Liqui Grow®
BALANCED FERTILIZERS

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Davenport, IA 52807

Agronomy Research Summary 2019

QR SCAN
Banded Suspended Fertilizer Explained

improve your yields and profits with

Science Driven Decisions

Authored by our Agronomy Researchers

Dr. Jake Vossenkemper
Dr. Brad Bernhard

Family Owned and Operated Since 1958

Founded in Iowa by the Tinsman brothers, Hovey and Scott, Liqui-Grow developed a manufacturing process for clear liquid fertilizer analysis for the agricultural market in eastern Iowa and northwestern Illinois. Since then, we have grown to include three production plants, sixteen retail locations, and a network of dealers that serve our customers in the Midwest.

We are wholly committed to the 4 R's and provide farmers with the right fertilizer, at the right rate, in the right place, at the right time.

As agriculture continues to rapidly change, we strive to provide innovative crop solutions, quality nutrient products, knowledgeable staff, and dependable service to satisfy our growers' needs.

The 4Rs of Nutrient Stewardship

examples of 4R practices which help keep nutrients in the root zone when crops need them

RIGHT SOURCE

match fertilizer type to crop needs

- Avoid surface broadcasting urea-based fertilizers if soil incorporation is not possible.
- Apply ammonium thiosulfate with UAN to slow nitrification and N loss via nitrate.
- Apply nitrification inhibitors (Instinct II, N-Serve) with pre-plant nitrogen source.

RIGHT TIME

nutrients available when crops need them

- Apply nitrogen only in the spring to reduce nitrogen loss.
- Split apply nitrogen to increase plant availability.
- Do not apply phosphorous to frozen soils that are moderately or steeply sloping.

RIGHT RATE

match amount of fertilizer to crop needs

- Utilize current soil sampling to determine fertilizer P&K rates.
- Use the N-Rate calculator (cnrc.agron.iastate.edu) to determine economically optimum N rates for corn.
- Manage fertilizer (P&K) inputs based on historical crop removal to match fertilzer needs with crop demand.

RIGHT PLACE

keep nutrients where crops can use them

- Incorporate or subsurface place phosphorus and nitrogen sources when possible.
- Band fertilizer to increase plant uptake - nutrients in plants cannot be readily lost.
- Use precision guidance technology to place nutrients where they are needed.

Our Agronomy Research Team

Science Driven Decisions

Dr. Jake Vossenkemper

Agronomy Research Lead

Our Agronomy Research Lead Dr. Jacob Vossenkemper earned a Master of Science in the Plant and Soil Sciences from Oklahoma State University and a Doctorate of Philosophy in Crop Sciences from the University of Illinois. You will not find an individual more passionate than Dr. Vossenkemper about helping farmers make practically minded science based management decisions. He has been conducting applied crop management research and presenting his research findings to farmers for over 12 years.

Before joining Liqui-Grow as our Agronomy Research Lead in 2015, Dr. Vossenkemper was a research fellow at the University of Illinois in the Department of Crop Sciences and an Agronomy Research Manager for DuPont Pioneer. Dr. Vossenkemper brings an extraordinary wealth of knowledge and experience to the Liqui-Grow team.

We are proud to have him as a leader in our organization and look forward to sharing what he continues to learn about corn and soybean production with our valued customers for their own continued future success.

Dr. Brad Bernhard was born and raised on his family's hog and grain farm in northeast Illinois. Upon completion of his Bachelor's degree in Crop Sciences from the University of Illinois, Brad received his Masters degree under the advisement of Dr. Fred Below in the Crop Physiology Laboratory studying the use of innovated foliar micronutrient sources in high yielding corn and soybean production systems. Brad continued in Dr. Below's program at the University of Illinois and earned a Ph.D. focusing on in-season fertility using different fertilizer sources and application methods. In addition, he investigated ways to manage higher corn planting densities using narrower row spacings along with characterizing hybrids for use in these more intensive cropping systems.

Dr. Bernhard's past experience includes managing a field research program conducting over 15,000 plots a year. He brings his strong background in agronomy and crop physiology to the Liqui-Grow team.

Dr. Brad Bernhard

Agronomy Research Manager

Dear Valued Customers:

Liqui-Grow has a proud history of manufacturing superior fertility products along with making recommendations to our customers based on evidence from internal or university research trials. This started as early as the 1960s, when it was clearly recognized that broadcasting liquid suspensions was a mechanism to deliver phosphorus and potassium fertilizer much more uniformly than broadcasting dry fertilizer with spinner spreader machines. In the mid 1970s, Liqui-Grow transitioned to banding liquid suspensions following findings from Midwestern university crop scientists that showed concentrating fertilizer in bands resulted in greater overall nutrient uptake and crop yields for both corn and soybeans. In the mid 1990s the company made the strategic decision in the interest of our customers to stop selling fall applied anhydrous ammonia, given the overwhelming evidence that applying fall nitrogen sources results in poor nitrogen fertilizer recovery, lower crop yields and higher nitrate concentrations in drinking and river waters compared to spring or in-season nitrogen fertilizer applications.

As a result of Liqui-Grow's historical commitment to manufacturing superior fertility products and making science based recommendations to their customers, I joined Liqui-Grow in the spring of 2015 in a leadership role helping to direct their future agronomy decisions and research.

The idea for this publication is to highlight some of the crop management and product comparison research that Liqui-Grow is conducting on our customers' behalf. Like our customers, we have many potential vendors and product manufacturers to choose from and we are interested in bringing to market those products or practices that provide our customers the largest return on their investment.

In the 2019 growing season, we implemented **2,200 plots across 6 locations.**

In the 2019 growing season, Brad and I conducted 14 different experiments and had research at 6 different locations (not all experiments were at each location) dispersed throughout eastern IA and northwest IL testing new products and crop management practices. At each location treatments are replicated at least 4 times and follow strict principles of experimental design so that fair comparisons between products or practices can be made.

Brad and I hope that the information presented in this publication can help our customers make informed management decisions that increase net profitability and lower production risks.

Sincerely,

Jacob P. Vossenkemper, Ph.D.

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What Are Liquid Suspension Fertilizers?

Should I Consider them for my farm?

authored by
Dr. Jake Vossenkemper

Liquid Fertilizers – Some Unique Advantages

Liquid fertilizers offer unique advantages over dry granular fertilizers. Liquid fertilizers can be applied extremely accurately, can be tank-mixed with many different pesticides, and micro nutrients can be evenly blended in liquid solutions. These factors result in uniform nutrient application for both macro and micro nutrients, and increased profitability due to higher crop yields and fewer trips across a field when compared to dry granular fertilizers.

Liquid Suspension Fertilizers – Unique Advantages at Affordable Costs

Liquid suspension fertilizers provide the same agronomic and economic advantages as clear liquids (starter fertilizer, foliar sprays, those used in drip tape or over the top irrigation systems), but are more reasonably priced than clear liquids.

How can this be?

FIRST: the phosphoric acid used to make the phosphorus fertilizer source in liquid suspensions takes fewer manufacturing/processing steps than the phosphoric acid used to make starter fertilizer-grade clear liquids.

SECOND: in liquid suspensions, a small amount of clay is used to keep fertilizers suspended in a liquid solution. This is particularly important for the potassium source used to make liquid suspension fertilizers.

Article Summary

- Liquid fertilizers offer some unique advantages compared to dry granular fertilizers:
  - Accurate nutrient application distribution
  - Can be tank mixed with many pesticides
  - Macro & micro nutrients can be evenly blended
  - Can be easily surface or subsurface banded
- Liquid suspension fertilizers offer the same unique advantages as starter grade clear liquids but are cost competitive with dry granular fertilizers.
- A recent summary of 39 science-based studies showed that banding fertilizer reduced phosphorus fertilizer fixation in the soil, caused roots to concentrate in nutrient rich fertilizer bands, and resulted in increased nutrient uptake and 4.5% higher corn yields.
- Local on-farm research shows that surface banding liquid suspension fertilizers increases corn yields by 5 bu/ac and profitability by 17.2 $/ac compared to broadcasting equivalent rates of dry granular fertilizer.

For example, without the added clay, only about 1 lb of potassium chloride could be dissolved in 1 gallon of water, but with the addition of a small amount of clay, that same 1 gallon of water can hold about 3 lbs of potassium chloride. Liquid suspensions are higher analysis fertilizers (higher % plant nutrients per/gallon material), which reduces transportation costs. When lower transportation cost are paired with more cost-effective raw materials, liquid suspensions can be priced lower than clear liquids, and are cost-competitive with dry granular phosphorus and potassium fertilizers.

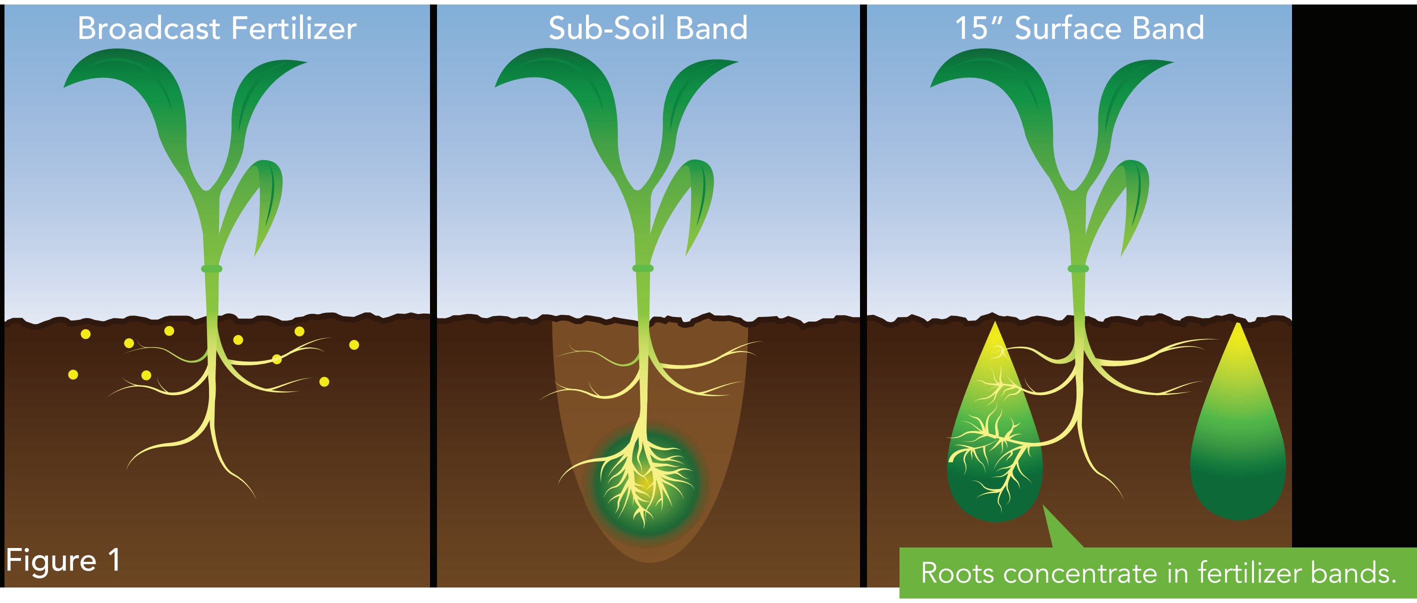


Figure 1

Table 1

Fertilizer Source	N-P-K-S-Zn-B Rate lb/ac	Yield bu/ac	Fertilizer Cost	Net Return $/ac
Liquid Dribble Band	21-50-75-15-0.5-0.2	242.1	47.6	**+ 17.2** $/ac Liquid Dribble Band
Dry Broadcast		237.1	44.7	

Banding Liquid Suspensions for Increased Fertilizer Nutrient Uptake and Crop Yields

Besides being cost-effective, liquid suspensions are extremely easy to surface or subsurface band. Banding nutrients achieves two goals: reduced phosphorus fertilizer fixation with Ca^{2+}, Al^{3+}, and Fe^{3+}, and roots become highly concentrated in nutrient-rich fertilizer bands (Figure 1).

As a result of reduced phosphorous fertilizer fixation (tied up in non-plant-available forms) and increased root activity in nutrient-rich fertilizer bands, the amount of applied fertilizer that is taken up by both corn and soybean crops is increased. In fact, a group of crop scientists recently organized 39 science-based studies with the objective of comparing the effects of banding vs broadcasting fertilizer sources on nutrient uptake and crop yields (Nkebiwe et al. 2016).

Averaged over 112 comparisons of banded vs broadcasted fertilizer sources, they found that banding increased relative nutrient (N+P+K+S) uptake 12.2% and corn yields 4.5% compared to broadcasting the same fertilizer sources and rates.

Avg over 112 comparisons of banded vs broadcasted fertilizer, they found that banding **increased relative nutrient (N+P+K+S) uptake** by **12.2%** & **corn yields by 4.5%.**

Even Modern Spinner Spreaders Can Not Accurately Distribute Dry Fertilizer

Despite many advancements in agricultural machinery, dry spinner spreaders remain incapable of accurately distributing dry fertilizer across each swath/pass. The reason why dry fertilizer can still not be evenly distributed is due to dry fertilizer quality (differences in size, shape, and density of individual fertilizer prills), dry fertilizer segregation, increasingly wider swaths and infrequent calibration. For example, ag engineers and equipment manufacturers recommend recalibration when rates change significantly, when humidity changes (humidity changes dry fertilizer followability, i.e. the way fertilizer feeds into spinner discs) and when changing from one dry fertilizer source to another (MESZ to DAP for example). Unfortunately, tight application windows make frequent recalibration not practical, and therefore often does not get performed even when needed. Other factors such as cross winds, variable rate applications (VR = significant rate changes) and sloping topography are also contributing factors that make it difficult to accurately spread dry fertilizer in real field situations.

In fact, a recent Ohio State University study shows that even the most modern dry fertilizer applicators with recent calibration are still incapable of achieving accurate dry fertilizer applications (Colley et al., 2018). In this particular Ohio State University study, the applicator was calibrated to apply 226 lbs/ac of DAP (104 lbs/ac P_2O_5) across a 100 ft swath. The ag engineers at Ohio State, however, found that the middle 50 ft of the 100 ft swath only received approximately 142 lbs/ac of DAP (Figure 1). In other words, about 84 fewer lbs/ac of DAP (39 lbs/ac P_2O_5) than what the machine was calibrated to apply. These inaccurate dry fertilizer applications can no doubt lead to corn and soybean yield reductions when concentrations of phosphorus and potassium in the soil are at or below optimum concentrations.

