of split nitrogen applications. Trials were conducted at six locations, illustrated in Figure 1, where 3 mid maturity locations (Mason City, IA; Sac City, IA; Oregon, IL) and 3 full season locations (Clinton, IL; Seward, NE; Slater, IA), investigated the impact of nitrogen rate and application timing on corn yield. Each site compared hybrids with contrasting nitrogen efficiency (Table 1) based upon a response to nitrogen ratio (RTN) from previous trials. RTN ratios are 0-1 value derived by dividing the yield difference of non-limited nitrogen yield and nitrogen limited yield, divided by non-limited nitrogen yield. Hybrids with a higher RTN ratio (nitrogen inefficient) are believed to be more responsive

	MID RM LOCATIONS	FULL RM LOCATIONS
N efficient	G05K08-3010A	G11A33-5222
N inefficient	G08M20-3010	G13T41-3120

Table 1. Hybrid nitrogen efficiency classification and hybrid sets utilized

APPLICATION TIMING				
Treatment Timing	**Pre/Early Post**	**V6**	**V18**	**Total lbs/A Nitrogen Applied**
PRE/Early Post	0			0
	75			75
	150			150
	225			225
	300			300
SPLIT-Early	0			0
	75			75
	75	75		150
	75	150		225
	75	225		300
SPLIT-Late*		0		0
		75		75
		75	75	150
		75	150	225
		75	225	300

* Preemergence applications were used in place of V6 applications at Oregon and Clinton, IL SPLIT-Late treatments

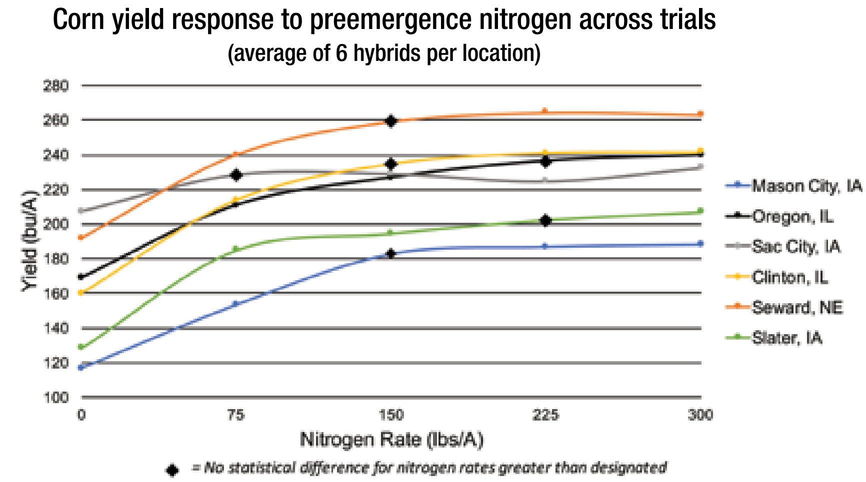
Table 2. Nitrogen application treatment rates, timings and totals applied for season

to incremental nitrogen rates and split nitrogen application strategies.

Nitrogen, in the form of UAN (32% N) plus Agrotain® (urease inhibitor) was applied to the base of each row on the soil surface in total amounts of 0, 75, 150, 225 and 300 lbs/A as either a single preemergence/ early postemergence application or as one of two split applications. Nitrogen treatments are described in more depth in Table 2.

Planting dates ranged from April 25 in Seward to June 3 at Slater due to wet spring conditions. The remaining 4 trials were planted in early to mid-May. Previous crops were soybeans at all sites except for Oregon, IL, which was long-term continuous corn.

DIFFERENCES IN NITROGEN REQUIREMENTS BY SITE



Graph 1. Individual location response to nitrogen rate

Corn yield increased with increasing applied nitrogen rates at all sites except Sac City (Graph 1). In the absence of applied nitrogen, yields of 206 bu/A were reached due in part to applied turkey litter (2 ton/A) and organic matter content of 4.4% which likely contributed significant in-season soil nitrogen mineralization to supplement crop nitrogen demands.

Mason City, Clinton and Seward responded similarly with minimal yield increase for nitrogen rates greater than 150 lb/A even though the overall yield environment at each site was distinctly different. This illustrates the challenge of nitrogen recommendation based solely on yield potential. Yield dropped rapidly at a rate of 0.42-0.48 bushels for each pound of nitrogen applied below 150 lb/A rates at all three sites. Oregon and Slater trials both maximized yield at nitrogen rates of 225 lb/A or greater, even though both trials had very different overall yield potential. Considering the Oregon trial was a 10+ year continuous corn site, it is not surprising to see a response to higher nitrogen rates (225 lb/A).

Based on these trials, it is not possible to identify a single one-size-fits-all nitrogen rate for all situations. The majority of trial locations only required 150 lb N to reach economic optimum yield, although outliers such as Sac City required less (75 lb), likely due to turkey litter, whereas Oregon and Slater required increased rates (225 lb) to reach the economic optimum grain yield.

HYBRID RESPONSE TO SPLIT NITROGEN APPLICATIONS

Corn grain yield response to application timing varied by location. Seward was the only site in which a split application of any type improved yield potential (~12 bu/A) over applying all nitrogen at or near planting. The Seward site encountered abundant amounts of rainfall shortly after preemergence nitrogen application that may have reduced available nitrogen and therefore enabling this response.

Slater and Oregon yields were not influenced by application timing, however, Mason City, Sac City, and Clinton observed yield

N Application Timing	Corn Grain Yield (bu/A)					
	Mason City	Sac City	Oregon*	Clinton*	Seward	Slater
PRE/Early Post	189 a	234 a	250 a	236 a	244 b	210 a
SPLIT-Early	200 a	230 ab	250 a	235 a	256 a	213 a
SPLIT-Late	159 b	227 b	249 a	228 b	256 a	210 a

* SPLIT-Late at Oregon and Clinton, IL substituted PRE for V6 applications at equivalent rates to other sites.

Table 3. Corn grain yield response to single and multiple nitrogen applications averaged across 4 nitrogen rates and 2 hybrids

reductions when the late split applications were delayed just prior to silking (Table 3). The optimum nitrogen rate for a site remained the same regardless of the application timing.

In general, rainfall was abundant at all locations during this study. Surface-applied nitrogen had ample opportunity to reach corn roots. In this situation, these results show that in most cases, a single preemergence nitrogen application can maximize corn yield potential. High precipitation totals after preemergence application, which may reduce available nitrogen, will likely result in more consistent responses from split applications.

UNIQUE NITROGEN INTERACTIONS WITH HYBRIDS

Nitrogen combined with good growing conditions such as water and temperatures can influence growth rates of corn. Between the V5 growth stage and prior to pollination a phenomenon known as green snap can occur from wind events resulting in the plant breaking or "snapping" off below the ear leaf. Hybrids vary in sensitivity to green snap, but can become more sensitive from rapid growing conditions, which has been known to result from nitrogen rates and timings. The Mason City site encountered a wind event just prior to pollination resulting in significant green snap differences. G08M20 is known to be more sensitive to green snap than G05K08 and was reflected in this trial.

Interestingly, splitting nitrogen applications where it was applied just days before the wind event increased the green snap rates of both hybrids as shown in Table 4.

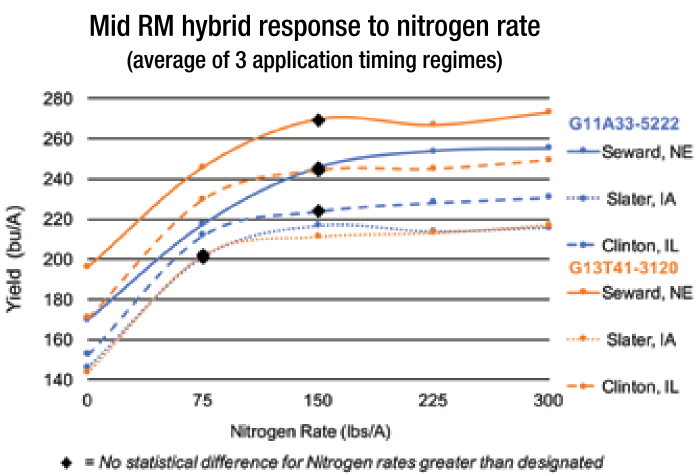
HYBRID/ APPLICATION TIMING	% GREEN SNAP	BU/A
G05K08-3010A		
PRE/Early Post	3 c	206 ab
SPLIT-Early	4 c	219 a
SPLIT-Late	9 bc	190 bc
G08M20-3010		
PRE/Early Post	16 b	172 c
SPLIT-Early	16 b	182 c
SPLIT-Late	29 a	129 d

Yield and green snap values followed by the same letter are not significantly different by Student's t p=0.05.