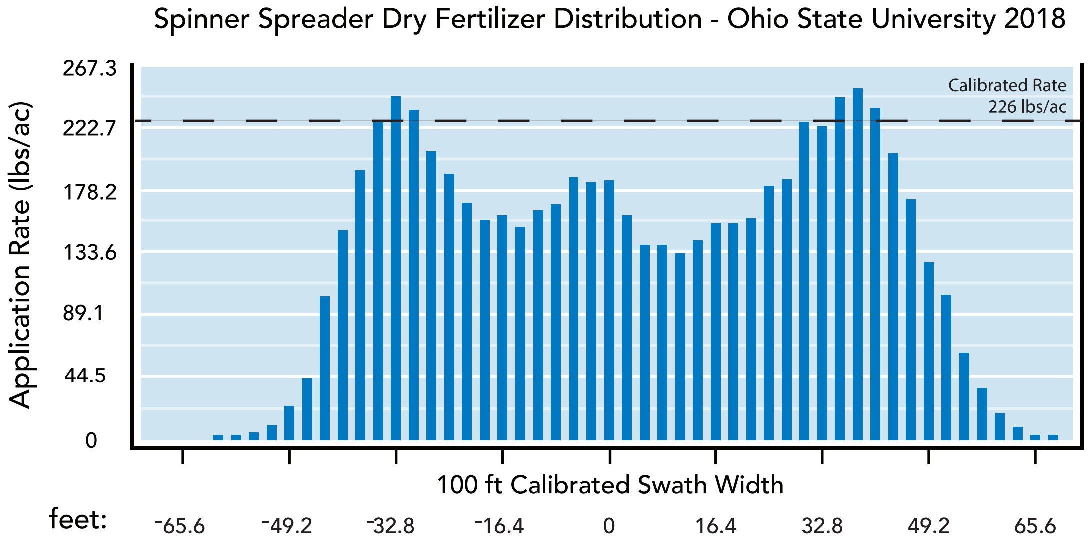


Figure 1. DAP distribution from a modern dry fertilizer spinner spreader calibrated to apply across a 100 ft swath. Figure originated from Colley et al., 2018.

Advantages / Disadvantages

- **Broadcasting** Advantages
  - + Many acres can be covered rapidly
  - + Low application costs

- **Broadcasting** Disadvantages
  - – Application uniformity is poor & can result in reduced crop yields
  - – Broadcasting results in fertilizer fixation in the soil & lower crop nutrient uptake when compared to banding fertilizer
  - – Blended dry fertilizers sift or segregate during transportation and handling which can lead to lower or higher fertilizer application rates than intended

- **Subsurface Banding** Advantages
  - + Application uniformity is very consistent
  - + Replenishes subsoil plant nutrients
  - + Banding reduces fertilizer fixation in the soil, increases root activity in nutrient rich bands, and leads to higher nutrient uptake and often higher grain yields
  - + During dry weather, subsurface placed nutrients remain more plant-available than fertilizer nutrients placed on the soil surface
  - + Eliminates the chance for fertilizer runoff during high intensity rainfall events

- **Subsurface Banding** Disadvantages
  - – **3 to 5 times** slower than broadcasting or dribble banding fertilizer nutrients
  - – Slower application increases labor costs
  - – Initial investment in high horsepower tractors and subsurface placement implements can be high
  - – Yield increases when compared to broadcasting or dribble banding fertilizer may not always be high enough to cover added labor and equipment costs

- **Dribble Banding** Advantages
  - + Many acres can be covered rapidly
  - + Application is uniform across applicator swath width
  - + Banding reduces fertilizer fixation in the soil, increases root activity in nutrient rich bands, and leads to higher nutrient uptake and often higher grain yields
  - + Low application costs

- **Dribble Banding** Disadvantages
  - – Floaters equipped with high capacity pumps and oversized hoses are needed to apply liquid suspension fertilizers

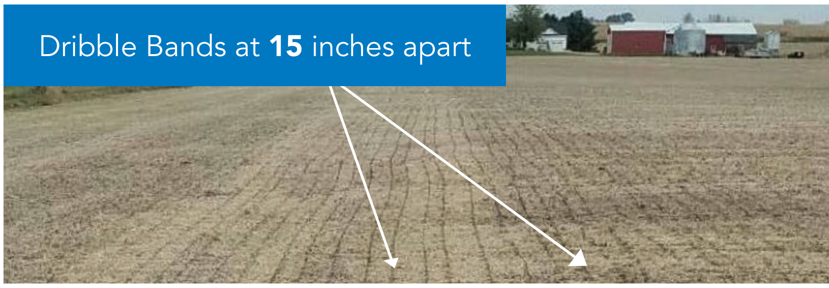
Liqui-Grow's Local On-farm Research 2016-2018 Results

During the 2016 to 2018 growing seasons we partnered with local growers to compare what effects broadcasting dry granular fertilizers vs surface dribble banding liquid suspension fertilizers had on corn yields. These studies were on-farm strip trials set up as valid experiments with randomized treatments and multiple replications. The dry fertilizers and liquid suspension fertilizers were applied at the same plant nutrient rates per acre. These trials were located in Traer, IA, Morning Sun, IA, Washington, IA, Roseville, IL, and Joy, IL. We applied the fertilizer and the farmer cooperator harvested the plots.

In 79% of the side-by-side comparisons, surface-banded liquid suspension fertilizers produced more corn grain than equivalent rates of dry broadcasted granular fertilizers (Figure 3). Moreover, in 75% of those side-by-side comparisons, net returns were higher for the liquid suspension fertilizers (Figure 4). Overall we found that yields were increased by 2.1% (5 bu/ac) and profit per acre was increased by $17.2/ac from banding vs broadcasting fertilizer nutrients (Table 1 on pg 2). Our findings are similar to those recently summarized by Nkebiwe et al. 2016, and are yet another example of what effects banding has on fertilizer nutrient availability, crop nutrient uptake, and grain yields.

Summary

Liquid suspension fertilizers offer unique agronomic and financial advantages. These advantages include accurate fertilizer placement and distribution, macro and micro nutrients that stay blended in solution, and a product that is exceptionally easy to surface or subsurface band. These factors together result in reduced fertilizer fixation, increased nutrient availability, and often higher crop yields and net returns than broadcasted granular fertilizers.



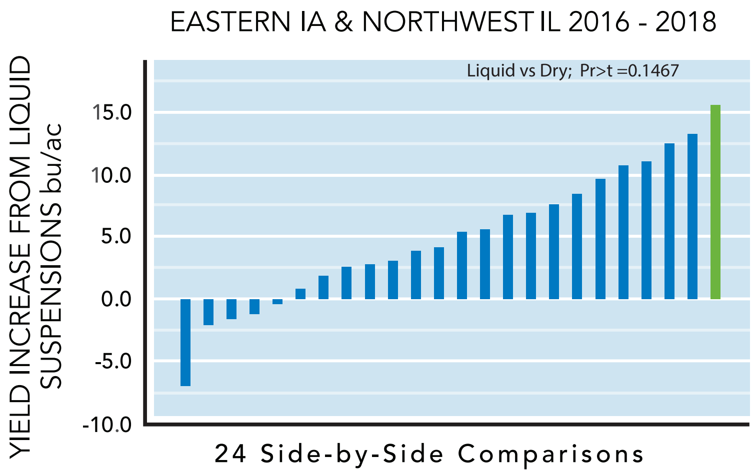


Figure 3. Yield increase from using banded liquid suspension fertilizers vs broadcasted dry granular fertilizers in 24 side-by-side comparisons.

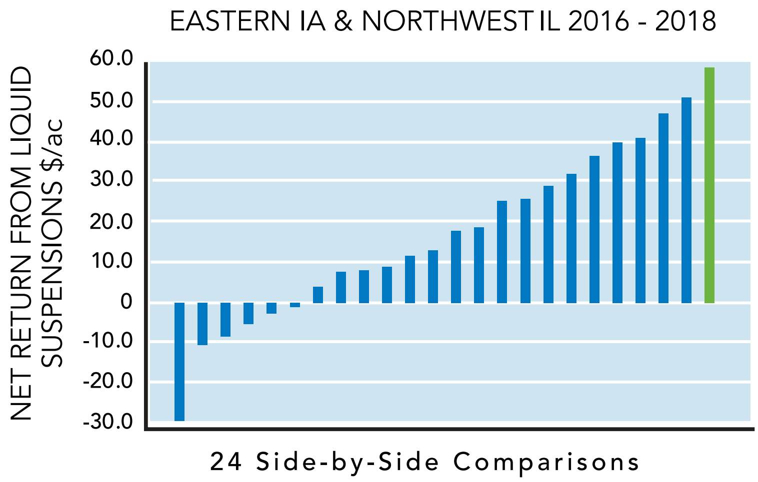


Figure 4. Net return from using banded liquid suspension fertilizers vs broadcasted dry granular fertilizers in 24 side-by-side comparisons.

References

Nkebiwe, P.M., M. Weinmann, A. Bar-Tal, and T. Müller. 2016. Fertilizer placement to improve crop nutrient acquisition and yield: A review and meta-analysis. Field Crops Res. 196:389–401.

Colley, R. III, J. Fulton, S. Virk and E. Hawkins. 2018. Obtaining uniform distribution of granular fertilizers with a spinner disc spreader in variable rate scenarios. Paper presented at: CAFES Annual Research Conference. Ohio State University, Columbus, OH. 27 April

Liqui-Grow Quarterly Newsletter

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Liqui-Grow BALANCED FERTILIZERS

Family Owned Since 1958

OCT 2019

- Liqui-Grow's Agronomy Research Book
- Hidden Genetic Potential in Seeds
- Potassium Deficiencies in Soybeans, 2019

Owners' Update

Liqui-Grow is committed to sourcing farmer crop input financing on your behalf. We know that you have many choices when making your 2020 input partner decision. We have diligently worked on our customer's behalf to line up options for 12-15 mo. financing choices at VERY LOW APR'S.

Many of these are through John Deere Financial & Rabobank, but there are also other options available. Liqui-Grow is able to offer fertilizer financing as well as Crop Protection & Seed. Ask us for further details.

- Scott, Hov & Bruce Tinsman

Agronomy Research Book Coming Soon

Agronomy Research Summary 2019

Since the spring of 2015 I have been conducting research on new products and management practi farmers can potentially use to increase both corn a soybean yields and profitability. By now I have amassed a bunch of results that are finalized and r to share.

I will share these results in the form of a book, whi will contain research on fertilization products and practices, seed treatments for soybeans, fertilizer additives and much more. These research summar books will be available later this fall at any of our Liqui-Grow locations. You can also request a book calling the main office (563-359-3624) or via email emailing Tammie Suhl at tjs@liqui-grow.com.

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Hidden Genetic Potential in Seeds

Katie Hess
Seed & Seed Treatment Manager

Technology can come in many forms. Most of the time it looks and feels new. Seed is not that way. A kernel of corn or a soybean still appears to be the same as it was 30-50 years ago. What potential seed has, is what has changed. More precise research and development has brought us more yield potential, 2019 is proof of that. As farms are being harvested, and in areas not lost completely to Mother Nature's dealt hand, yields are meeting or exceeding expectations. So, as I continue to get the question, "Why does this seed cost so much?" I will continue to answer with, "Because of the genetic potential and technology suppliers are putting into it."

Seed is the first decision to make when setting yield goals. It can't be the only decision. There has to be a solid fertilizer, weed management, and plant health program put together to help seed reach its genetic capabilities. Our staff at Liqui-Grow is fully trained to help you reach yield goals and the return on your investment. Over the past year we have been training on hybrids and varieties more than ever to help you make the right decision on your own acre.

Unfortunately, we lost some planned plots to the spring weather events. The remaining plot results will be posted once again on our website: www.liqui-grow.com. It's a great start to see the genetic potential these hybrids and varieties have.

Potassium Deficiencies in Soybeans - 2019

Dr. Jake Vossenkemper
Agronomy Research Lead

In the summer of 2019, I observed more potassium deficiencies in soybeans than I have ever seen in my 12 years as an agronomist. Why? These deficiencies in 2019 could be explained by a number of factors, including poor root development from early saturated soils, the dry soil conditions that most of us experienced from mid-June to mid-August or that potassium soil test levels are well below the optimum in some fields.

Dropping soil test potassium levels could be a key culprit given many of us have had exceptional soybean yields over the past few years (2016, 2017 and 2018). While higher than normal soybean yields are clearly a good thing, high soybean yields also remove large amounts of potassium from the soil.

Many may be surprised that a 65 bu/ac soybean crop removes nearly 80 lbs of potassium per acre from the soil. Ramp that up to 80 bu/ac and removal increases to nearly 100 lbs of potassium per acre. While it's hard to complain about above average soybean yields in the not so distant past, it's also important to replenish your soils with fertilizer potassium so that high soybean yields can be maintained.

Potassium deficient soybeans near Morning Sun, IA in 2019. Potassium deficiencies in soybeans are indicated by yellowing and or necrotic leaf margins often in the upper half of the canopy.

Soybean Yield (bu/ac): 100, 90, 80, 70, 60, 50, 40, 30
Potassium Removal (lbs/ac): 40, 60, 80, 100, 120

Each newsletter features updates from the owners, Scott, Hov, and Bruce Tinsman, along with articles written by the leads of our seed and agronomy divisions.

Visit our website liqui-grow.com to join. If you would prefer to receive the newsletter by mail, please call us at (800) 397-8946.

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Selecting the Best Nitrogen Fertilizer Timing, Placement, & Source

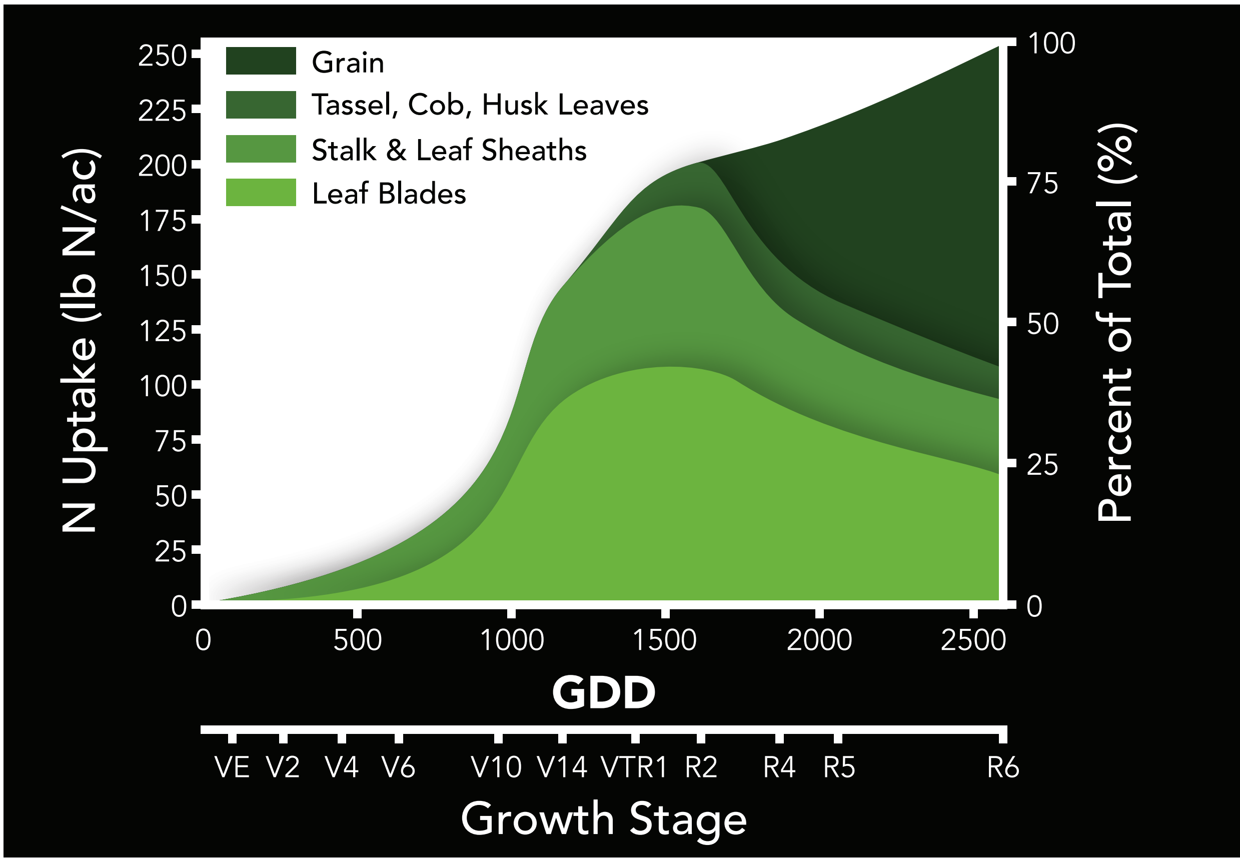
authored by
Dr. Brad Bernhard
researched at University of Illinois

Article Summary

- Nitrogen supplying power of the soil is a good indication of plant yield-response to split-applied N.
- When side-dressing N, placing the N in close proximity to the crop row resulted in greater yields.
- The side-dress N treatment that resulted in the greatest corn grain yield was placing UAN along the crop row using Y-drops.

Assuring adequate nitrogen (N) availability during key stages of plant growth is a major factor affecting yield and profitability of corn. Nitrogen uptake by modern corn hybrids follows a sigmoidal pattern over time with limited uptake before the V8 growth stage (Figure 1). Between V8 and flowering, two thirds of total plant N uptake occurs, equal to a rate of 7 lbs of N per acre per day for a period of at least 21 continuous days. Side-dressing N to coincide with this period of maximum uptake is a logical approach to assure adequate N availability, while limiting its potential for loss. A relatively new technology known as the Y-drop, allows for placement of side-dressed N directly next to the crop row, where proximity to roots and stem flow of water helps to assure availability by creating a zone of high N concentration directly in the plant's rooting zone.

Figure 1: The seasonal uptake and partitioning of N for a corn crop yielding 230 bu/ac (Bender et al., Agron. J. 105:161-170 (2013).



N Fertilizer Treatments

Different combinations of N fertilizer sources, timing of application, and placement were evaluated at Yorkville, Champaign, and Harrisburg, IL in 2017 and 2018. All treatments received a total of 180 lbs of N/ac. Treatments included supplying all N upfront as broadcasted urea (46-0-0) compared to split-applications that received 90 lbs of N pre-plant as broadcasted urea and 90 lbs of N side-dressed at the V8 growth stage.

Side-dress applications included broadcasted urea, urea placed next to the crop row, UAN (Urea Ammonium Nitrate; 32-0-0) down the center of the row, or UAN placed next to the row using Y-drops (Figure 2). Soil N availability throughout the season was estimated by comparing yield results of the fertilized treatments to unfertilized check plots.

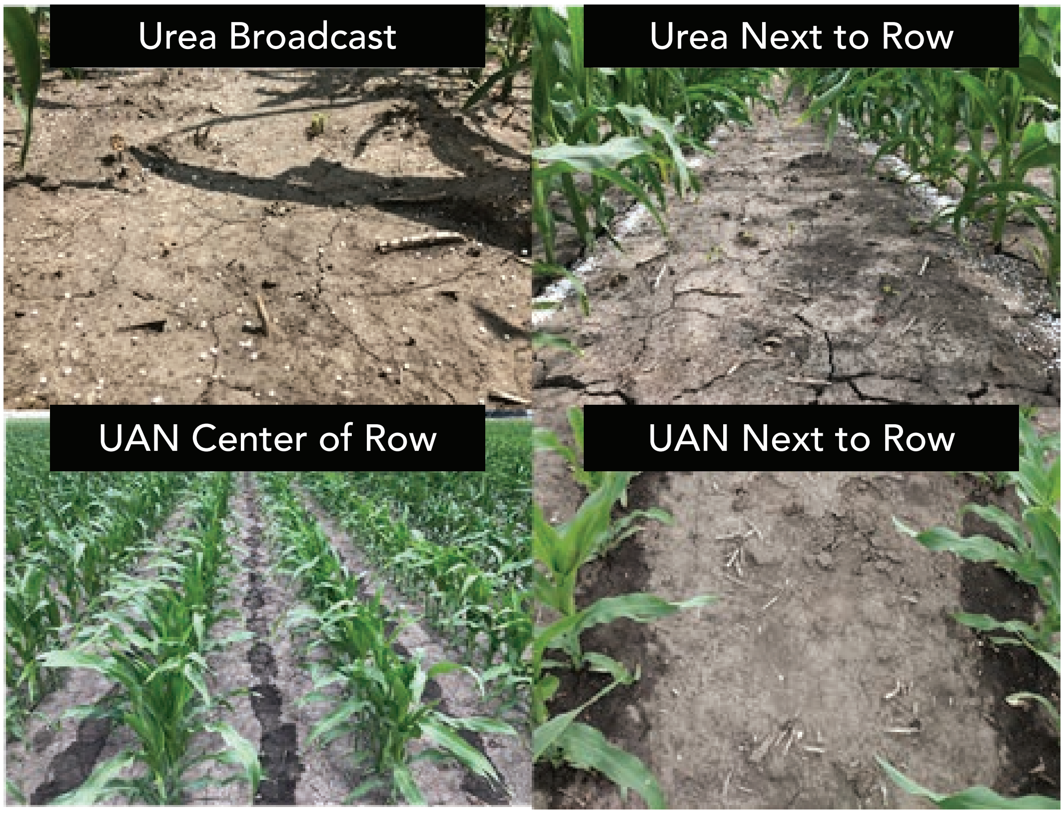


Figure 2: Different methods used for side-dress application of N to corn.

Upfront vs Split-Applications

There was a large range in check plot yields across the six site-years ranging from 97-224 bu/ac (Table 1). The check plot can be used as a proxy for how much N was supplied by the soil. A lower check plot yield indicates that there was an insufficient supply of N from the soil, likely due to low N mineralization and/or high N loss, while a high check plot yield indicates a sufficient supply of N from the soil with high N mineralization and little N loss.

The three lowest check plot yielding site-years were 2017 Champaign, 2018 Champaign, and 2018 Harrisburg, suggesting that the corn plants required more N supplied by fertilizer to maximize yields.

Under-fertilizing corn at an early growth stage hindered plant growth when kernel number was being determined.

Applying more of the N upfront at pre-plant as broadcast urea tended to generate higher yields than when the plants received 50 percent of the N upfront at pre-plant and 50 percent of the N side-dressed at the V8 growth stage as broadcast urea at those three site-years (Table 1). Under-fertilizing corn at an early growth stage hindered plant growth when kernel number was being determined and the side-dress application was not sufficient for the plants to regain lost yield potential.

At 2017 Yorkville, 2017 Harrisburg, and 2018 Yorkville, there was a sufficient amount of available N supplied from the soil at the early growth stages, and at these sites the yield potential was not affected by the fertilizer application time and the side-dress application was more beneficial than supplying all the N fertilizer upfront (Table 1).

Table 1. Grain yield as influenced by N fertility treatment for corn grown at Yorkville, Champaign, and Harrisburg, IL in 2017 and 2018.

Treatment Timing		Location						
Pre-plant	Side-dress	2017 Yorkville	2017 Champaign	2017 Harrisburg	2018 Yorkville	2018 Champaign	2018 Harrisburg	Avg
		bu/ac						
No N Applied	-	208	184	224	195	103	97	169
Urea Broadcast	-	265	256	265	232	222	190	238
Urea Broadcast	Urea Broadcast	272	253	273	236	213	183	238
Urea Broadcast	Urea Next to Row	270	253	272	237	234	192	243
Urea Broadcast	UAN Mid of Row	265	231	274	241	205	188	234
Urea Broadcast	UAN Next to Row	278	245	277	247	228	199	246

Average LSD (0.05) = 5

Best Side-dress Application

When averaged across all site-years, placing the N closer to the crop row as either urea or UAN tended to increase grain yield by 5 and 12 bu/ac, respectively, compared to if the same source was broadcast or placed in the center of the row (Table 1). Nitrogen movement in the soil is mostly vertical with little horizontal movement. In addition, the horizontal spread of a corn root system is roughly 6-8 inches. When planting in a 30-inch row spacing, little root mass will grow into the center of the corn row.

Placing the N directly in the root zone is critical for N uptake by the corn plant. When comparing side-dressed urea and UAN fertilizer sources placed along the crop row, UAN, which is half comprised of immediately available nitrate-N, yielded 3 bu/ac greater than when using urea. On average across all site-years, split-applying nitrogen with half of the nitrogen applied in-season as UAN with a Y-drop resulted in an increase of $16/ac of partial profit compared to applying all of the nitrogen pre-plant as urea (Table 2).

Table 2. Partial profit as influenced by N fertility treatment for corn grown at Yorkville, Champaign, and Harrisburg, IL in 2017 and 2018.

Treatment Timing		Partial Profit	Change in Partial Profit from Applying All N Upfront as Broadcast Urea
Pre-plant	Side-dress	$/ac	Δ $/ac
Urea Broadcast	-	747	-
Urea Broadcast	Urea Broadcast	740	-7
Urea Broadcast	Urea Next to Row	751	5
Urea Broadcast	UAN Mid of Row	721	-25
Urea Broadcast	UAN Next to Row	759	12

Application and fertilizer costs were included in the partial profit | Price of corn $3.50 per bushel.

Summary

Because sufficient N is needed early in the plant's development to set yield potential, an understanding of environmental and soil conditions is important when choosing the best management practices for N fertilization of corn. Corn plants need to sense enough N early in the growing season to set a high yield potential and also require available N later in the season to maintain that high yield potential.

Reference

(Bender, R.R., J.W. Haegele, M.L. Ruffo, and F.E. Below. 2013. Nutrient uptake, partitioning, and remobilization in modern, transgenic insect-protected maize hybrids. Agron J. 105:161-170).

Urea - A Poor Choice of Nitrogen Fertilizer for In-Season N Application

authored by
Dr. Jake Vossenkemper

Urea, anhydrous ammonia and liquid urea ammonium nitrate (UAN 28 or 32%) are by far the most common sources of nitrogen fertilizer used in corn production. Moreover, all 3 sources of nitrogen fertilizer have their own unique advantages and disadvantages, but in particular, dry urea is an exceptionally poor source of nitrogen for in-season applications to corn. At first glance, urea seems to be an attractive in-season nitrogen source, because it can be applied rapidly with high clearance dry spinner spreaders and urea is commonly a few cents per lb of nitrogen cheaper than UAN. Urea, however, is highly susceptible to N loss via ammonia volatilization, and uniform fertilizer nitrogen distribution can be a serious problem for top yields and maximizing economic returns.

Dry Urea

Elevated Risk for N Loss via Ammonia Volatilization

Ammonia volatilization occurs when the urease enzyme hydrolyzes urea fertilizer to ammonia on the soil surface. Given ammonia (NH_3) is a gas and lighter than air, the ammonia literally floats away into the atmosphere. The most effective way to prevent ammonia volatilization is for urea hydrolysis to occur beneath the soil surface where the ammonia gas can interact with hydrogen ions to form ammonium (NH_4^+).

Nitrogen from surface broadcasted dry urea is **50%** more likely to be lost via volatilization than surface banded UAN

Article Summary

- Urea fertilizer, if not incorporated by tillage or precipitation, is highly susceptible to ammonia volatilization (loss to the atmosphere as ammonia gas).
- Uniform application of urea can be problematic due to segregation of larger and smaller urea prills and due to physical spread pattern interference from standing corn during in-season applications.
- Liquid UAN (32 or 28%) is only 50% urea and is about half as susceptible to ammonia volatilization as dry urea.
- Banding UAN further reduces the probability of nitrogen loss via ammonia volatilization.
- Averaged over 3 on-farm plots side-dressing surface banded UAN gave 16.2 $/ac greater net returns and yielded 5.5 bu/ac more than surface broadcasted urea.

To avoid serious N loss, urea must be incorporated with tillage, moved below the soil surface by precipitation or subsurface injected. For in-season N application, however, physical incorporation or injection of dry urea is not practical, leaving a rainfall event that must exceed 0.5 inches to move the urea below the soil surface (Figure 1). This significant rainfall event must occur no later than 4 days after urea application (Figure 2) or N loss from ammonia volatilization could drastically accelerate in subsequent days (Jones et al., 2013). UAN is also susceptible to ammonia volatilization, but only 50% of the nitrogen in UAN is urea. Therefore, UAN is roughly half as susceptible to ammonia volatilization as dry urea.

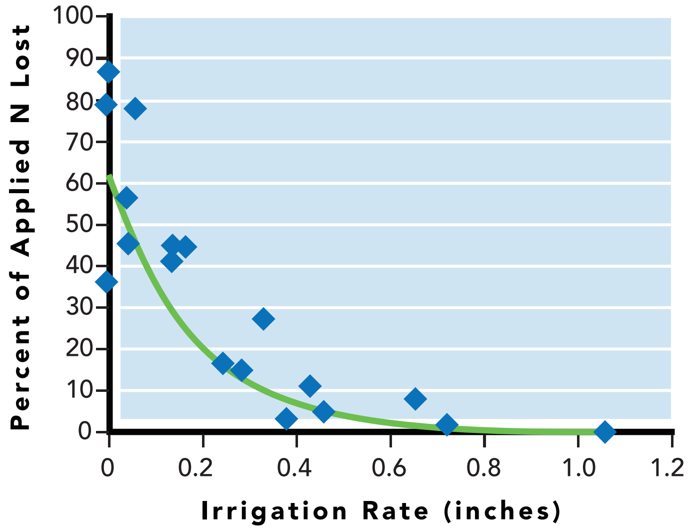


Figure 1. Percent of applied N lost to volatilization from urea broadcast in the spring on moist soil followed by different rates of irrigation on winter wheat (15). Avg soil temperature was 44°F, pH 6.5.

At least a 0.5 inches of rain is required to completely incorporate dry urea and for N loss to be avoided.

UAN also provides more flexibility regarding in-season applications than dry urea. UAN can be subsurface injected or surface banded within the row. Subsurface injection of UAN strongly reduces the potential for ammonia volatilization because urea hydrolysis occurs below the soil surface. Banding UAN on the soil surface does not eliminate ammonia volatilization, but reduces the risk of ammonia volatilization considerably (Figure 2, Jones et al., 2013). The reduction in ammonia volatilization risk with banding UAN occurs because banding physically reduces the amount of N fertilizer exposed to the urease enzyme.