Table 4. Nitrogen application timing impact on corn plant green snap at Mason City, IA, averaged across 4 nitrogen rates

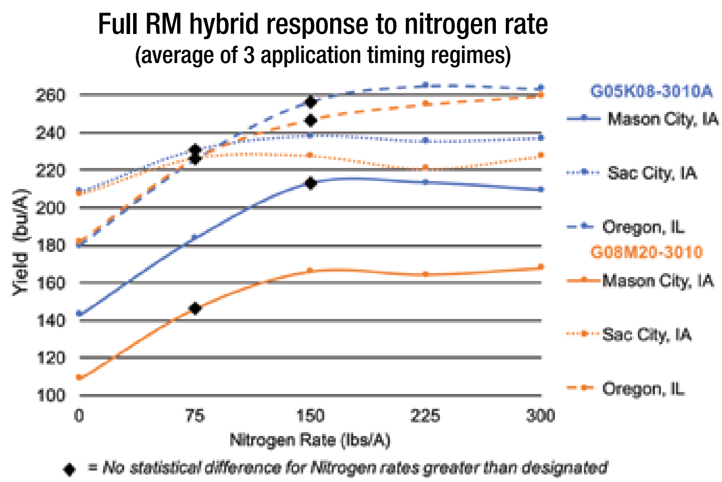
HYBRID RESPONSE TO NITROGEN

All trial locations included a nitrogen efficient and inefficient hybrid to understand if they behave differently to nitrogen management. Nitrogen efficient hybrids are reported to be less responsive to incremental nitrogen, whereas inefficient hybrids should be managed with supplemental nitrogen. Individual hybrid response of 4 hybrids can be observed across 3 locations for each hybrid in Graphs 2 and 3. The optimum nitrogen rate for each hybrid is indicated with a black diamond on the regression line in the graphs.



Graph 2. Individual hybrid nitrogen response curves for mid RM trial locations

Optimum nitrogen rates changed with location. In all but one location, the optimum nitrogen rate was always the same for efficient and inefficient hybrids at a location. Even though the difference in yield between highest and lowest nitrogen rates may differ slightly with some hybrids, the optimum nitrogen rate did not. Utilizing RTN ratios to interpret how to best manage individual hybrids is likely not the best approach to an overall nitrogen management plan.



Graph 3. Individual hybrid nitrogen response curves for full RM trial locations

SUMMARY

In summary, single preemergence applications of total nitrogen needed will often achieve top yield potential. If multiple nitrogen applications are planned, applying a portion of your total nitrogen just prior to or shortly after planting followed by in-crop application of remaining nitrogen around the V6 growth stage will deliver optimum yield potential. Initial nitrogen applications to V6 corn often results in lower grain yield. In our results, 150 lb/A of nitrogen on corn after soybeans typically helped maximize yield. Some locations may need less. In corn following corn situations, 225 lb/A nitrogen was needed to help maximize yield at one location in this study.

The same overall nitrogen rate is needed to achieve optimum corn yield potential, whether the hybrid is nitrogen efficient or inefficient, in most cases. When nitrogen availability is severely limited, there may be a benefit from a nitrogen efficient over inefficient hybrid, although this was not observed in our trials.

When selecting hybrids for your operation, nitrogen use efficiency should not be key selection criteria since yield gained or lost by this trait is relatively small. Applying adequate nitrogen rates and considering supplemental nitrogen in springs with high rainfall will be more impactful on overall yield potential and return on investment. Criteria such as yield potential, disease tolerance, maturity and adaptation for your area will also be critical.

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 and timely in-season decisions for a more profitable N management program is not a good indicator for optimal nitrogen rate.

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 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). 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 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

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

Figure 1

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

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	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**

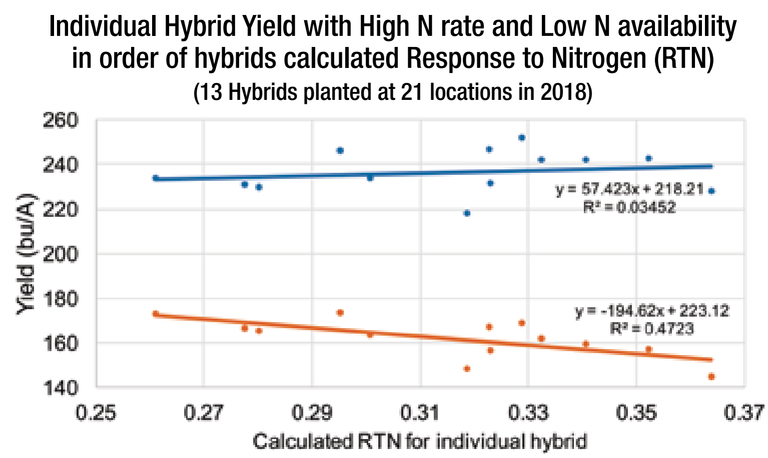
Table 2

HYBRID RESPONSE TO USING RTN

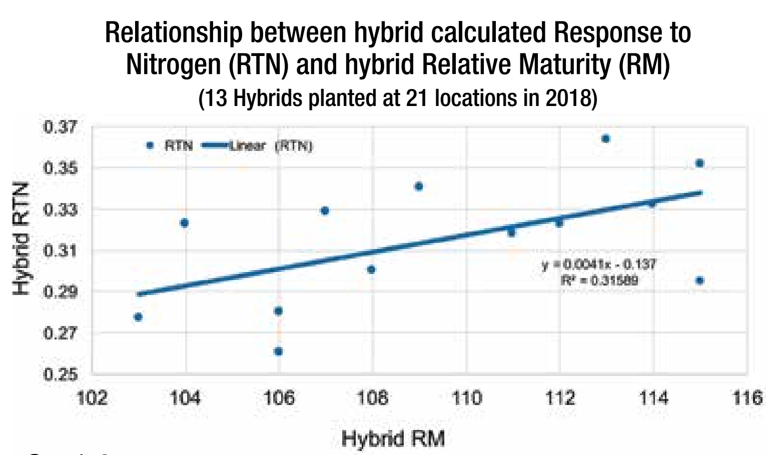
For identification of hybrids that most consistently have high/low RTN ratings, all 21 trials were combined and summarized for response trends. RTN ratings averaged 0.32 across 13 hybrids and ranged from 0.26 to 0.36 (Table 2). Yield loss in limited N environments ranged from 61-85 bu/ac across all hybrids 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 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

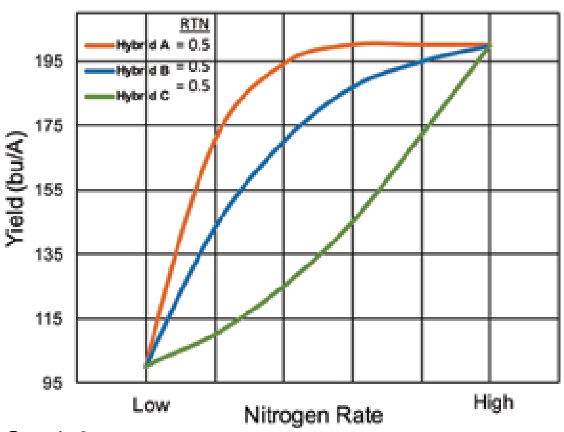


Graph 2

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.

SOIL N MODELING AND REMOTE SENSING FOR MONITORING NITROGEN DEFICIENCY

INSIGHTS

- Adapt-N reliably predicts in-season nitrogen shortages and recommended rates to minimize yield loss.
- Remote sensing approaches are able to recognize nitrogen stress.
- Adapt-N offers simplicity over other nitrogen monitoring approaches while maintaining accuracy in recommendations.

INTRODUCTION

Fall and early spring are the two most common times for applying nitrogen (N), although plans can quickly change due to weather. Precipitation amounts not only dictate when applications occur, but also have a direct impact on soil nitrogen loss after application. Monitoring soil nitrogen availability and adding supplemental in-season nitrogen when needed can help minimize lost yield potential. Multiple options exist for monitoring and prescribing in-season nitrogen such as soil sampling, remote sensing and use of nitrogen modeling software. Each of these approaches offers advantages and disadvantages over one another (Table 1).