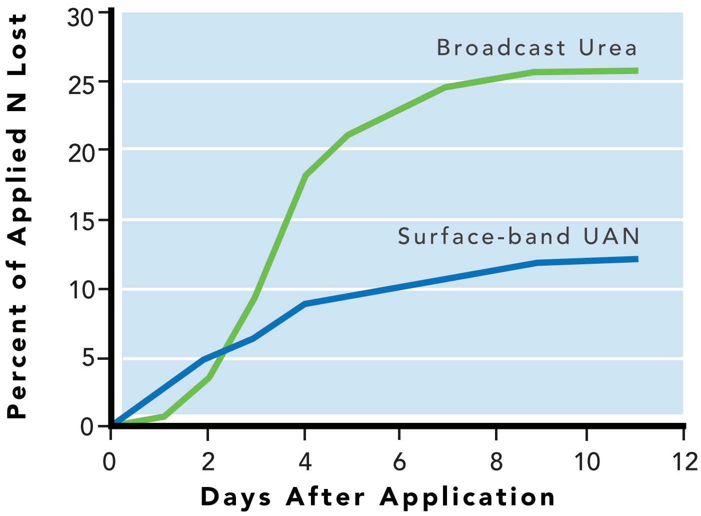
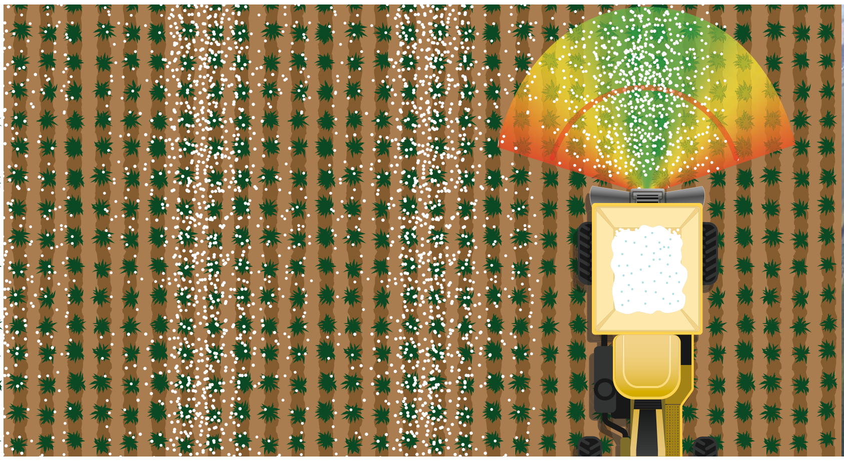
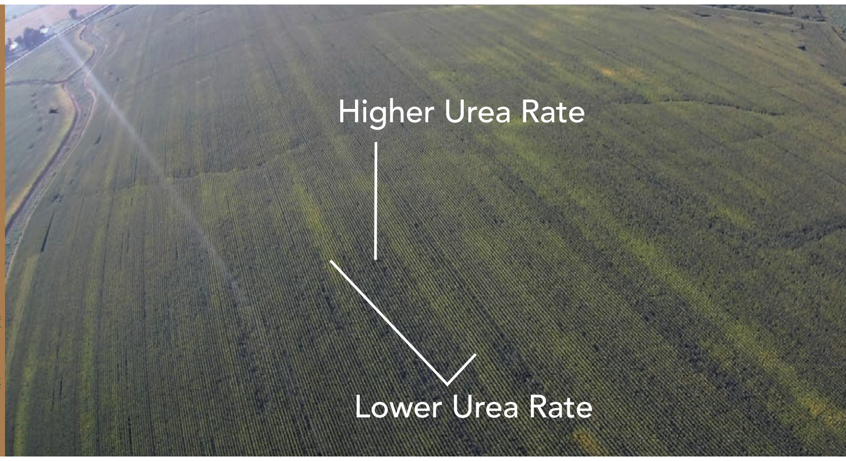


Figure 2. Percent of applied N lost from UAN and broadcast urea from a newly seeded field irrigated before fertilizer application. Figure modified from Jones et al., 2013.





Poor Fertilizer Distribution
Increases Yield Loss Risk

Achieving uniform application with dry fertilizer, which includes urea, can be a difficult task. Several problems exist that can lead to non-uniform urea applications. If urea is not uniformly sized, the result is segregation of larger and smaller urea particles during loading, during transportation to the field and during spreading. Particle segregation is a problem because larger urea granules are thrown further from the dry spinner spreader machine than smaller particles, resulting in a higher application rate directly behind the machine and a lower applications rate at the edges of each pass.

Segregation is not the only concern. When side-dressing corn, poor urea distribution can be exacerbated by the standing corn crop, particularly when corn reaches over a few feet in height. Tall corn acts as a funnel, cutting down the distance at which the urea granules can be thrown compared to when no crop was present to disrupt the flow of urea toward the edges of each pass. In fact, a recent Iowa State study shows (Figure 4) that a standing corn crop can magnify the uneven urea distribution. In this Iowa State study, the target application rate was 108 lbs of urea/ac, but in the middle 30 ft of the 60 ft swath 271 lbs of urea was applied, and on the outer 15 ft of the swath on each side of the machine only 54 lbs of urea was applied.

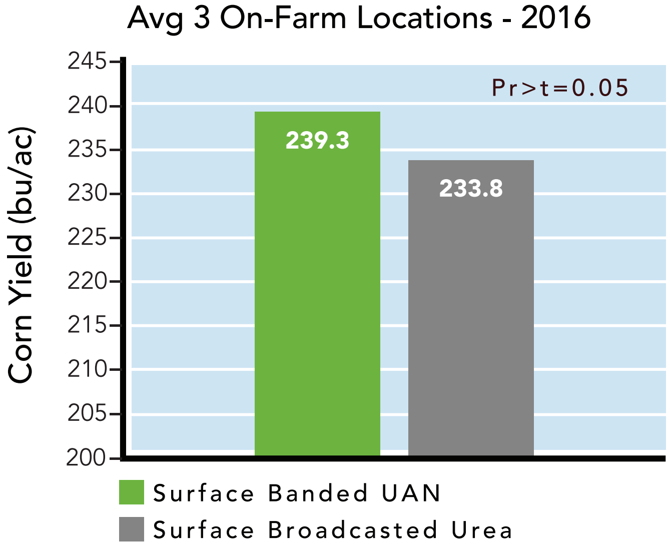


Figure 3. Avg corn yield from side-dressing surface banded UAN or surface broadcasted urea at 1 WI and 2 IA locations during the 2016 growing season.

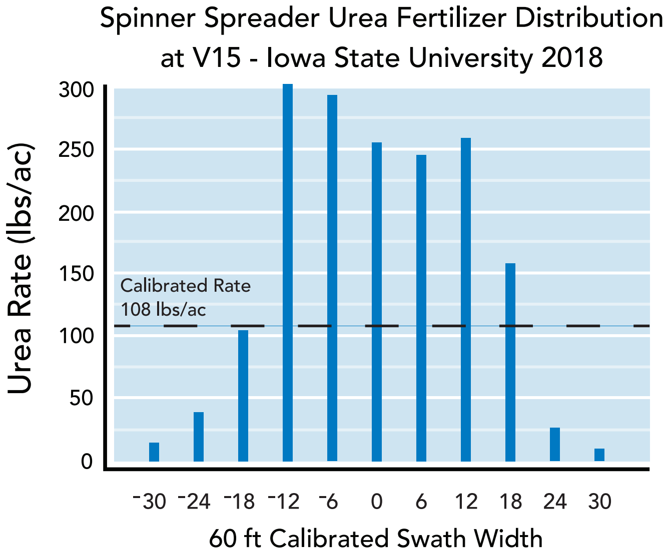


Figure 4. Data in figure originated from Iowa State University study. (Darr, 2018)

On-Farm Comparisons

Broadcast Urea vs Surface Banded UAN as In-Season N Sources

The on-farm studies were conducted at 3 locations in the 2016 growing season. The locations included Elkhorn, WI, Tipton, IA and Morning Sun, IA. The base and side-dress N rates used at each location are listed in Table 1. At each location the side-dress nitrogen was applied at growth stages between V6 to V8 as either surface banded UAN or surface broadcasted urea. At each location these treatments were replicated 3 or 4 times. The price of UAN and urea used to calculate partial profit was 0.36 and 0.32 $/lb N. The price of corn used to calculate partial profit was $3.50/bu.

Averaged over the 3 locations yields were increased 5.5 bu/ac from surface banded UAN when compared to surface broadcast urea (Table 2 and Figure 3). In addition to higher yields from surface banding UAN vs broadcasting urea, net profits were 16.2 $/ac higher for the surface banded UAN treatments, despite slightly higher nitrogen costs (Table 3).

Summary

Because urea cannot be physically incorporated post-planting, it is susceptible to loss via ammonia volatilization (loss to the atmosphere as NH_3 gas). Moreover, uniform application with dry fertilizer, including urea, can be problematic due to segregation of larger and smaller urea prills and due to physical spread pattern interference from standing corn. For these reasons, urea is a particularly poor source of nitrogen fertilizer for in-season applications. In these 3 on-farm trials surface banding UAN increased yields 5.5 bu/ac and net profits 16.2 $/ac compared to surface broadcasting dry urea.

Table 1. Pre-plant and side-dress nitrogen rates used at 1 WI and 2 IA nitrogen source plots during the 2016 growing season.

Location	Pre- Plant	Side-dress	Total
	Nitrogen Rate (lb/ac)		
Elkhorn, WI	105	35	140
Morning Sun, IA	70	70	140
Tipton, IA	80	60	140
Avg	**85**	**55**	**140**

Table 2. Corn yield from side-dressing corn with surface dribbled banded UAN or broadcasted urea at at 1 WI and 2 IA nitrogen source plots during the 2016 growing season.

Location	UAN	UREA	Total
	Corn Yield (bu/ac)		
Elkhorn, WI	226.4	213.6	12.9
Morning Sun, IA	243.5	242.9	0.6
Tipton, IA	248	245.0	3.0
Avg	**239.3**	**233.8**	**5.5**

Table 3. Partial profit from side-dressing corn with surface dribbled banded UAN or broadcasted urea at 1 WI and 2 IA nitrogen source plots during the 2016 growing season.

Location	UAN	UREA	Delta Return
	Partial Profit ($/ac)		*$/ac*
Elkhorn, WI	779.7	736.2	43.5
Morning Sun, IA	826.6	827.8	-1.2
Tipton, IA	844.5	838.3	6.2
Avg	**816.9**	**800.8**	**16.2**

Reference

Jones, C., B.D. Brown, R. Horneck, D. Olson-Rutz. 2013. Management to Minimize Nitrogen Fertilizer Volatilization. Extension Publication EB0209. Montana State University. http://www.landresources.montana.edu /soilfertility/documents/PDF/pub/UvolBMPEB0209.pdf.

Darr, M. (ed.) 2018. Ag Chem. Dealer Update. 18 Dec 2018. Iowa State Univ. Ext., Ames, IA.

Corn N Recs Using Nitrogen Management Models
Are they "Big League" Ready?

authored by
Dr. Jake Vossenkemper

Article Summary

- Can nitrogen models increase net revenues when compared to traditional N management rates? What about when compared to an N rate recommendation from the Corn N Rate Calculator developed by several Midwestern land grant universities.
- The nitrogen management model produced the lowest net revenues. They were $22 and $27/acre lower than the net revenues produced by the growers' traditional N management rates and the N rate recommended by the Corn N Rate Calculator.
- While nitrogen management models may become more accurate with time, this study suggests that for now growers should proceed with caution before adopting N management models for wide-scale use.

Brief Introduction

Within the last few years, nitrogen management models seem to be all the rage. Corteva promotes Encirca Yield Nitrogen, Bayer has Climate Fieldview, and Agronomic Technology offers Adapt-N. This is a short list of the Big 3, but there are still the droves of Silicon Valley start-ups promising to solve all our nitrogen management woes.

The idea behind these N models is stellar: use less fertilizer N in years with low nitrogen loss conditions and more fertilizer N in years when more N loss has occurred. Potentially, this could reduce N pollution, save on fertilizer N costs, or increase yields in years when more fertilizer nitrogen is required. This is, of course, the utopia for which the agricultural industry has been searching.

Potentially, this could reduce N pollution, save on fertilizer N costs, or increase yields in years when more fertilizer nitrogen is required.

I am sure the aforementioned corporations have hired the best in the business to take on such a monumental task and that they are using the most advanced statistical models known to man. However, Mother Nature—and the complexities of the nitrogen cycle—will put up a formidable fight.

In the 2016 growing season, we implemented experiments to give both us and our customers some clearer answers to this important question.

The Applied Questions

Can a nitrogen management model recommend an N rate that results in net profit gains compared to growers' traditional N management rates?

Can a nitrogen management model recommend an N rate that results in net profit gains compared to the Corn Nitrogen Rate Calculator developed by several Midwestern land grant universities?

Answering the Applied Questions

In southeast Iowa, nitrogen fertilizer rates ranging from 0-to-250 lbs of N/acre were applied to three different farmers' fields in 50 lb increments. Soybeans were the previous crop for each field. Each N rate plot was 30 ft wide and approximately 300 ft long.

Most of the nitrogen was applied at the V-7 growth stage, dribbled on the soil surface as liquid UAN 32%. At each of these fields the soils were highly productive, prairie derived mollisols with OM ranging from 3.3-to-3.8%.

The specific nitrogen management model evaluated in these 3 locations was the Adapt-N model sold by Agronomic Technology Corp/Yara. Because we established a nitrogen rate response curve at each location the profitability of any N rate (or N rate recommendation system) can be calculated and compared to other N rates given the yield for any N rate will be known.

For the economic calculations, $0.39/lb of N was used. The price for a bushel of corn was assumed to be $3.50.

How Did the N Recommendation Systems Compare?

In the interest of being short and sweet, I will only discuss what happened on average across these three different trials. Nevertheless, I have included the results from each of the three locations in Table 1.

On average, these three growers typically apply 170 lbs of N/ac when corn follows soybeans. The Nitrogen Rate Calculator, developed by several Midwestern land grant universities, recommended 149 lbs of N/ac, and the N model recommended 136 lbs of N/ac.

The N model recommendation produced approximately
10 fewer bu of corn/ac
than either the grower-selected N rate or the N Rate Calculator recommendation.

In spite of the growers applying 21 more lbs of N/ac than the N Rate Calculator recommendation, the yields between these two N rates were nearly identical. The grower-chosen N rate produced a yield of 230.4 bu/ac and the N Rate Calculator recommendation produced a yield of 229.6 bu/ac.

The N model, however, recommended applying 34 and 13 lbs of N/ac less than the grower selected N rate and the N Rate Calculator recommendation. Therefore, the N model recommendation produced approximately 10 fewer bu of corn/ac than either the grower-selected N rate or the N Rate Calculator recommendation (Figure 1).

The N model recommendations reduced the N cost by a few dollars/acre. However, the lost yield meant that the N model had the lowest net revenue, at $719/acre. The grower-selected N rate and the N Rate Calculator recommendations followed, producing net revenues of $740 and $746/acre.

Results

So, are these N models ready for the "big league"?

With the current commodity climate, I think most farmers will find it hard to gut an extra $27/acre, not to mention access to these N models is not free. No doubt, these N models will likely get more accurate with time. While that happens, however, this small investigation that evaluated only one of these N models would suggest that growers should proceed with caution. Liqui-Grow will likely continue to evaluate these N management models, so stay tuned for further updates.