SOIL SAMPLING AND LATE SPRING NITRATE TEST

The Late Spring Soil Nitrate Test (LSNT) requires 12" depth soil cores be pulled from corn fields when plants are 6 to 12 inches tall to obtain valid nitrogen recommendations. Lab analysis of soil samples are used to determine nitrate concentration that can be used to recommend sidedress nitrogen rates.[1]

The 360 SOILSCAN is a recently introduced portable field analysis tool that enables in-field soil sampling to reduce time needed for developing nitrogen recommendations.

REMOTE NITROGEN SENSING

Light emitting sensors can quantify light reflectance from plant leaves to measure leaf "greenness" or chlorophyll content. Accuracy of this approach is dependent on having within-field reference strips, where adequate soil nitrogen levels exist to properly calibrate recommendations for deficient areas. Handheld remote sensors, as well as implement-mounted versions (RapidSCAN, GreenSeeker®, others), are available for scouting and on-the-go measurements that can be used to create nitrogen prescriptions.

COMPARISON OF NITROGEN MONITORING APPROACHES

	Soil Sampling with Late Spring Nitrate Test	Remote N Sensing	Nitrogen Modeling
No requirement for N reference strip for Rx	+	-	+
Low Labor Requirements for monitoring	-	+	+
Minimal Time Requirements (assessment to Rx)	-	+	+
Accuracy at soil N levels < 20-25 PPM	-	+	+
Soil sampling error from previous N band applications	-	+	+
Crop stage can be performed	6-12" corn	V8+	Anytime
Soil Conditions required	Dry/Moist	Dry/Moist	Anytime

Table 1. Advantages and disadvantages of various N monitoring approaches[2,3]

NITROGEN MODELING SOFTWARE

Nitrogen modeling software has been used more recently to better understand nitrogen needs throughout the entire growing season. These systems (Adapt-N, FieldView and Granular Agronomy) utilize field spatial boundaries to define specific fields and interpret nitrogen availability based on weather (current and historic), soil type, organic matter, crop history, and current crop inputs. Additional management information such as planting date, seeding rate, hybrid relative maturity (RM), manure application and irrigation scheduling help to further refine model predictions. One of the biggest benefits of nitrogen modeling is the ease of monitoring nitrogen status on a daily basis throughout the entire season.

2019 ASSESSMENT OF NITROGEN MONITORING PRACTICES

Golden Harvest® Agronomy In Action Research conducted trials at 2 mid maturity (Mason City, IA; Oregon, IL) and 3 full season locations (Clinton, IL; Seward, NE; Slater, IA) in 2019 to investigate the utility of remote sensing and the Adapt-N model for providing accurate in-season nitrogen recommendations (Figure 1). All sites, shown in Table 2, had similar yield potential and management with exception of Oregon, IL (long term continuous corn) and Slater, IA (late planting).

Location	Previous Crop	Yield Goal	Plant Date	Soil Type	Soil OM
Clinton, IL	soybean	250	17-May	silty clay loam	3.9
Mason City, IA	soybean	220	15-May	silty clay loam	5.5
Oregon, IL	corn	260	15-May	silt loam	3.4
Seward, NE	soybean	220	25-Apr	silty clay loam	2.8
Slater, IA	soybean	220	3-Jun	clay loam	3.0

Table 2. Trial site information for crop production and soil characteristics

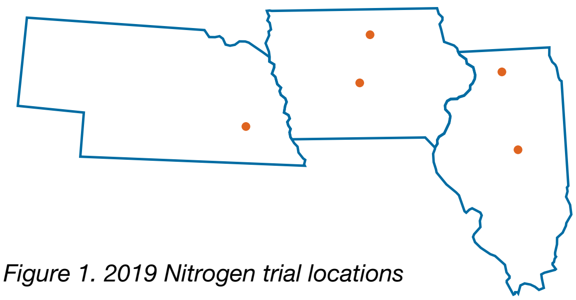
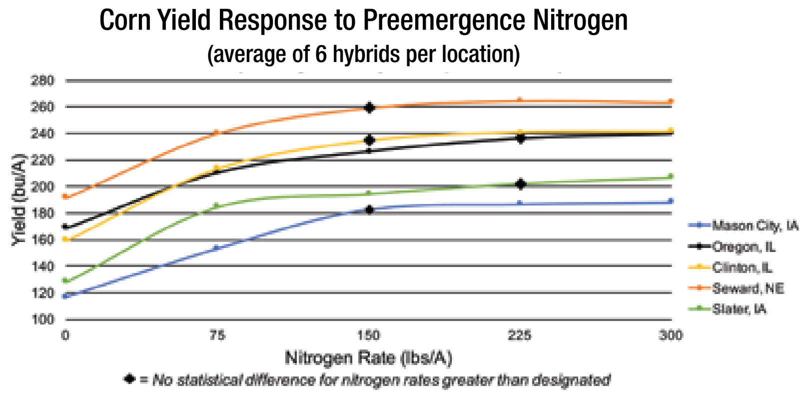


Figure 1. 2019 Nitrogen trial locations

Hybrids with different perceived nitrogen efficiency were planted at each site based upon response to nitrogen ratios (RTN) from previous trials to understand if hybrids respond differently to nitrogen availability. Nitrogen rates of 0, 75, 150, 225, and 300 lbs N/acre were applied preemergence (PRE) at all locations to establish the minimum nitrogen rate needed to maximize yield. Additional PRE treatments of 75, 150, and 225 lbs N/acre were established for the purpose of applying incremental in-season nitrogen recommendations based on Adapt-N recommendations. Adapt-N nitrogen recommendations were generated every other week once corn reached 5-leaf stage and continued through silk emergence. A minimum recommendation of 40 lbs N/acre was required prior to Adapt-N sidedress applications being made. The majority of Adapt-N recommendations occurred between 5- to 7-leaf corn stages. UAN (32% N) plus Agrotain® (urease inhibitor) was broadcast preemergence or in a band on soil surface next to emerged corn rows after emergence.

atLEAF chlorophyll meters were utilized to evaluate remote sensing. The atLEAF handheld units were used to measure leaf “greenness” or chlorophyll content in the 0, 75, 150, 225 and 300 lbs N/acre PRE only treatments. Relative chlorophyll meter (RCM) values, also known as nitrogen sufficiency index measurements, were calculated from 20 plants at the 10-leaf stage for each hybrid and preemergence applied nitrogen rate. Chlorophyll readings from the highest nitrogen rate were then used as the nitrogen sufficient measurement for calculating the RCM value. In-season nitrogen rate recommendations were derived from Iowa State University[4] and University of Nebraska[5] guidelines using individual hybrid RCM values. In-season nitrogen applications yield results from Adapt-N recommendations were used to access remote sensing recommendations accuracy.



Graph 1. Individual location response to nitrogen rate

2019 RESULTS

Overall yields were good at all test sites. Early season rainfall was ample to excessive, which delayed planting and preemergence nitrogen application at some sites. Initial nitrogen applications at Oregon, IL were delayed until the 1-leaf corn stage or 19 days after planting. At this site, preemergence nitrogen treatments were replaced with a banded stream of nitrogen close to the row to maximize root uptake and minimize potential crop damage. Early season rainfall ensured good nitrogen movement into the soil profile.

Figure 2. 2019 Nitrogen trial with yellowish-green nitrogen limited corn blocks showing lack of chlorophyll

Maximum corn yields varied from 180 to 260 bu/A across the 5 test locations (Graph 1). The minimum nitrogen rate for optimum yield was 150 lbs N/acre at Clinton, Mason City and Seward. Optimum nitrogen rates for Oregon (continuous corn site) and Slater (late planted) were slightly higher at 225 lbs N/acre. Optimum nitrogen rates are illustrated in Graph 1 with a black diamond on yield curves for each location. Yields from nitrogen rates greater than the designated optimum were not statistically different.

ADAPT-N RECOMMENDATIONS IN N-LIMITED ENVIRONMENTS

In order to test the accuracy of Adapt-N in nitrogen limited situations, the yield of the optimum preemergence nitrogen rates was compared to the yield of in-season Adapt-N recommendation treatments. Adapt-N treatments were applied over 75 lbs N/ acre preemergence treatments to mimic recommendations on a nitrogen limited field situation. Equal to or greater yield results from Adapt-N treatments indicate that the model effectively recommended adequate nitrogen rates to recover yield that would have otherwise been lost due to inadequate nitrogen availability. Table 3 shows the yield of optimum preemergence nitrogen rate and corresponding yield from in-season Adapt-N recommendations at each location. The Adapt-N model recommended sidedressing 50 to 170 lbs N/acre nitrogen depending upon the site. Surface dribble applications of nitrogen to 5- to 6-leaf corn significantly increased corn grain yield at all locations to levels statistically equivalent to optimum preemergence nitrogen rate. This shows how potential nitrogen deficiencies can be corrected through model-driven recommendations to apply nitrogen early postemergence without lost yield potential. Full yield recovery occurred using a reduced total rate (25 lbs N/acre less) compared to optimum preemergence rate at 2 locations. The other 3 locations recommended total rates 10-20 lbs N/acre greater than the preemergence optimum rates.

Location	Optimum Preemergence N		Adapt-N Recommendation in “Non-Limiting” N Environment		Yield difference (bu/A)
	Pre rate (lbs N/acre)	Yield (bu/A)	PRE + Adapt-N rates (total lbs N/acre)	Yield (bu/A)	
Clinton, IL	150	235	75 + 85 (160)	239	4
Mason City, IA	150	183	75 + 50 (125)	192	9
Oregon, IL	225	236	75 + 170 (245)	238	2
Seward, NE	150	259	75 + 85 (160)	261	2
Slater, IA	225	202	75 + 50 (125)	204	2

Table 3. Adapt-N recommendations in nitrogen limited environments and yield response

ADAPT-N RECOMMENDATIONS WHERE N WAS NOT LIMITED

Adapt-N recommendations were also validated where soil nitrogen was less limited by looking at scenarios in which the model called for additional nitrogen to be applied to the optimum preemergence nitrogen rate (Table 4). Optimal preemergence nitrogen rate yields (150 or 225 lbs N/acre depending on location) were compared to yields of treatments receiving incremental in-season nitrogen as a result of the Adapt-N recommendation. Adapt-N recommended additional nitrogen at 3 of 5 locations ranging from 40-55 lbs N/acre. Yield responses ranged from -1 to 7 bu/A across locations and were not significantly different from where no nitrogen was sidedressed. Adapt-N accurately did not recommend additional nitrogen at the other two locations. Little yield benefit was seen from sidedress applications at the 3 locations, although recommendations were in line with management practices routinely utilized by many growers.

Location	Optimum Preemergence N		Adapt-N Recommendation in “Non-Limiting” N Environment		Yield difference (bu/A)
	Pre rate (lbs N/acre)	Yield (bu/A)	PRE + Adapt-N rates (total lbs N/acre)	Yield (bu/A)	
Clinton, IL	150	235	150 + 40 (190)	242	7
Mason City, IA	150	183	No additional N recommended		-
Oregon, IL	225	236	225 + 40 (265)	238	2
Seward, NE	150	259	150 + 55 (205)	258	-1
Slater, IA	225	202	No additional N recommended		-

Table 4. Adapt-N recommendations in near optimal nitrogen environments and yield response

There are 2 clear conclusions from this test. First, when soil nitrogen level is below the minimum rate needed for optimum yield, the model accurately provided a nitrogen recommendation that delivered yield equivalent to the optimum yield for the site. Second, when soil nitrogen levels were close to the minimum rate for optimum yield, Adapt-N recommended no additional nitrogen or if recommended, a limited nitrogen rate was suggested to ensure the crop did not suffer nitrogen deficiency. This mentality is one that brings comfort to many corn growers as this represents an inexpensive insurance policy for yield yet minimizes nutrient losses and potentially negative environment impact.

REMOTE SENSING POTENTIAL FOR NITROGEN RECOMMENDATIONS

Chlorophyll meters were used to demonstrate the potential of remote sensing by collecting measurements from the uppermost collar leaf at V9-V10 corn growth stages. These results were used to calculate relative chlorophyll measurements (RCM) for each hybrid. Low RCM values indicate a lack of plant chlorophyll, which is highly correlated with nitrogen deficiency. Previous research published by Iowa State University (ISU)[4] and University of Nebraska (UNL)[5] was used to cross reference RCM values into nitrogen rate recommendations. Table 5 shows the average results for these recommendations as well as Adapt-N and the optimum nitrogen rate (bold font) at each site.

University recommendations derived from chlorophyll measurements appear conservative when compared to Adapt-N recommendations. Only one location (Oregon, IL) triggered a supplemental nitrogen recommendation following 75 lbs N/acre preemergence when using the UNL recommendations whereas ISU reference charts recommended additional nitrogen at 3 of 5 locations. The UNL guidelines are likely more suited for the irrigated western corn belt and may not be as well suited for the eastern corn belt.

Since we did not apply chlorophyll meter recommended nitrogen rates, it is more difficult to compare potential results. However, through use of earlier discussed Adapt-N treatments we can make some conclusions. Previous Adapt-N results (Table 4) validated the yield response when sidedressing additional in-season nitrogen

		Chlorophyll meter results			
Location	Pre* N rate	RCM** 10-lf stg	N recommendation (lbs/A)		
			ISU	UNL	Adapt-N
Clinton, IL	75	0.98	0	0	85
	150	0.99	0	0	40
	225	0.99	0	0	0
Mason City, IA	75	1.04	0	0	50
	150	1.12	0	0	0
	225	1.06	0	0	0
Oregon, IL	75	0.94	60	40	170
	150	0.98	0	0	105
	225	1.00	0	0	40
Seward, NE	75	0.97	30	0	85
	150	1.00	0	0	55
	225	1.01	0	0	0
Slater, IA	75	0.96	30	0	50
	150	0.96	30	0	0
	225	0.97	0	0	0

*__Bold font__ identifies minimum N rate required for optimum yield.
**RCM = relative chlorophyll meter value (low N value/ample N value)

Table 5. Comparison of handheld chlorophyll meter and Adapt-N nitrogen recommendations at 5 test locations averaged over 6 hybrids

following 75 lbs N/acre preemergence rates at Clinton and Mason City, although chlorophyll measurements called for no additional nitrogen applications at those sites.

Chlorophyll measurements at Oregon, Seward and Slater all correctly predicted the need for additional nitrogen following the preemergence 75 lbs N/acre rate. Chlorophyll meters did not recommend supplemental nitrogen following preemergence 150 lbs N/acre at Oregon, IL, although we know there was a statistical 12 bu/A increase in yield from sidedressing 105 lbs N/acre recommend by Adapt-N at that site (data not shown).

SUMMARY

Single applications of nitrogen shortly after planting can provide optimum yields when conditions delay preplant applications. Use of soil sampling, modeling, or remote sensing to determine soil nitrogen deficiencies are all viable options, each with pros and cons.

Adapt-N was simple to use and allowed users to incorporate production practices and tailor recommendations accordingly. It reliably detected soil nitrogen shortage or excess and provided a nitrogen recommendation that optimized corn yield. In conditions where nitrogen was less of a limiting yield factor, Adapt-N recommended small incremental rates to avoid deficiency.

The potential for remote sensing to identify when plants are under nitrogen stress also has much potential. The same principals of handheld meters have been applied to high speed equipment mounted sensors for quickly assessing field nitrogen status. Due to low nitrogen demand at early growth stages and remote sensor inability to measure nitrogen deficiency until being signaled by the plant, remote sensing will need to occur at 8-leaf or bigger corn. Requiring nitrogen sufficient strips to calibrate recommendations for deficient areas further complicates this approach. In contrast, early spring nitrate testing requires much earlier sampling (6-12-inch corn) in dry/moist soil conditions which can be challenging in some years.

SOIL SAMPLING AND FERTILITY

To manage fertility inputs for fields, it is important to frequently assess nutrient levels in the soil. Understanding soil sample results for key fertility components such as pH, nitrogen, phosphorus and potassium can help to make informed decisions around soil inputs. Fall soil sampling is a relatively inexpensive tool to help plan for the next crop season.