Table 1. Net revenue from grower-selected N rates, Corn N Rate Calculator recommended N rates, and an N rate prescribed by an N management model at 3 southeast Iowa locations in 2016.

N Recommendation System	N- Rate (lb/ac)	Yield (bu/ac)	Gross Revenue ($/ac)	Cost N ($/ac)	Net Revenue ($/ac)
	Field A				
Grower N Practice	168	239	836.5	65.5	771.0
Univ. N Rate Calculator (MRTN)	149	236.6	828.1	58.1	797.0
PSNT Iowa State	189	240.7	842.5	73.7	768.7
Nitrogen Model	123	230.2	805.7	48.0	757.7
	Field B				
Grower N Practice	155	237.1	829.9	60.5	769.4
Univ. N Rate Calculator (MRTN)	149	235.6	824.6	58.1	797.0
PSNT Iowa State	189	240.7	842.5	73.7	768.7
Nitrogen Model	123	230.2	805.7	48.0	757.7
	Field C				
Grower N Practice	200	217	759.5	78.0	681.5
Univ. N Rate Calculator (MRTN)	149	216.7	758.4	58.1	700.3
PSNT Iowa State	69	216.4	757.4	26.9	730.5
Nitrogen Model	185	216.1	756.4	72.2	684.2
	Average of 3 Fields				
Grower N Practice	174.3	231.0	808.6	68.0	740.6
Univ. N Rate Calculator (MRTN)	149.0	229.6	803.7	58.1	745.6
PSNT Iowa State	149.0	232.6	814.0	58.1	755.9
Nitrogen Model	136.0	220.3	771.2	53.0	718.1

Saturated Soils & Nitrogen Loss

Rescue Nitrogen Applications & Profitability

authored by
Dr. Jake Vossenkemper

Article Summary

- A wet growing season in east-central and southeast IA in 2015 led to many fields with saturated soils and N loss, leaving growers and salesmen wondering if this crop can be saved with extra N fertilizer.
- Rescue N plots were implemented in three farmers' fields in eastern IA to test this idea.
- Rescue nitrogen increased profitability over the zero N control \$90, \$61, and \$16/ac in severely N deficient corn, moderately N deficient corn, and corn that was not apparently N deficient at the time of rescue N applications.
- The most profitable N rate in the severely N deficient corn, moderately N deficient corn, and corn that was not apparently N deficient at the time of rescue N applications was 57.5, 71.5, and 44.3 lbs N/ac.
- Rescue N is likely to increase corn yields, but the soil should be given a chance to dry out before attempting rescue N treatments. In other words, applying more N isn't likely to help if corn continues to stand in water

The Problem

It will soon be a distant memory, but it was rather wet in parts of east-central and southeast Iowa in 2015. Most of the above normal precipitation fell in the last half of May and June in east-central Iowa, whereas the wettest two months in south-east Iowa tended to be June and July (Table 1). Regardless of when the rain fell, this excess precipitation caused saturated soils and nitrogen (N) loss via leaching and denitrification (loss as N_2 or N_2O to the atmosphere) leading to corn fields with varying levels of N deficiencies.

Because of the above normal rain and subse-quent N loss I was asked to visit many fields in the summer of 2015, and a common question from farmers and salesmen was can this corn be "rescued" by applying more N? My response tended to be the available evidence says we can, but the number of experiments that have been conducted to reach these conclusions are few. Moreover, we are even less confident that if more N can help this corn crop recover from saturated soils and N loss how much more N will it take? On top of all this there is the problem of the nitrogen loss not being evenly distributed across the entire field. In other words, in fields where N loss is caused by standing water (denitrification primarily) it is very common for there to be severely N deficient corn, moderately N deficient corn, and corn that does not appear to be at all N deficient in the same field.

Table 1. Normal precipitation and the departure from normal precipitation averaged over the 11 counties in east-central Iowa and 11 counties in southeast Iowa for the months of May, June, and July in the growing season of 2015.

	East-central		South-east	
	Normal	Departure Norm	Normal	Departure Norm
	Inches of Precipitation			
May	4.34	+1.29	4.89	+0.12
June	4.95	+3.32	4.82	+2.89
July	4.36	–0.56	4.47	+3.45

Given these drastic changes in apparent N status of the crop it would seem plausible that the entire field may not need N, or at least a different rate of N, but that isn't at this time well known either. Moreover, it isn't easy to vary the rate of N across fields such as these. It can be technically done, but the equipment to apply N based on crop canopy color isn't widely available. As you can see, there are many questions to be asked and few available answers. In addition, these questions have important financial ramifications for farmers, and applying more N that doesn't results in financial gains will result in environmental pollution. So the main questions we set out to answer are as follows.

The Applied Question

Can applying more N to corn that's been previously fertilized and exposed to several days of saturated soils and N loss result in a net profit increases?

- If so, how much additional N does it take?

In these situations, should the whole field receive additional N, or just parts of it?

What Was Done

To answer these questions, we established replicated rescue N rate plots in three different farmers' fields. All three fields were in Clinton County Iowa, two near the town of DeWitt, and the third close to Andover. Each of these fields had been fully fertilized with N prior to the establishment of these experiments, and the N rates prior to the initiation of these experiments ranged from 179 to near 200 lbs N/ac. In each of these three fields there were three separate N rate plots established. One in what appeared to be severely N deficient corn (stunted yellow tinged corn), moderately N deficient corn (normal height but with the classic inverted V shaped yellow chlorosis in the lower canopy leaves) and corn that did not appear to be N deficient (corn was normal height, and green from top to bottom) when the experiments were initiated.

In each of these levels of N deficiency there were 5 treatments, 4 evenly spaced N rates from 30 to 120 lbs N/ac and a control (zero N applied). The source of N used was liquid urea ammonium nitrate (32% UAN) dribbled on the soil surface next to the base of the plant. The experiments at each field were established just prior to or after the beginning of reproductive growth (VT/silking). So the reader can envision the differences between the severely N deficient corn, moderately N deficient corn, and corn that did not appear to be N deficient, I have included a table with the average plant height, average number of green leaves per plant, and the nitrate nitrogen in ppm in the top 2 ft of soil prior to the initiation of the experiments.

Table 2. Crop condition characteristics prior to rescue N treatments in each level of N deficiency. These crop characteristics are averaged over the three rescue N locations.

Level of N Deficiency	Soil Nitrate (ppm)	Plant Height (in)	Green Leaf Number	Plants/ac (x1000)
None	14.6	83.7	10.8	32.5
Moderate	7.5	66.0	9.2	31.0
Severe	6.8	48.7	7.7	32.3

Lastly, below are three pictures (Figure 1) taken in the same field and at a similar distance above the soil surface showing the drastic difference in crop height between the severely N deficient corn, moderately N deficient corn, and corn that did not appear to be N deficient.

Figure 1. The three different levels of N deficiency symptoms where N rate trials were established at one grower's field in east-central IA. From left to right is the severely N deficient corn, moderately N deficient corn, and corn that had no apparent N deficiency symptom at the time of experiment initiation. The dedicated intern in these photos (Ryan Cruise) who helped establish these plots is approximately 5'7" tall.

Answering the Applied Questions

In these experiments applying more N to corn that had been previously fertilized and exposed to several days of saturated soils and N loss clearly resulted in net profit returns. Moreover, at the corn ($3.80/bu) and nitrogen ($0.48 lb/N) prices used here applying more N to corn increased net profitability in all three levels of N deficiency. The nitrogen rate that produced the greatest return to N varied some in the three different levels of N deficiency symptoms. In the severely N deficient corn, moderately N deficient corn, and corn with no apparent N deficiency symptoms the N rate that maximized economic return was 57.5, 71.5, and 44.3 lbs N/ac (Table 3), producing net profit increases over the zero N control of $90, $61, and $16 dollars per acre (Figure 2).

While all three levels of N deficient corn were responsive to rescue N applications, the moderately N deficient corn was the most responsive, producing 32.1 bu/ac more corn than the zero N control. These large yield increases in the moderately N deficient corn were followed by N increasing the yields of the severely N deficient and corn with no apparent N deficiencies by 23.5 and 10.1 bu/ac.

This was not a terribly surprising finding. Corn that still has good height and a canopy to capture sunlight probably has the best chance of responding to rescue N applications. On the other hand, corn that has had its height and leaf size severely reduced and presumably its yield potential, probably needs less N to reach maximum yield. Corn that does not appear N deficient may not always respond to rescue N applications, but it's possible that good looking corn (none N deficient) at the beginning of reproductive growth can run out of N, as I suspect happened here.

Conclusion

So should we rescue corn next time we think it needs rescued from standing water and N loss? These results tend to suggest that, and they align with some University trials conducted by Dr. Peter Scharf at the University of Missouri. However, I think it's important to keep in mind that corn roots must be actively taking up mineral nutrients if the rescue N is going to make it in to the crop. To do so corn cannot be in standing water that is depleted in oxygen.

So before applying rescue N it might be worthwhile to wait for the soil to dry, and to see if standing water kills large portions of the crop, because applying more N to dead corn or corn that can't take up the rescue N will not help.

Table 2. The nitrogen rate that achieved maximum economic return, the nitrogen rate that produced the maximum yield, yield at zero nitrogen (check plot), the maximum yield obtained with rescue nitrogen fertilizer, and the difference between the maximum yield attainable with nitrogen fertilizer and the check plot yield averaged across 3 locations in east-central IA in the 2015 growing season. These parameters are from 3 levels of N deficiency, severely N deficient corn, moderately N deficient corn, and corn that had no apparent N deficiency symptoms at the time of rescue N applications.

Level of N Deficiency	N-Rate at Max Economic Return	N-Rate at Max Yield	Yield at Zero N	Max Yield	Difference in Max Yield & Yield at Zero N
	lbs/ac		*bu/ac*		
None	44.3	71.7	192.0	202.1	10.1
Moderate	71.5	85.6	145.0	177.1	32.1
Severe	57.5	70.4	102.0	125.5	23.5

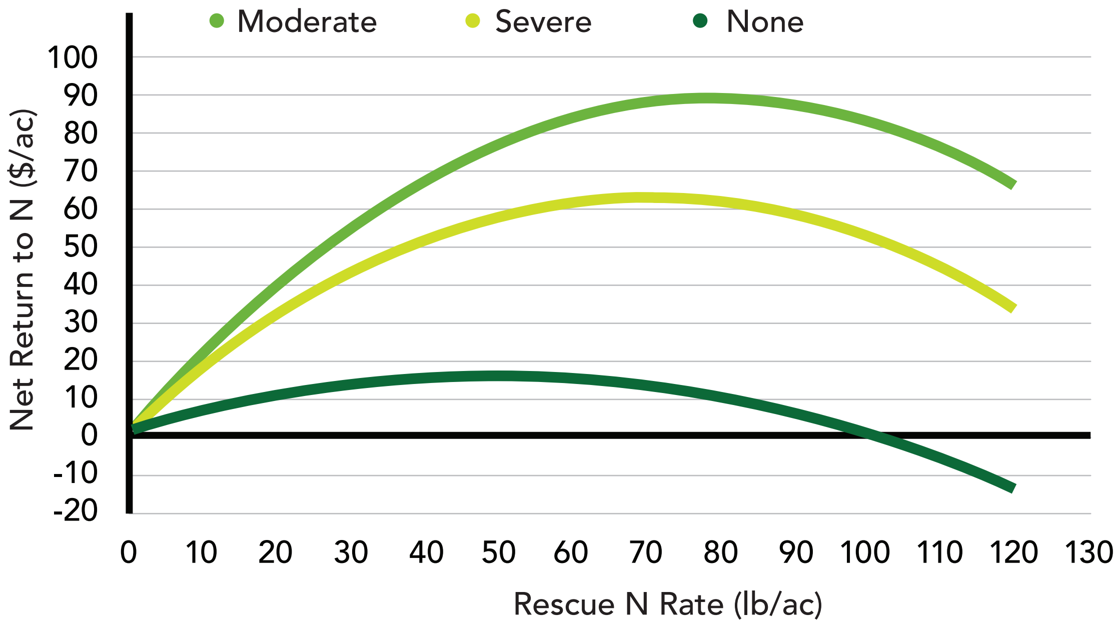


Figure 2. The net return to rescue nitrogen fertilizer in severely N deficient corn, moderately N deficient corn, and corn that was expressing no apparent N deficiency symptoms at the time of rescue N applications. Price of corn used in the calculations was $3.80/bu and price of N was $0.48 lb/N.

Nitrogen Application Timing
Is "Cheap" & "Easy" Really that Cheap After All?

authored by
Dr. Jake Vossenkemper

Article Summary

- Fall anhydrous ammonia application timings required 54 more lbs/N per acre to maximize economic returns and yielded 6% less when compared to spring or early side-dress N application timings.
- Lost yields and substantially higher N requirements for the fall anhydrous applications meant economic losses of $47.10 per acre when compared to the spring or early side-dress N application timings.

Iowa State University Study

Each year I try to attend the North Central Extension-Industry Soil Fertility Conference in Des Moines, IA. A couple years ago at the 2016 conference, Dr. John Sawyer (ISU's Soil Fertility Specialist) presented some research regarding the impacts of nitrogen timing effects on corn grain yields and economic optimum nitrogen rates that I feel must be shared with farmers. Dr. Sawyer applied N rates from 0 to 200 lbs/N per acre at 3 different timings: in the fall, as a pre-plant application, and at an early side-dress timing (V4). Dr. Sawyer did this for 3 seasons in central IA. The previous crop was always soybean and the nitrogen source for all 3 N application timings was anhydrous ammonia.

Averaged over the 3 seasons of the study, Dr. Sawyer found that the economic optimum N rate for the fall applied anhydrous ammonia was 200 lbs/N per acre, but for the spring pre-plant N application and the early side-dress N application timings the economic optimum N rate was about 146 lbs/N per acre.

What's more, corn that received all fall applied N had yields that were 6% lower than the corn that was side-dressed or had all the N applied prior to planting in the spring (Figure 1).

I wish I could say I was surprised by Dr. Sawyer's findings, but I was not. What Dr. Sawyer shows here is not new. Other university studies over the years have reached similar conclusions and when you use data sets like this to make some simple economic conclusions, it appears that what initially seemed "cheap" and "easy", may not be so cheap after all.