SOIL SAMPLING

Good soil sampling techniques can make a difference in receiving accurate test results and help with making the most economical decisions around fertility inputs. Avoiding sampling non-representative areas such as field edges and collecting an adequate number of samples will provide better information for making fertility decisions. Sampling can also be used to describe spatial variability with sampling strategies such as grid sampling or targeted management zone sampling based on soil types or historic yield productivity maps.[1] If nutrient variability is not well understood in a field, it may be worth the extra expense of high-density grid zone sampling the first time to get a high-resolution understanding of the variability that may exist. For instance, pulling 5 subsamples and mixing them together into one sample from the middle of one-acre grid-plots (Figure 1) will give a good distribution of pH, organic matter, cation-exchange capacity (CEC), phosphorous and potassium.[2]

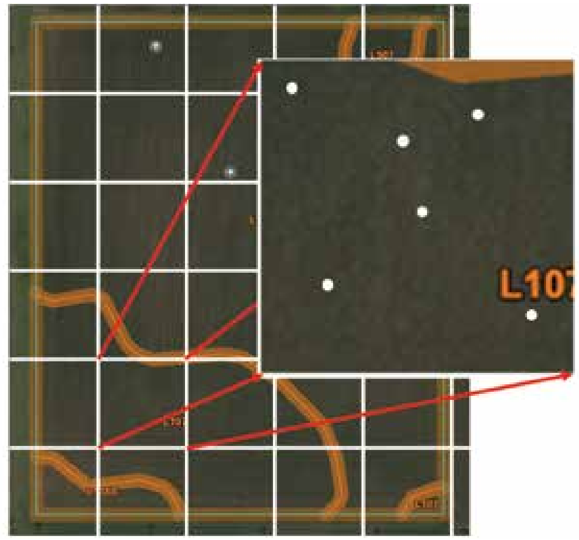


Figure 1. Example of grid soil sampling across a field

Once variability is better understood, less dense targeted sampling from defined management zones every 3-5 years can help understand how successful nutrient management has been (Figure 2). Targeted management zones can be created using multiple sources of historic information that describe patterns within the field. Historical yield maps, satellite and drone imagery, previous grid soil sample maps and prior management

Figure 2. Example of zone soil sampling

knowledge of the field are all examples of ways to create targeted soil sampling zones. Within defined management zones, collect 15 to 20 soil samples for every 20 acres and mix together into one sample to determine needed inputs for the specified zone.

Get the most out of soil samples by:

- Taking a sample from a field every 3 to 5 years
- Sample fields at the same time of year to help when comparing changes in nutrient levels
- Sampling after harvest when there are no crops in the field
- Avoiding sampling where inputs were recently applied (lime or fertilizer)
- Removing soil residue before sampling
- Allowing enough time for application and soil nutrient level adjustments to occur prior to next crop by sampling 3-6 months in advance of planting

UNDERSTANDING SOIL PH

Soil pH is described as the measure of acidity or alkalinity of the soil.[3] The pH scale is 1 to 14, where 7 is neutral. The type and amount of clay and organic matter content in the soil influences the hydrogen ion activity in the soil solution which is the basis of the soil pH result. Soil tests may show a buffer pH result which indicates the amount of agricultural lime required to neutralize the hydrogen ions from the soil. "Buffer" refers to the ability of the soil

to release acidity ions into the solution. For example, high clay soils are highly "buffered" and require more lime to raise pH to a certain level than sandy soils.

Field crops perform best at a soil pH between 6.0 – 6.8 depending on the crop, as the availability of some plant nutrients are affected by soil pH (Figure 3). Macro nutrients that appear to be less directly affected by soil pH are nitrogen (N), potassium (K), and sulfur (S), whereas phosphorus (P) is directly affected.[3]

Soil pH can decrease or become more acidic due to factors like nutrient removal by crops, leaching of basic nutrients (cations in the soil) or using ammonia-based nitrogen fertilizers. Adding liming materials can raise soil pH levels for ideal crop production where nutrients are more available to the plant and create a healthy environment for critical soil microbes.

ACTIVITY OF POTASSIUM AND PHOSPHORUS IN SOIL

Potassium (K) in the soil is typically unaffected by soil pH, but it may be limited by factors such as soil type, wetting and drying cycles, soil aeration and moisture.

Potassium Facts

- K is an exchangeable ion that easily binds with charged soil particles.[4]
- The only other nutrient absorbed in larger quantities than K is Nitrogen.
- K is vital to many plant functions and cycles back into the soil from crop residue with precipitation.
- Dry conditions limit the movement of K in the soil.

Another critical nutrient is phosphorus (P). Soil test results report P as an estimate of what is available to plants, not the total P in soil.

Phosphorous Facts

- P is frequently a limiting nutrient in crop production.
- Deficient soils often have adequate supply of P, but it is unavailable to the plant due to slow mineralization into a form that can be taken up by the plant.
- P moves very little in soil and does not leach even with large amounts of precipitation.[4]
- The pH of the soil solution impacts P availability because it changes the P form (usable ionic form or unusable form).
- Soil pH between 6.5 – 7.0 allows the most P availability in the soil solution.

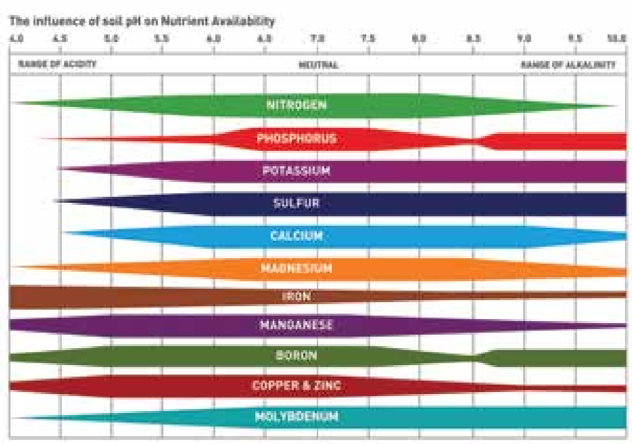


Figure 3. Nutrient availability across the pH scale

Understanding key nutrients and soil factors provides information on potential soil inputs to apply in order to maximize crop potential. Soil sampling allows a fine-tuned nutrient management plan to build healthy, resilient soils over time.

E-LUMINATE DIGITAL EXPERIENCE

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. With E-Luminate, you'll quickly assess field attributes and choose the best products and actions to support your seed decisions, from selection to successful harvest.

PRODUCT ANALYZER LITE

- Showcases all Syngenta® and Golden Harvest research in a tap or click, allowing you to see the breadth of product trialing while focusing on data at the local level
- Consolidates all field data characteristics into 1 convenient digital portal, including genetics, agronomy, environmental factors and soils
- Robust research technology equates to less comparison locations to provide alike performance results – Product Analyzer Lite uses proprietary methods to classify soils and weather environments, enabling you to compare similar locations

SEED SELECTOR

- Premier digital ag platform that calculates soil, climate and agronomy insights affecting yield, and ultimately the profit potential of seed selection options
- Designed to extrapolate seed characteristics across terrains and environmental pressures, this feature arms you with data-backed accuracy you can trust
- Seed recommendations reflect actual performance comparisons across hybrids and varieties, by year and region, based on precise statistical analysis