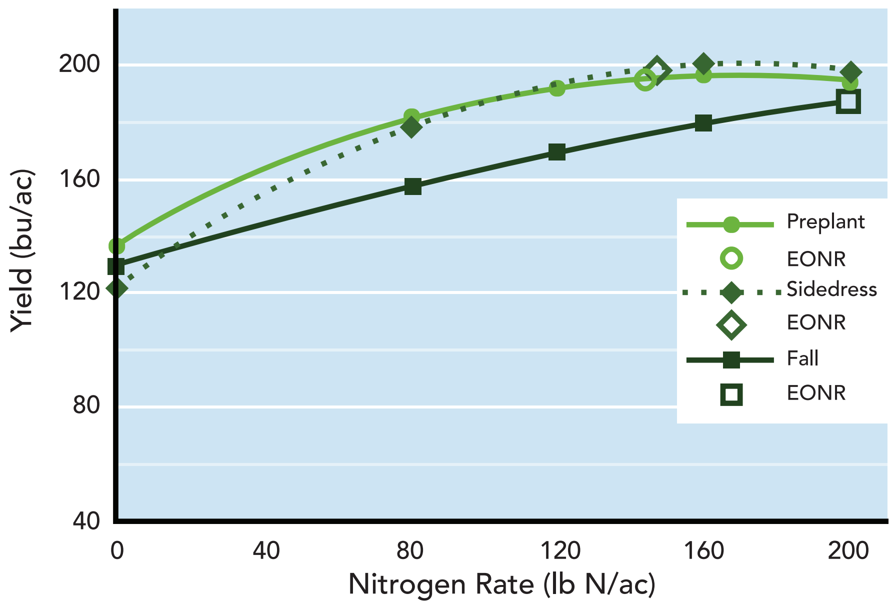


Figure 1. Fall, spring pre-plant and side-dress anhydrous ammonia application effects on EONR and corn yields. Figure from Sawyer et al., 2016.

Economic Optimum Nitrogen Rates and Application Timing

To belabor my point regarding the economics of these nitrogen timing practices, I show (Table 1) that applying N as either a pre-plant or early side-dress N application is $47.10 per acre more profitable than fall anhydrous ammonia applications. To reach this conclusion I used the economic optimum nitrogen rates found in Dr. Sawyer's latest research for the pre-plant/side-dress (EONR = 146 lbs/N ac) and fall (EONR = 200 lbs/N ac) applied N application timings. In addition, I assumed that the fall anhydrous ammonia application timing yielded 6% less (188 bu/ac) than the pre-plant or side-dress N application timings (200 bu/ac), and that the price received for a bushel of corn was $3.50. Lastly, I assumed the fall anhydrous cost $0.31 per/lb of N and spring or side-dress sources of N cost $0.39 per/lb of N (typical price spread for AA bought in the fall vs. UAN that would be applied pre-plant or in-season).

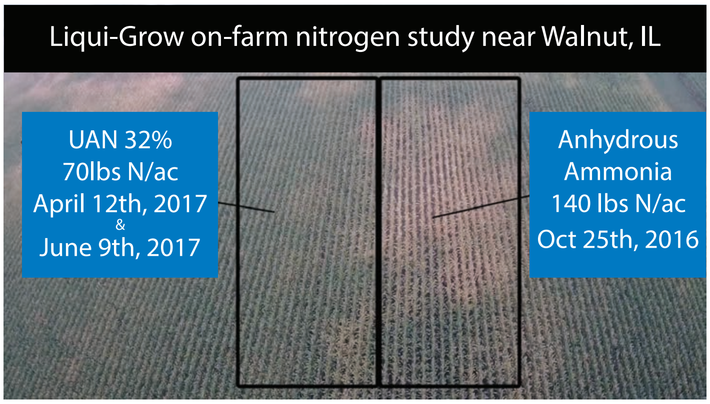


Figure 2. Fall anhydrous vs. split applied pre-plant and in-season UAN.

What I show in (Table 1) makes it very clear which N application timings are more profitable. So the question really is at what economic (to the grower) and environmental price does the convenience of applying N in the fall no longer seem reasonable? While lower yields and higher economic optimum nitrogen rates for fall applied N applications are not new, widespread availability to high clearance self-propelled sprayers is new, and gives growers yet another reasonable option for applying N in-season closer to when the crop actually requires it.

Table 1. Corn yield and profitability from fall applied or pre-plant/side-dress N application timings. The nitrogen price used for spring or side-dress application would represent nitrogen cost if UAN were used.

	Corn after Soy	Nitrogen Cost		
Nitrogen Timing	N Rate lbs/ac	$/lb	$/ac	Difference $/ac
Fall Applied	200	0.31	62	Fall N costs $3.60 more per acre
Pre-plant or side-dress	146	0.39	56.9	

	Return @ $3.50 Corn			
Nitrogen Timing	Corn Yield bu/ac	Gross $/ac	Net $/ac	Difference $/ac
Fall Applied	188	658	596.0	Pre-plant or Side-dress N increases profits $47.10
Pre-plant or side-dress	200	700	643.1	

Reference

Sawyer, J.E., D.W. Barker, and J.P. Lundvall. 2016. Impact of nitrogen application timing on corn production. North Central Extension-Industry Soil Fertility Conference proceedings. 39:56-60.
http://extension.agron.iastate.edu/NCE/index.aspx (accessed 11 of Nov 2016)

Sulfur for Corn & Micronutrients for Corn & Soybeans

authored by
Dr. Jake Vossenkemper

Article Summary

- One of the key advantages of using a fluid fertilizer is that each fluid ounce of fertilizer material contains nearly identical ratios of N-P-K-S and micronutrients.
- With dry granular fertilizer each dry pound of material may contain quite different ratios of N-P-K-S and micronutrients due to segregation during transportation and application.
- A fertilizer that can maintain consistent ratios of N-P-K-S and micronutrients may be an important factor in yield increases from micronutrients.
- As an example, with fluid fertilizers we have observed that when zinc and ATS (sulfur) are applied together yield increases are larger than when either are applied independently.

One of the key advantages of using a fluid fertilizer is that each fluid ounce of fertilizer material contains nearly identical ratios of N-P-K-S and micronutrients. With dry granular fertilizer, however, each dry pound of material may contain quite different ratios of N-P-K-S and micronutrients. The reason why dry fertilizer does not contain consistent ratios of N-P-K-S and micronutrients is due to dry fertilizer segregation. While dry sources of fertilizer can be evenly blended, once the blended product leaves the blender segregation begins to take place. Segregation takes place during transportation to the field and during application as a result of each dry fertilizer material having varying degrees of densities and shapes. To demonstrate the effects of segregation after dry fertilizer transportation I took 5 samples from our liquid suspension fertilizers and 5 samples from a blended dry fertilizer after being transported on a few short road trips on the same trailer. Of the 5 liquid suspension fertilizers collected the zinc within those 5 samples varied by 2.7%, but the zinc in the 5 dry fertilizer samples varied by 58.7% (Table 1).

Dry fertilizer segregation and generally poor fertilizer distribution by spinner spreader machines may be one reason why some folks fail to find yield increases when micronutrients are added to N-P-K-S dry fertilizer blends, but there may be some other reasons why we tend to see more consistent yield increases from micronutrients than folks applying dry fertilizer. For example, when ammonium thiosulfate (ATS) rapidly oxidizes to plant available sulfate, acid is produced, and as a result of this acid forming oxidation reaction the soil pH drops in and around the fertilizer band. This drop in pH in and around the fertilizer band has important consequences for plant zinc uptake because zinc availability increases as soil pH decreases.

Table 1. Coefficient of variation for plant available potassium and zinc from a liquid suspension fertilizer and a dry blended fertilizer after transportation.

	K_2O Blend %		Zinc Blend %	
Sample	Liquid	Dry	Liquid	Dry
1	7.55	28.4	.056	1.4
2	7.54	31.5	.059	3.4
3	7.43	30.8	.056	0.8
4	7.62	28.3	.057	2.2
5	7.51	33	.055	1.1
Variation %(CV)	0.9	6.7	2.7	58.7

In table 2, 3 and 4 are some examples from multi-year experiments where we have observed yield increases when sulfur, zinc and boron are added to liquid suspension fertilizers for corn, and when manganese is added to liquid suspension fertilizers for soybeans. These experiments were conducted at our Walcott, IA research farm by my predecessor and long-term Senior Agronomist, Ken Washburn.

Table 2. Corn yield from the addition of .5 lb/ac of ammoniated zinc or the addition of .5 lb/ac of ammoniated zinc plus 10 lb/ac of sulfur as ATS at the Walcott research farm from 2004 to 2006. Plots were replicated 4 times each year. The price received for a bu of corn was assumed to be $3.80/bu. LSD at an alpha level of 0.10 = 5 bu/ac.

Fertilizer NPKSZn (lb/ac)	Yield (bu/ac)	Increase (bu/ac)	Gross Return ($/ac)	Fertilizer Cost ($/ac)	Net Return ($/ac)
24-45-65	210.9	-	-	-	-
24-45-65-0.5zn	212.8	1.9	7.2	1.6	5.6
24-45-65-10s-0.5zn	218.1	7.2	27.4	8.1	19.3

Table 3. Corn yield from the addition of .5 lb/ac of ammoniated zinc and 10 lb/ac of sulfur as ATS, or the addition of .5 lb/ac of ammoniated zinc plus 10 lb/ac of sulfur as ATS and .2 lb/ac as fertibor at the Walcott research farm from 2011 to 2014. Plots were replicated 4 times each year. The price received for a bu of corn was assumed to be $3.80/bu. LSD at an alpha level of 0.10 = 10 bu/ac.

Fertilizer NPKSZnB (lb/ac)	Yield (bu/ac)	Increase (bu/ac)	Gross Return ($/ac)	Fertilizer Cost ($/ac)	Net Return ($/ac)
29-55-85	197.2	-	-	-	-
29-55-85-10s-0.5zn	204.9	7.7	29.3	8.1	21.2
29-55-85-10s-0.5zn-0.2B	206.8	9.6	36.5	9.9	26.6

Table 4. Soybean yield from the addition of 1.3 lb/ac of manganese from manganese sulfate at the Walcott research farm from 2008 to 2015. Plots were replicated 4 or 5 times each year. The price received for a bu of soybeans was assumed to be $9.50/bu. LSD at alpha level of 0.10 = 1.7 bu/ac.

Fertilizer NPKSMn (lb/ac)	Yield (bu/ac)	Increase (bu/ac)	Gross Return ($/ac)	Fertilizer Cost ($/ac)	Net Return ($/ac)
21-40-80	64.6	-	-	-	-
21-40-80-1.3Mn	66.7	2.1	20.0	4.9	15.1

Soybean Sulfur Requirements on the Increase

"Free" Sulfur Additions on the Decrease

authored by
Dr. Jake Vossenkemper

Article Summary

- Reduced atmospheric sulfur deposition in combination with higher soybean yields and greater sulfur requirements suggest yield increases from the addition of sulfur fertilizer will become more common.
- In a 7 yr study conducted near Walcott, IA from 2008 to 2015 soybean yields were increased by 1.8 bu/ac from the addition of 10 lb S/ac from ATS.
- Applying 10 lbs S/ac in the fall with liquid suspension fertilizers resulted in a $10.60/ac net return.

Several factors are resulting in crop scientists around the Midwest seeing more consistent and larger yield increases from sulfur fertilizer applications to soybean than 1 or 2 decades ago. There are several contributing factors that may help explain these more recent observations. There are fewer trace amounts of sulfur in modern phosphorus fertilizer sources (DAP, MAP and 10-34-0), there is less sulfur from atmospheric deposition than a few decades ago (Figure 1) and soybean grain yields are higher than ever before in history. Given we are getting less "free" sulfur from the atmosphere and little if any trace amounts of sulfur in today's modern phosphorus fertilizer sources means we are counting on sulfur mineralization from the soil to provide the balance for ever higher crop sulfur requirements and yields. So can the soil meet the task?

Nutrient Balances Suggest The Soil Can't Provide Enough Sulfur

Given soybean requires about 0.35 lbs of sulfur ac/yr in the above ground biomass to produce 1 bushel of soybeans we would expect a 70 bu/ac soybean crop to need 24.5 lbs of sulfur ac/yr. So can the soil provide that much? The answer is probably not or not always.

Soil can mineralize about 3.5 lbs of sulfur ac/yr for every 1% of soil organic matter (SOM), therefore, a soil with 3% organic matter would supply 10 to 12 lbs of sulfur ac/yr, roughly half of the total required. If you count the 6 lbs of sulfur ac/yr we are still getting from the atmosphere then we are at approximately 16 to 18 lbs sulfur ac/yr from the atmosphere plus the soil.

This is still not at the 24.5 lbs of sulfur ac/yr required. So you need higher SOM or the addition of sulfur fertilizer if you're going to make it to 70 bu/ac soybeans based on this nutrient balance exercise. You can visualize sulfur shortcoming at different yield levels and SOM% in the nutrient balance table within this article (Table 1).

Table 1. Sulfur balance table. Yield levels and SOM concentrations that are yellow or red indicate a high likelihood of a yield increase from added sulfur fertilizer. Yield levels and SOM concentrations in green indicate less likelihood of a yield increase from added sulfur fertilizer.

		Soil Organic Matter (%)				
		1	2	3	4	5
Yield (bu/ac)	Sulfur Req (lbs/ac)	"Free" Sulfur - Atmosphere + Soil (lbs/ac)				
		10	13	17	20	24
40	14	-5	-1	3	6	6
50	18	-8	-5	-1	3	3
60	21	-12	-8	-5	-1	-1
70	25	-15	-12	-8	-5	-5
80	28	-19	-15	-12	-8	-5

Sulfur For Soybeans Field Research

In addition to these nutrient balance assumptions, we also ran field research trials to find out how often and how much profit a grower might expect from sulfur applications to soybeans. These field trials were conducted at the Walcott, IA research farm from 2008 to 2015. For all 7 years of the trial, the treatments were a 21-40-80 (NPK lbs/ac) base rate of liquid suspensions applied in the fall, or the same base rate of liquid suspensions applied in the fall plus 10 lbs sulfur/ac from ATS. These two treatments were replicated 4 or 5 times per year for each of the 7 years of the study. Averaged over the field trial duration, 10 lbs/ac of sulfur applied in the fall with liquid suspensions increased soybean yields 1.8 bu/ac over the no sulfur control (Pr>t 0.0135, Table 2). I might add that the Walcott research farm is not a low SOM farm. The SOM at the Walcott research farm averages 3.4%, therefore I would expect larger yield increases on farms with lower SOM levels than these.

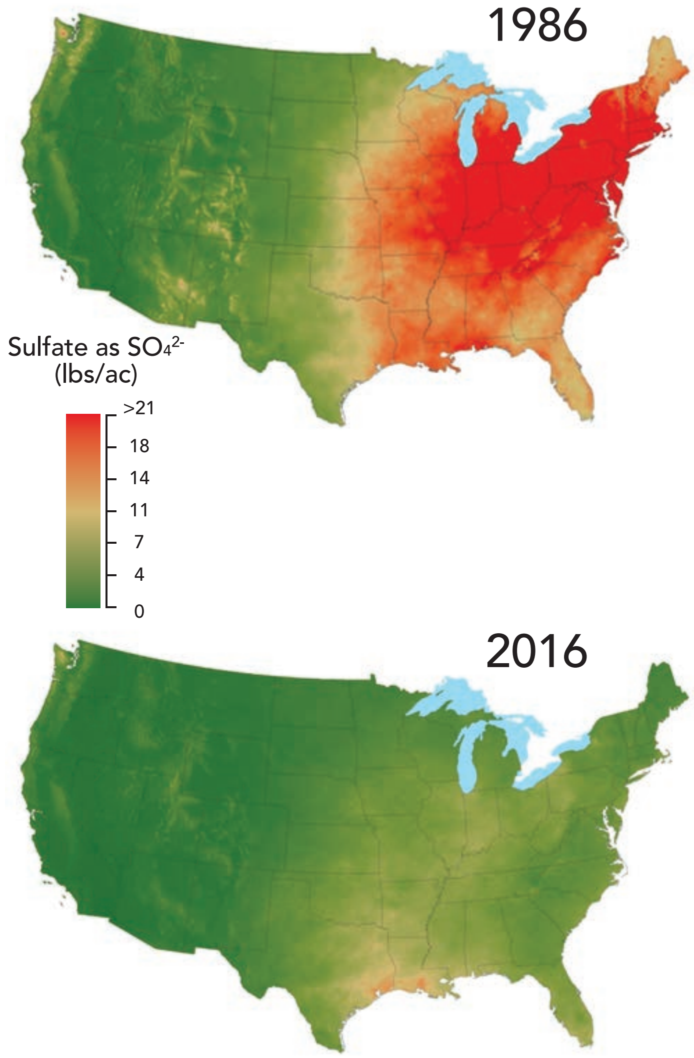


Figure 1. Changes in atmospheric sulfur deposition from 1986 to 2016. Figure provided by the National Atmospheric Deposition Program/National Trends Network. http://nadp.isws.illinois.edu.

Expected Conditions For Soybean Sulfur Responses

- **Soybeans no-tilled into corn residue**
- **When early planting is a serious objective (cool soils mineralize less sulfur)**
- **Fields with 4% or less organic matter**
- **Sandy well drained farms – spring sulfur should be applied in these cases**

Table 2. Soybean yield from the addition of 10 lbs/ac of sulfur from ATS at the Walcott research farm from 2008 to 2015. Plots were replicated 4 times each year. The price received for a bu of soybeans was assumed to be $9.50/bu. Treatment averages with different letters are significantly different at an alpha level of 0.10

Fertilizer NPKS (lbs/ac)	Yield (bu/ac)	Increase (bu/ac)	Gross Return ($/ac)	Fertilizer Cost ($/ac)	Net Return ($/ac)
21-40-80	64.5a	-	-	-	-
21-40-80-10s	66.3b	1.8	17.1	6.5	10.6

Are Bio-Fertilizers the Next Frontier in Soil Fertility & Fertilizer Technology?

authored by
Dr. Jake Vossenkemper

Are bio-fertilizers the next frontier in soil fertility and fertilizer technology? That has yet to be determined, of course, but we do know that the biological and bio-fertilizers market is estimated to grow from a current market worth of $6.7 billion to $12.9 billion by the year 2022. What does this increase in the biological market mean if I am a farmer? A rapidly growing biological market aimed at the agricultural sector means farmers need to become educated about what biologicals and bio-fertilizers may and may not be able to offer them. Over the last couple years, I have been browsing the scientific literature educating myself about what we do and do not know about these bio-fertilizers. I have learned that due to advancements in genome sequencing it is now much easier, faster and cheaper to identify and isolate specific bacterial and fungal strains that do in-fact provide services that can improve plant growth and yield.

Some of the agronomically important services bio-fertilizers may be able to provide include: atmospheric nitrogen fixation for row crops (corn, wheat, etc..), bacteria that are able to convert non-plant available forms of soil nutrients into plant available forms (phosphorus and potassium solubilizing bacteria), bacteria that can compete with plant pathogenic fungi and other harmful bacteria, and specific strains of bacteria have been shown to produce plant growth regulators (Indole acetic acid, gibberellic acids, etc.) that can stimulate root growth and development.

See the bulleted list for more specific details about what bio-fertilizers have been shown to be able to achieve in science-based studies.

Article Summary

- Scientific advancements in gene editing and the cost to sequence genomes has resulted in large investments in biological research and marketing.
- As a result of these investments farmers will be hearing much more about these new biological and bio-fertilizers and need to partner with trusted advisors to help them understand which of these products are actually financially viable.
- Liqui-Grow will be field testing some of the most promising biological and bio-fertilizers in local research plots to understand which if any can help our customers be more profitable.

Liqui-Grow Will Implement Bio-Fertilizer Field Testing

The unfortunate part is that many of these known benefits of bio-fertilizers have been tested more often under greenhouse vs. actual field conditions. That said, there is an increasing amount of evidence that these bio-fertilizers may, in fact, be able to increase corn and soybean yields in actual field environments, but our knowledge in actual field conditions is clearly more limited than what has been shown in greenhouse studies. On this note, Liqui-Grow has partnered with several biological companies that are leaders in the bio-fertilizer market. We will be testing their most promising bio-fertilizer products at several locations throughout eastern IA and northwest IL in the 2020 growing season and beyond. Our main objective at Liqui-Grow is to identify and investigate (in-formal field research trials) new and innovative products and crop management practices that can make our customers and our company more profitable. Partner with us to find out what we learn.

Key Bio-Fertilizer Characteristics

- Nitrogen-fixing bacteria can add 25+ lbs N/ac/yr (azospirillum, azotobacter, gluconacetobacter diazotrophicus, klebsiella variicola) under optimum soil conditions and thus can potentially increase grain yields.
- Application of bio-fertilizers can result in increased mineral and water uptake, root development, and vegetative growth.
- Some bio-fertilizers (eg, Rhizobium BGA, Azotobacter sp) stimulate the production of growth promoting substance like vitamin-B complex, Indole acetic acid (IAA) and gibberellic acids.
- Phosphate mobilizing or phosphorus solubilizing bio-fertilizers/microorganisms (bacteria, fungi, mycorrhiza, etc.) converts insoluble soil phosphate into soluble forms by secreting several organic acids and under optimum conditions have been shown to solubilize/mobilize as much as 30-55 lbs P_2O_5/ac.
- Bio-fertilizers can act as antagonists/competitors and suppress the incidence of soil-borne plant pathogens and thus, help in the bio-control of diseases.
- Bio-fertilizers are a cheap, pollution free and renewable energy source.
- Bio-fertilizers improve physical properties of soil, soil tilth and soil health in general.
- Bio-inoculants containing cellulolytic and ligninolytic microorganisms enhance the degradation/decomposition of organic matter in the soil, as well as enhance the rate of crop residue decomposition.
- Azotobacter inoculants, when applied to many non-leguminous crop plants, promote seed germination and initial vigor of plants by producing growth promoting substances.

http://www.agriinfo.in/default.aspx?page=topic&superid=5&topicid=176

Corn In-Furrow Additives for Starter Fertilizer

authored by
Dr. Jake Vossenkemper

Article Summary

- The in-furrow additives market is growing and will continue to do so for the foreseeable future.
- Most of the market growth in the coming years will be focused on biological products, particularly strains of bacteria and fungi that may have properties that promote plant growth and yield.
- But do any of these new in-furrow biological products produce consistent yield increases and are they profitable?

Companies including major manufacturers down to startup companies with as few as 10 to 15 employees are developing in-furrow products that can be tank mixed with starter fertilizers or other agro chemicals. This in-furrow additives market is growing and will continue to do so for the foreseeable future. Most of the market growth in the coming years will be focused on biological products, particularly strains of bacteria and fungi that may have properties that promote plant growth and yield.

While some of these new biological products may in fact increase plant growth and yields, we also understand that yield is a very complex trait and that yield increases may be year and environment dependent (soil type, crop rotation, soil fertility levels, etc).

Most of the market growth in the coming years will be **focused on biological products,** particularly strains of bacteria and fungi that may promote plant growth and yield.

In an effort to help us and our customers have a better understanding of which or any of these newest in-furrow additives on the market may increase yields and profitability, we have been field testing some of them for the last couple growing seasons in eastern IA and northwest IL.

Field Testing In-furrow Additives

The products were tested in small plot trials (10 ft wide by 30 ft long) replicated 4 to 8 times depending on the location. The check plots were 5.5 gal/ac of 6-24-6 and each in-furrow additive treatment was applied with this same 5.5 gal/ac rate of 6-24-6 starter fertilizer. There were two sets of in-furrow additives. The first set of in-furrow additives was tested at Durant, IA in 2018, and at Durant, IA, Morning Sun, IA and Hampton, IA in 2019 for a total of 4 locations (Table 1). The 2nd set of in-furrow additives were tested at Durant, IA, Morning Sun, IA and Hampton, IA in 2019 for a total of 3 locations (Table 2). Net profits were calculated assuming $3.50 bu corn.

Research Findings

When averaged over locations none of the in-furrow additives dramatically increased corn yields or profits and none increased yields statistically (alpha level of 0.10 or 90% probability) compared to the check plots. At individual locations, however, some of the in-furrow additives did increase yields and profits. For example, Terrasym 408 increased yields by 10.8 bu/ac (LSD = 8.0 at 0.10) at the Hampton, IA location and Fulvex increased yields by 10.7 bu/ac (LSD = 7.7 at 0.10) at Morning Sun, IA location. Other in-furrow additives did not show large yield increases at any one location, but showed small yield increases at most locations tested. These products included Vertex-IF and Nutrio Unlock. We will continue to evaluate the most promising in-furrow additives from these trials in future years to see if we can zero in on how often we might expect a profitable yield increase.

Table 1. 1st set of in-furrow additives, yields are averaged over 4 locations (29 reps). Net profit calculations assumed $3.50 bu/ac corn.

In-Furrow Additive	Yield (bu/ac)	Net Profit ($/ac)
Vertex-IF	235.5	-1
Product A	234.7	-3
iNvigorate	234.7	-4
Levesol	234.7	0
Check	233.3	N/A
Product B	232.8	-11
LSD at 0.10	4.9	

Table 2. 2nd set of in-furrow additives, yields are averaged over 3 locations (19 reps). Net profit calculations assumed $3.50 bu/ac corn.

In-Furrow Additive	Yield (bu/ac)	Net Profit ($/ac)
Terrasym 408	233.5	5
Nutrio Unlock	232.8	1
Fulvex	232.0	3
EndoPrime	232.0	-4
GoGreen	230.6	N/A
Check	230.2	N/A
K-Gain	226.9	-14
LSD at 0.10	5	

Managing for Higher Corn Plant Populations

authored by
Dr. Brad Bernhard
researched at University of Illinois

Article Summary

- Higher plant populations can be managed by planting in narrower row spacings.
- As plant population increases, the size of each individual root system becomes significantly smaller, which increases the need for better crop management, especially fertility.
- When growing corn at higher plant populations and/or narrower row spacings, it is important to select a hybrid that has a positive yield-response to these more intensive management practices.

Corn yields have increased significantly since the 1930s largely due to genetic improvement and better crop management. Grain yield is the product of the number of plants per acre, kernels per plant, and weight per kernel. Of the three components that make up grain yield, the number of plants per acre is the factor that the grower has the most direct control over. Kernel number and kernel weight can be managed indirectly through proper fertility, weed, pest and disease management to optimize plant health. Weather also plays a major role. Currently, the average U.S. corn planting population is just under 32,000 plants/ac and has increased 400 plants per acre per year since the 1960s. If this trend continues, the average U.S. corn planting population will reach 38,000 plants/ac in 15 years and 44,000 plants/ac in 30 years.

Narrower Row Spacings

Today, the vast majority of corn in the U.S. is planted in 30" row spacings, with narrower rows generally defined as any row spacing or configuration less than 30" row spacings.

The most common narrower row spacings include 20" and 15" rows, along with twin rows that are spaced 7.5" apart (22.5" between rows, but are on 30" centers). Narrower row spacings can be used to increase plant-to-plant spacing within a row to reduce crowding at higher plant populations, thereby, allowing the crop to better utilize available light, water, and nutrients (Figure 1).

In 2017 and 2018, six commercial DeKalb hybrids were planted at 38,000, 44,000, 50,000, and 56,000 plants/ac in a 30" and 20" row spacing at Yorkville and Champaign, IL.

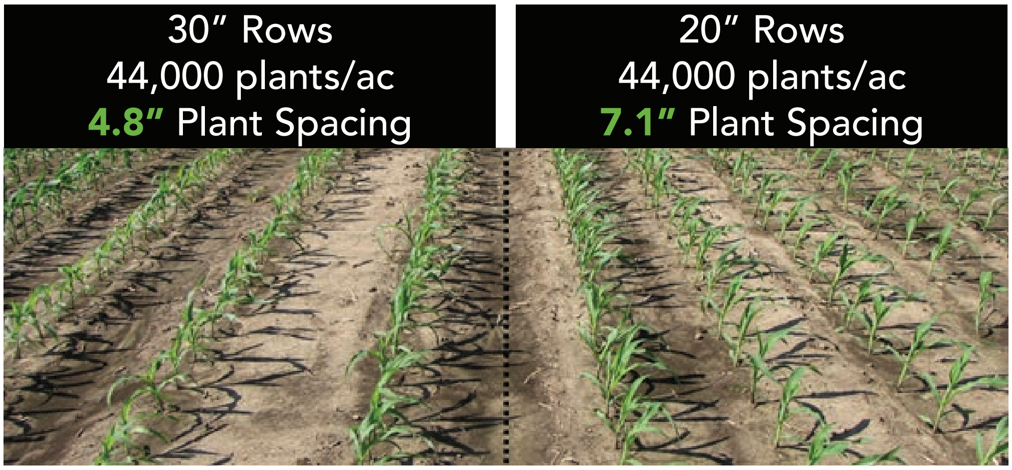


Figure 1. At the same plant population of 44,000 plants/ac, greater plant-to-plant spacing is achieved in the 20" row spacing compared to the 30" row spacing.

The management system that resulted in the highest grain yield of 294 bushels per acre was planting 44,000 plants/ac in a 20″ row spacing (Table 1). The minimum plant population that maximized grain yield in a 30″ row spacing was 38,000 plants/ac. On average, across plant population, plants in a 20″ row spacing yielded 12 bu/ac more than when planted in a 30″ row spacing. However, as plant population increased the yield advantage of the 20″ rows over the 30″ row spacing was greater. Planting 56,000 plants/ac at either row spacing was too high of a population and yield decreased without a sufficient amount of resources such as water or nutrients to support that many plants. Evidence suggests that there is a limit on how high planting population can be pushed in either a 30″ or 20″ row spacing without any additional fertilizer, crop protection, or irrigation.

Better Crop Management

Management systems that decreased plant-to-plant spacing within a row, such as wider row spacing and higher plant population, decreased the size of the root system. On average, for every additional 6,000 plants planted per acre there was a 15-18% decrease in the size of the root system (Figure 2). However, when planted in a 20″ row spacing, the greater plant-to-plant spacing increased the size of the root system by 22%. At higher plant populations, not only are there more plants that require nutrients and water, but each of those plants also have a significantly smaller root system. Crop fertility becomes even more important under these more intensive growing conditions. Placing nutrients directly in the root zone at the right time using the correct source and rate, increases the probability that roots will take up and utilize those nutrients.

For every additional 6,000 plants planted per acre there was a 15-18% decrease in the size of the root system.