Figure 2. Seed selector example

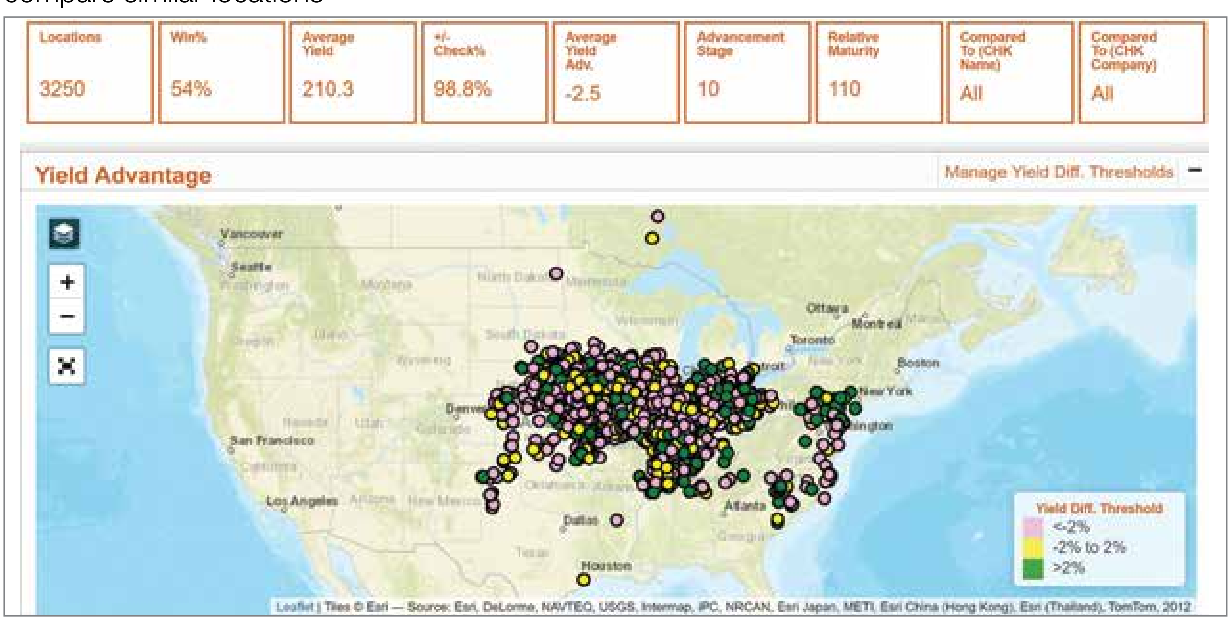


Figure 1. Product analyzer lite example

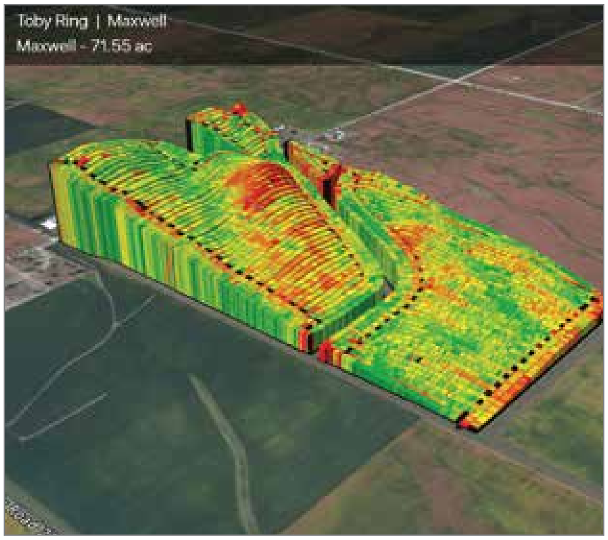


Figure 3. Decision hub example view

DECISION HUB

- The 3-D look and feel allows you to view your data differently than ever before, consolidating precision information for better decision making
- Integration with the John Deere® Operations Center offers an automatic and seamless assimilation with yield data to further improve seed decisions
- As of 2020, harvest data can be automatically shared with Golden Harvest Seed Advisors via E-Luminate to determine tailored seed decisions for the season ahead

FIELD-SPECIFIC WEATHER RADAR

- Builds off 20 years of weather data on a fieldby-field basis to identify environmental patterns

Figure 4. Field-specific weather radar example

- Evaluates environmental factors such as precipitation, wind, humidity and dew point to allow more educated management decisions
- Available as a mobile-friendly app that allows you to see real-time Doppler radar weather insights as you walk from one field to another, or perhaps sit back in the comfort of your home

SATELLITE AND DRONE FIELD IMAGERY

- Illustrates close-up analysis of detailed satellite and drone field imagery
- Digitally maps out potential signs of diseases, pests and poor nutrition, reducing the area that needs to be covered by on-site scouting up to 90%
- With blazing-fast, high-resolution imagery, detecting crop problems and resolving field issues is easier than ever

Figure 5. Satellite and drone field imagery view

Contact your Golden Harvest Seed Advisor or find one near you at GoldenHarvestSeeds.com to enhance your corn and soybean product placement.

PYTHIUM IN CORN AND SOYBEANS

Among the most important seed and seedling diseases in US 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] Pythium is often the first pathogen active in the US 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 US corn and soybean production? Many factors promote Pythium infection but cooler, wetter conditions are most conducive. 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 that 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.

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 loss.[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 soil-borne 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.

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

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 allowing 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] 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. 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 and 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 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]

Figure 3. Corn plant lost to Pythium postemergence damping off

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 getting nourishment from dead or decaying organisms, can occur for many years.[6] Under favorable conditions, oospores germinate and produce mycelium or sporangia which produce and then release zoospores. Both mycelium 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. A more recent addition to the fungicides effective against these pathogens has been the commercialization of ethaboxam. Very limited choices are available beyond these two options for broad-spectrum activity across the diverse Pythium species spectrum.[1,6] New entries to the oomycete (the group that includes Pythium) fungicide market have been very limited over the last 40 years and innovations are needed to properly steward currently available options. By protecting from primary pathogen infection, germination, early plant growth and seedling development is 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]

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.

Low and High Seed Vigor Lab Testing Samples

The agronomic value of a perfect corn stand emerging evenly over a 24-48-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.

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. 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. 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

INDUSTRY SEED VIGOR TESTING TECHNIQUES

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

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 germ, 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. 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 comparison 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.

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.

Ultimately, Golden Harvest stands behind every unit of seed to be of the best quality.

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 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 lower vigor test result. The lack of 3rd party testing calibration for specific germplasm behavior has to be considered.

WEED RESISTANCE MANAGEMENT

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

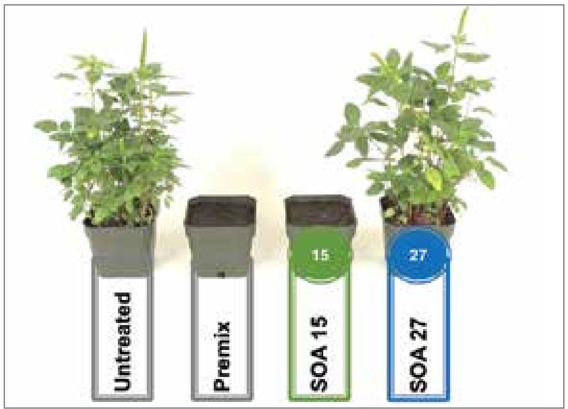
3. ***Multiple Effective SOA With Overlapping Residuals –*** Target-weed control is nearly impossible without good residual herbicide activity. Overlapping residual activity is the best way to manage resistant weeds. This means applying a second residual herbicide before the residual activity of the 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 27 active ingredient brought no agronomic value.



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

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 quick 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 up 70 years.

6. ***Good Agronomic Practices –*** Narrow rows, increased plant populations and other practices promote faster canopy closure and enable the crop to out compete 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
- Use premixes that deliver multiple effective SOA on driver weeds, or hard-to-control weeds.
- Resistance can be managed. It is in your control.

REFERENCES

CORN DEVELOPMENT AND MANAGEMENT

Seeding Rate Management to Optimize Corn Yields

[1] Westgate, M., F. Forcella, D. Reicosky and J. Somsen. 1997. Rapid canopy closure for maize production in the northern US Corn Belt: radiation-use efficiency and grain yield. Field Crops Research 49:249-258.

[2] Porter, P., D. Hicks, W. Lueschen, J. Ford, D. Warnes and T. Hoverstad. 1997. Corn response to row width and plant population in the northern Corn Belt. J. Prod. Agric. 10:293-300.

[3] Widdicombe, W. and K. Thelen. 2002. Row width and plant density effects on corn grain production in the northern Corn Belt. Agron. J. 94:1020-1023.

[4] Farnham, D. 2001. Row spacing, plant density, and hybrid effects on corn grain yield and moisture. Agron. J. 93:1049-1053.

[5] Licht, M., Parvej, M. and E. Wright. 2019. Corn yield response to row spacing and plant population in Iowa. Crop, Forage, & Turfgrass Management. 5:0032. doi:10.2134/cftm2019.05.0032

Early Season Drought Stress on Corn

[1] Nielsen, R. 1996. Some of those corn plants are thirsty! Pest Management and Crop Production Newsletter, Purdue University Extension. https://www.agry.purdue.edu/ext/corn/news/articles.96/p&c9633.htm

[2] Licht, M. and S. Archontoulis. 2017. Influence of drought on corn and soybean. Integrated Crop Management News, Iowa State University Extension. https://crops.extension.iastate.edu/cropnews/2017/07/influence-drought-corn-and-soybean

[3] Heiniger, R. 2018. The impact of early drought on corn yield. Corn Production Kernels, North Carolina State Extension. https://corn.ces.ncsu.edu/corn-production-information/the-impact-of-early-drought-on-corn-yield/

Soil Compaction and its Effect on Corn Growth

[1] Duiker, S. 2005. Effects of soil compaction. Penn. State University Extension. https://extension.psu.edu/effects-of-soil-compaction

[2] Dyck, J. 2017. Soil compaction: stay off the field until the soil is ready. Ontario Ministry of Agriculture, Food and Rural Affairs. http://fieldcropnews.com/2017/05/soil-compaction-stay-off-the-field-until-the-soil-is-ready/

[3] DeJong-Hughes, J. 2018. Soil compaction. University of Minnesota Extension. https://extension.umn.edu/soil-management-and-health/soil-compaction

[4] Stewart, J. 2013. Purdue agronomist: don't fall for the three tillage temptations. Purdue University. https://www.purdue.edu/newsroom/releases/2013/Q2/purdue-agronomist-dont-fall-for-the-three-tillage-temptations.html

[5] Wolkowski, R. Identifying and managing soil compaction in field crop production. University of Wisconsin Extension. https://fyi.extension.wisc.edu/forage/identifying-and-managing-soil-compaction-in-field-crop-production/

[6] Duiker, S. 2005. Avoiding soil compaction. Penn. State University Extension. https://extension.psu.edu/avoiding-soil-compaction

Volunteer Corn Management

[1] Underwood M., N. Soltani, D. Hooker, D. Robinson, J. Vink, C. Swanton, and P. Sikkema. 2016. The addition of dicamba to POST applications of quizalofop-p-ethyl or clethodim antagonizes volunteer glyphosate-resistant corn control in dicamba-resistant soybean. Weed Technology, 30(3), 639-647.

Corn Response to Western Corn Belt High pH Soils

[1] Bickelhaupt, D. Soil pH: what it means. State University of New York, College of Environmental Science and Forestry. https://www.esf.edu/pubprog/brochure/soilph/soilph.htm

[2] Goldy, R. 2011. Understanding soil pH, Part I. Michigan State University Extension. https://www.canr.msu.edu/news/understanding_soil_ph_part_i

[3] Paulitz, T. and K. Schroeder. 2016. Acid soils: how do they interact with root diseases? Washington State University Extension. http://pubs.cahnrs.wsu.edu/publications/wp-content/uploads/sites/2/publications/fs195e.pdf

[4] Stanton. M. 2012. Managing soil pH for optimal soybean production. Michigan State University Extension. https://www.canr.msu.edu/news/managing_soil_ph_for_optimal_soybean_production

Solar Radiation: Effect on Corn Yield or Standability

[1] Liu, W. and Tollenaar, 2009. Physiological mechanisms underlying heterosis for shade tolerance in maize. Crop Sci. 49:1817-1826.

[2] Reed, A., G. Singletary, J.Schussler, D. Williamson and A. Christy, 1988. Shading effects on dry matter and nitrogen partitioning, kernel number, and yield of maize. Crop Sci. 28: 819-825.

CORN INSECT AND DISEASE MANAGEMENT

Western Bean Cutworm

[1] Purdue University. 2009. Western bean cutworm. Field Crops IPM. https://extension.entm.purdue.edu/fieldcropsipm/insects/western-bean-cutworm.php

[2] Seymour, R., G. Hein, R. Wright. 2010. Western bean cutworm in corn and dry beans. Nebraska Extension, NebGuide G2013. http://extensionpublications.unl.edu/assets/html/g2013/build/g2013.htm

Tar Spot of Midwestern Corn

[1] Crop Protection Network. 2019. Corn Disease Management, Tar Spot, CPN-2012, https://crop-protection-network.s3.amazonaws.com/publications/tar-spot-filename-2019-03-25-120313.pdf

[2] Hock J. J.Kranz, and B.L. Renfro. 1995. Studies on the epidemiology of the tar spot disease complex of maize in Mexico. Plant Path. 44:490-502.

[3] Bajet, N.B., B.L. Renfro, J.M. Valdez Carrasco. 1994. Control of tar spot of maize and its effect on yield. International J. of Pest Man. 40:121-125.

Physoderma Brown Spot and Stalk Rot in Corn

[1] Robertson, A. 2015. Physoderma brown spot and stalk rot. Integrated Crop Management News, Iowa State University Extension. https://crops.extension.iastate.edu/cropnews/2015/07/physoderma-brown-spot-and-stalk-rot

[2] Kleczewski, N. 2018. Physoderma brown spot and node rot in corn. Illinois Field Crop Disease Hub, University of Illinois Extension. http://cropdisease.cropsciences.illinois.edu/?p=792

SOYBEAN DEVELOPMENT AND MANAGEMENT

Soybean Seed Treatment: What's on Your Seed?

[1] The Seedcare Institute. http://www.syngenta-us.com/crop-protection/seed-treatment

[2] Esker, P. and S. Conley. 2012. Probability of return on investment with using soybean seed treatments. Cool Bean Advisor. www.coolbean.info/library/documents/Seed_Trt_Prob.pdf

Factors Influencing Soybean Planting Date Response

[1] Hu, M. and P. Wiatrak. 2012. Effect of planting date on soybean growth, yield, and grain quality. Review. Agronomy Journal 1004:785-790. doi:10.2134/agronj2011.0382.

[2] Pedersen, P. Soybean planting date. Iowa State University. https://crops.extension.iastate.edu/files/article/PlantingDate_000.pdf

[3] Specht, J., J. Rees, G. Zoubek, K. Glewen, B. VanDeWalle, J. Schneider, D. Varner and A. Vyhnalek. 2012. Soybean planting date – when and why. University of Nebraska-Lincoln Extension. EC145. http://extensionpublications.unl.edu/assets/pdf/ec145.pdf

[4] Boyer, C., M. Stefanini, J. Larson, S. Smith, A. Mengistu and N. Bellaloui. 2015. Profitability and risk analysis of soybean planting date by maturity group. Agronomy Journal 107:2253-2262. doi:10.2134/agronj15.0148

Soybean Herbicide Trait and Tolerance Response

[1] Hartzler, B. 2004. Sulfentrazone and flumioxazin injury to soybean. Iowa State University Extension. http://extension.agron.iastate.edu/weeds/mgmt/2004/ppoinjury.shtml

Soybean Yield Response to Management Strategies

[1] Hanway, J. and H. Thompson. 1967. How a soybean plant develops. Special Report, 62. Iowa State University Repository. https://lib.dr.iastate.edu/specialreports/62/

[2] Mueller, D. and K. Pecinovsky. 2010. Effect of fungicides and plant populations on soybean disease and yield. Iowa State Research Farm Progress Reports. 387. http://lib.dr.iastate.edu/farms_reports/387

[3] Licht, M. Accessed 2019. Soybean plant population. Integrated Crop Management Encyclopedia Article. Iowa State University. https://crops.extension.iastate.edu/encyclopedia/soybean-plant-population

SOYBEAN INSECT AND DISEASE MANAGEMENT

Soybean Cyst Nematode and Actions to Reduce Damage

[1] Wrather, J.A., T.R. Anderson, D.M. Arsyad, J. Gai, L.D. Ploper, A. Porta-puglia, H.H. Ram and J.T. Yorinori. 1997. Soybean disease loss estimates for the top 10 soybean producing countries in 1994. Plant Dis. 81:107-110.

[2] University of Illinois. 1991. The soybean cyst nematode problem. Report on Plant Disease. RPD 501. http://ipm.illinois.edu/diseases/series500/rpd501/

[3] Pedersen, P. Managing soybean cyst nematode. Iowa State University. https://crops.extension.iastate.edu/files/article/SCN_000.pdf

[4] Schmitt, D.P., J.A. Wrather and R.D. Riggs. 2004. Biology and management of soybean cyst nematode. 2nd Edition. Schmitt & Associates of Marceline.

[5] Niblack, T.L. and G.L. Tylka. SCN management guide 5th Edition. Plant Health Initiative – A North Central Soybean Research Program.

[6] Tylka, G. L. 2012. Soybean cyst nematode field guide 2nd Edition – Iowa State University Extension and Outreach.

[7] Faghihi, J., and V. R. Ferris. 2006. Soybean cyst nematode. Department of Entomology. Purdue University.

[8] Creech, J. E., and W. G. Johnson. 2006. Survey of broadleaf winter weeds in Indiana production fields infested with soybean cyst nematode (Heterodera glycines). Weed Technol. 20:1066-1075.

[9] Mock V.A., J.E. Creech, B. Johnson, J. Faghihi, V.R. Ferris, A. Westphal and K. Bradley. 2007. Winter annual weeds and soybean cyst nematode management. Purdue University Extension bulletin WS-36.

Bean Leaf Beetle on Soybeans

[1] Hodgson, E., J. Bradshaw, M. Rice. 2017. Bean leaf beetle. Iowa State University Extension and Outreach. https://crops.extension.iastate.edu/bean-leaf-beetle

[2] Smelser, R., and L. Pedigo. 1992. Bean leaf beetle (Coleoptera: Chrysomelidae) herbivory on leaf, stem, and pod components of soybean. Journal of Economic Entomology 85: 2408–2412.

[3] Hadi, B., J. Bradshaw, M. Rice, and J. Hill. 2012. Bean leaf beetle (Coleoptera: Chrysomelidae) and bean pod mottle virus in soybean: Biology, ecology, and management. Journal of Integrated Pest Management 3(1).

White Mold in Soybeans

[1] Crop Protection Network. 2015. Soybean Disease Management, White Mold, CPN-1005. https://www.soybeanresearchinfo.com/pdf_docs/WhiteMold_CPN1005_2015.pdf

Japanese Beetle Identification and Management in Soybeans

[1] Purdue University, 2009. Japanese beetle, Popillia japonica Newman. Field Crops IPM. 2009. https://extension.entm.purdue.edu/fieldcropsipm/insects/soybean-japanese-beetle.php

[2] University of Illinois at Urbana Champaign. Japanese beetle. http://extension.cropsciences.illinois.edu/turf/insects/japanese_beetle/

[3] Wright, R. 2017. Japanese beetles emerging in corn and soybean. CropWatch, University of Nebraska. https://cropwatch.unl.edu/2017/japanese-beetles-soybean

Seed Treatment Options for Soybean Sudden Death Syndrome

[1] Westphal, A., T.S. Abney, L.J. Xing, and G.E. Shaner. Sudden death syndrome of soybean. 2008. The Plant Health Instructor. DOI:10.1094/PHI-I-2008-0102-01.

[2] Soybean Research and Information Network. 2019. https://soybeanresearchinfo.com/soybean-disease/sudden-death-syndrome/

[3] Crop Protection Network. 2016. Sudden death syndrome of soybean. https://cropprotectionnetwork.org/resources/articles/diseases/sudden-death-syndrome-of-soybean

[4] Collins, A, and A. Murillo-Williams. 2018. Soybean sudden death and brown stem rot: how to tell the difference. Penn State Extension. https://extension.psu.edu/soybean-sudden-death-and-brown-stem-rot-how-to-tell-the-difference

HARVEST MANAGEMENT

Harvesting Soybeans at Higher Moisture to Maximize Yield

[1] Philbrook, B. and E. Oplinger. 1989. Soybean field losses as influenced by harvest delays. Agron. J. 81:251-258.

[2] Dorn T. 2009. Harvest soybeans at 13% moisture. CropWatch. University of Nebraska-Lincoln. https://cropwatch.unl.edu/harvest-soybeans-13-moisture

Timing Harvest Decisions Based on Corn Drying Method

[1] Nielsen, R. 2018. Field Drydown of Mature Corn Grain. Corny News Network. Purdue University. https://www.agry.purdue.edu/ext/corn/news/timeless/GrainDrying.html

Yield Monitor Preparation for Harvest

[1] Nielsen, R. 2017. Yield monitor calibration: garbage in, garbage out. Corny News Network, Purdue University. https://www.agry.purdue.edu/ext/corn/news/timeless/yldmoncalibr.html

[2] Pennington, D. 2016. Yield monitor calibration procedure. Michigan State University Extension. https://www.canr.msu.edu/news/yield_monitor_calibration_procedure

[3] Hawkins, E., J. Fulton, and K. Port. 2017. Tips for calibrating grain yield monitors – maximizing value of your yield data. The Ohio State University. ANR-8. https://ohioline.osu.edu/factsheet/anr-8

[4] Luck, J. and J. Fulton. 2014. Best management practices for collecting accurate yield data and avoiding errors during harvest. University of Nebraska Extension, EC2004. http://extensionpublications.unl.edu/assets/pdf/ec2004.pdf

FERTILITY MANAGEMENT

Soil N Modeling and Remote Sensing for Monitoring Nitrogen Deficiency

[1] Iowa State University Extension and Outreach. 2017. Use of the late-spring soil nitrate test in Iowa corn production, CROP 3140. file:///C:/Users/s965959/Downloads/CROP3140.pdf

[2] Morris, T. et. al. 2017. Strengths and limitations of nitrogen rate recommendations for corn and opportunities for improvement. Agronomy Journal Vol. 110 p. 1-37. https://dl.sciencesocieties.org/publications/aj/articles/110/1/1

[3] Sawyer, J. 2013. Options for in-season adjustment of nitrogen rate for corn. Integrated Crop Management Conference, Iowa State University. http://www.agronext.iastate.edu/soilfertility/info/In-Season-N_2013ICM.pdf

[4] Sawyer, J., J. Lundvall, J. Hawkins, D. Barker. 2011. Sensing nitrogen stress in corn. PM 2026. Iowa State University Extension. https://store.extension.iastate.edu/product/Sensing-Nitrogen-Stress-in-Corn

[5] Shapiro, C., D. Francis, R. Ferguson, G. Hergert, C. Wortmann. 2006. Using a chlorophyll meter to improve N management, G1632. University of Nebraska. http://extensionpubs.unl.edu/publication/9000016363832/using-a-chlorophyll-meter-to-improve-n-management/

Soil Sampling and Fertility

[1] Ackerson, J. 2018. Soil sampling guidelines. Purdue University Extension. AY-368-W. https://www.extension.purdue.edu/extmedia/AY/AY-368-w.pdf

[2] Ferguson, R. and G. Hergert. 2000. Soil sampling for precision agriculture. University of Nebraska Extension. EC 00-154. https://cropwatch.unl.edu/documents/Soil%20Sampling%20for%20Precision%20Agriculture%2C%20EC154.pdf

[3] Jensen, T. Soil pH and the availability of plant nutrients. IPNI Plant Nutrition TODAY, Fall 2010, No. 2. http://www.ipni.net/publication/pnt-na.nsf/0/013F96E7280A696985257CD6006FB98F/$FILE/PNT-2010-Fall-02.pdf

[4] Shaver, T. (ed.) 2014. Nutrient management for agronomic crops in Nebraska. University of Nebraska Extension. EC155. http://extensionpublications.unl.edu/assets/pdf/ec155.pdf

GENERAL MANAGEMENT

Pythium in Corn and Soybean

[1] Hartman, G., J.Sinclair and J. Rupe, eds. 1999. Compendium of Soybean Diseases, 4th Edn. Am Phytopath Soc, St. Paul, Minnesota.

[2] Sprague, G. and J. Dudley, eds. 1988. Corn and Corn Improvement. 3rd edition. Am Soc of Agron. Madison, Wisconsin.

[3] Broders, K., P. Lipps, P. Paul and A. Dorrance. 2007. Characterization of Pythium spp. associated with corn and soybean seed and seedling disease in Ohio. Plant Dis. 91:727-735.

[4] Chilvers, M., A. Rojas, J. Jacobs, A. Robertson and R. Matthiesen-Andersen. 2013. Pythium, seedling disease of soybean and more. Integrated Crop Management Conference – Iowa State University 2013. Ames, Iowa.

[5] Matthiesen, R., A. Ahmad and A. Robertson. 2016. Temperature affects aggressiveness and fungicide sensitivity of four Pythium spp. that cause soybean and corn damping off in Iowa. Plant Disease 100: 583-591.

[6] White, D. ed. 1999. Compendium of Corn Diseases, 3rd Edn. Am Phytopath Society, St. Paul, Minnesota.

[7] Van Doren, D., G. Triplett and J. Henry. 1976. Influence of long term tillage, crop rotation and soil type combinations on corn yield. Soil Sci Soc Am J 40:100-105.

[8] Wade, T., R. Claasen and S. Wallander. 2015. Conservation-practice adoption rates vary widely by crop and region. Economic Information Bulletin Number 147. USDA Economic Research Service.

[9] Wilcox, J.R. ed. 1987. Soybeans: improvement, production and uses. 2nd Edn. Am Soc of Agron. Madison, Wisconsin.

Weed Resistance Management

[1] Evans et.al. 2016. Managing the evolution of herbicide resistance. Pest Management Sci. 72(1):74-80.

[2] Gerber, C., J. Ackerson, and S. Brouder. 2019. Purdue Extension publication ID-179. Corn & Soybean Field Guide.

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SLC 12399A 01-27-2020