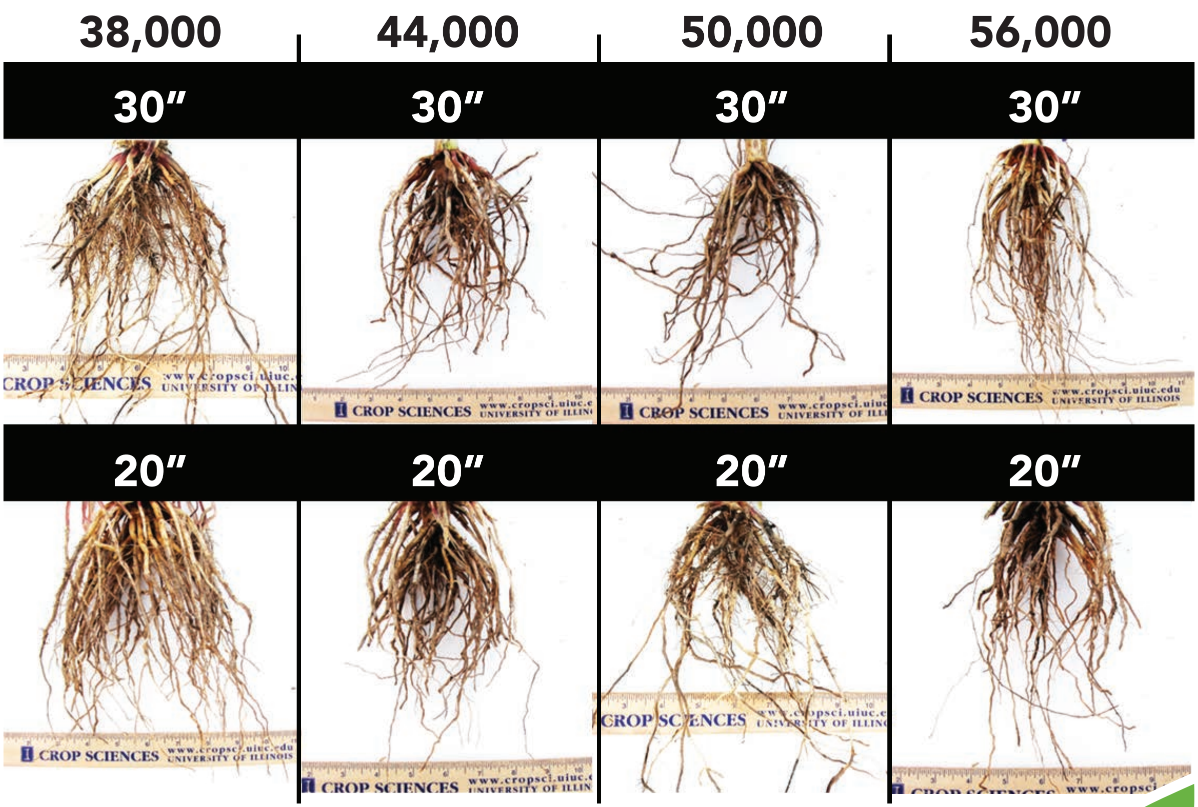


Figure 2. Individual plant root size decreases as plant population increases. At a given plant population, the 20″ row spacing has a larger root system compared to the 30″ root system.

Select the Right Hybrid

Hybrids vary greatly in their response to plant population and to narrower row spacings (Table 2). Hybrids also vary in their plant architecture and leaf trait characteristics. Understanding which hybrids better tolerate higher plant populations and narrower row spacings along with the plant growth and leaf traits that these hybrids possess would help lead the breeding effort for selecting hybrids that will perform even better in these management systems. Hybrids that produced greater yields in response to narrower row spacings and higher plant populations tended to possess the following plant growth and leaf traits: 1) greater above-ground biomass, 2) high leaf area index, 3) upright leaves, 4) thin leaves, and 5) less leafy plants.

Table 1. Grain yield as influenced by plant population and row spacing for corn averaged across six corn hybrids grown at Yorkville and Champaign, IL in 2017 and 2018.

Row Spacing	plants/ac				Avg
	38 k	44 k	50 k	56 k	
	bu/ac				
30″	279	281	276	268	276
20″	286	294	293	280	288

LSD (0.05) Spacing = 4
LSD (0.05) Plant Pop. = 3
LSD (0.05) Spacing x Plant Pop. = 5

Table 2. Grain yield and profit difference between planting 38,000 plants/ac in a 30″ row spacing compared to 44,000 plants/acin a 20″ row spacing for six DeKalb corn hybrids grown at Yorkville and Champaign, IL in 2017 and 2018.

Hybrid	38k 30″	44k 20″	ΔYield	ΔProfit
	bu/ac			$/ac
5806	265	270	5	-7
6067	271	286	15	29
6087	278	300	22	53
6208	285	291	6	-3
6434	281	300	19	43
6640	291	317	26	67
Avg	**279**	**294**	**16**	**30**

*Profit calculated with $3.50 corn & $320.00 per bag of seed.

Summary

As the trend of increasing planting populations continues, it is important to consider the effects that the reduced plant-to-plant spacing has on the corn plants. Crop management becomes even more important, especially fertility, under these crowded conditions. Narrower row spacings can be used as a tool to reduce the plant-to-plant competition at higher planting populations.

We're Out There

Liqui Grow®

Every Season

Armor Hybrid Performance Summary
2018 & 2019 Growing Seasons

authored by
Dr. Jake Vossenkemper

The Liqui-Grow family is excited to announce a new partnership with Armor Seed! Liqui-Grow will be the sole provider of Armor Seed and traits throughout our trade territory. This exclusive partnership between Liqui-Grow and Armor Seeds will allow us to bring to market the absolute best traits and genetics, tested locally and specifically chosen for our geography and our customers' needs. Through local testing and product selection, along with simplified pricing, we will provide our customers with a more enjoyable seed buying experience and top yields that are expected from Liqui-Grow products.

Local testing and Armor corn selection will be achieved via the independent FIRST seed testing trials, by our in-house agronomy research team and through observations from our strip trial plots at each of our local retail outlets. Below is a summary of the 2018 and 2019 strip trials plots, as well as a combined summary of the common hybrids from both the 2018 and 2019 strip trial plots. As you can see, the Armor corn hybrids Liqui-Grow is bringing to market via this local testing strategy are producing similar or greater yields than leading industry corn hybrids.

If you would like to learn more about Armor Seed, please inquire with your local Liqui-Grow location and visit our website www.liqui-grow.com for more details regarding our 2018 and 2019 Armor corn hybrid plots. Additional information about Armor Seed and genetics can also be gained by visiting their website at www.armorseed.com.

ARMOR®
Start Strong. Plant Armor.

Avg 13 On-Farm Strip Trials-Eastern IA & Northwest IL 2018				
Company	RM	Hybrid	MST (%)	Yield (bu/ac)
Armor	114	1447VT2P	18.9	255.5
Check	114	Check Hybrid	19.1	252.8
Armor	111	1118VT2P	18.0	251.2
Armor	109	0919VT2P	16.9	249.6
Armor	110	Experimental	17.7	247.8
Pioneer	111	P1197AMX	18.3	245.6
Armor	112	Experimental	18.3	238.1

LSD at 0.10 = 7.5

Avg 8 On-Farm Strip Trials-Eastern IA & Northwest IL 2019				
Company	RM	Hybrid	MST (%)	Yield (bu/ac)
Pioneer	111	P1197AM	20.5	228.2
Armor	111	1118VT2P	20.1	224.6
Armor	114	1447VT2P	21.7	222.6
Armor	112	Experimental	20.8	221.4
Armor	109	0919VT2P	20.1	211.2
Check	114	Check Hybrid	22.1	210.2
Armor	105	Experimental	19.8	198.8

LSD at 0.10 = 10.3

Avg 21 On-Farm Strip Trials-Eastern IA & Northwest IL 2018 & 2019				
Company	RM	Hybrid	MST (%)	Yield (bu/ac)
Armor	114	1447VT2P	19.9	242.9
Armor	111	1118VT2P	18.8	241.1
Pioneer	111	P1197AM	19.1	239.1
Check	114	Check Hybrid	20.2	236.5
Armor	109	0919VT2P	18.1	234.7

LSD at 0.10 = 6.7

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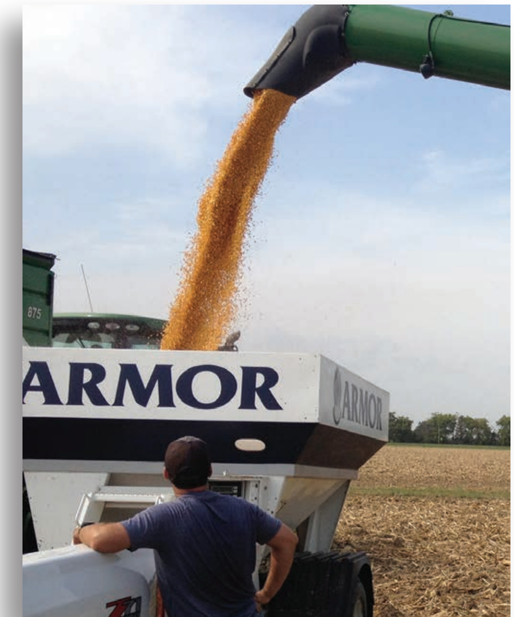
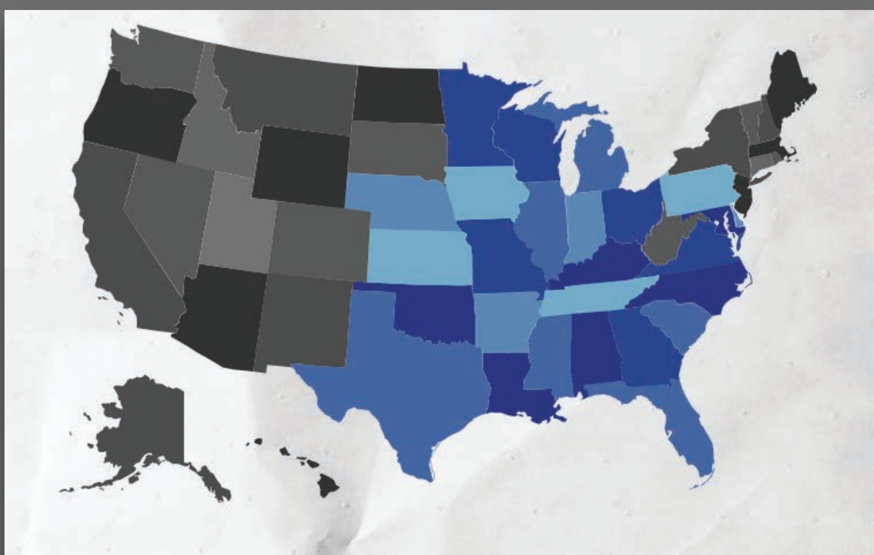


FIND PRODUCTS AVAILABLE IN YOUR STATE



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ILeVO Seed Treatment
Just Another Added Expense or Profitable Insurance Policy?

authored by
Dr. Jake Vossenkemper

Article Summary

- SDS is a frequent disease of soybean but does not reduce yields every year – suggesting that ILeVO will be used as insurance based management.
- Using ILeVO increased yields in all 7 on-farm trials in the 2016 growing season.
- The average yield increase across all 7 trials was 7.8 bu/ac resulting in net returns of $63 per acre (Figure 1).

Brief Introduction

Sudden Death Syndrome (SDS) is a fungal root rot of soybean that can routinely cause reduced soybean yields in the US Midwest. Soybeans are most susceptible to SDS within a few weeks after planting, presumably because it is easier for the SDS pathogen to penetrate young succulent root tissue vs. older root tissue that has had time to develop more ridged less penetrable cortical tissue. Given this early season susceptibility, crop scientists have been searching for a seed applied fungicide that controls the SDS pathogen. Since about 2012, Bayer CropScience has been testing a seed applied fungicide (a.i. fluopyram) that shows promise at reducing soybean SDS infection and yield losses associated with this disease. This seed applied fungicide, as of the 2015 crop season, has been sold commercially under the trade name ILeVO. In addition to controlling SDS, ILeVO treated plants have also been shown to have fewer soybean cyst nematode eggs (SCN) per gram of root than non ILeVO treated plants (Zaworski, 2014), and is currently labeled for control of SCN.

Given ILeVO controls SDS and SCN, this new seed treatment could dramatically increase soybean yields and provide significant financial benefits to Midwestern farmers when these diseases are at high enough levels to reduce yields.

> This new seed treatment could **dramatically increase** soybean yields.

Since it is not always known if these diseases will reduce yields at planting, ILeVO may be viewed as insurance-based management in the event these diseases do reduce yields. Given these important economic questions Liqui-Grow partnered with 7 different farmers to help them learn how often adding ILeVO to their seed treatment package would increase soybean yields, and if the yield increase would be large enough to pay for the added cost of the ILeVO seed treatment.

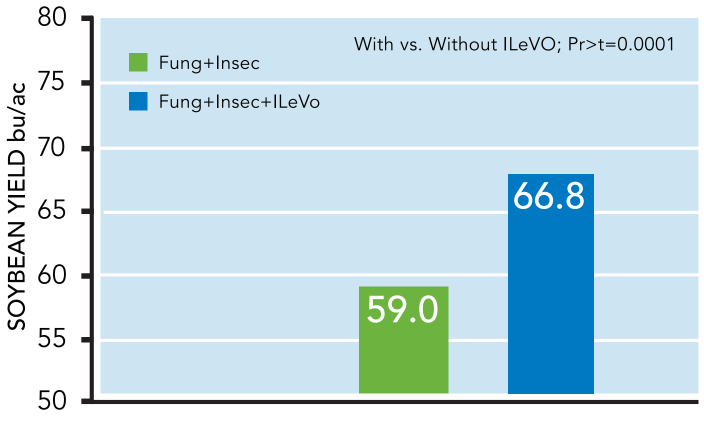


Figure 1. Average soybean yield for plots treated with base fungicide+insecticide seed treatments and base fungicide+insecticide+ILeVO seed treatments at 7 on-farm sites in Illinois and Iowa in the growing season of 2016.

The Applied Question

How often does ILeVO increase yields, and is the yield increase large enough to pay for the added cost of the ILeVO seed treatment?

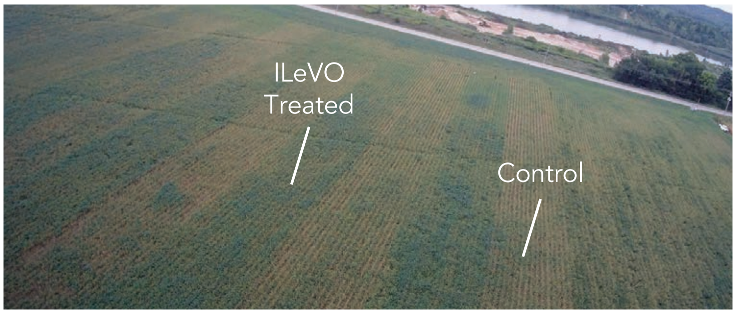
How Were the Applied Questions Answered?

4 on-farm studies were implemented in eastern IA and 3 in northern IL. At each of these sites, farmer cooperators planted soybeans treated with either base fungicides+ an insecticide+ILeVo seed treatments or soybeans treated with just base fungicides+ an insecticide in side-by-side plots. These side-by-side plots were replicated 5 times at each of these 7 location. Plot widths ranged from 30 to 80 ft wide and plot lengths ranged from 230 to 2,260 ft long. All varieties used in these studies were Credenz brand soybeans marketed and sold by BASF and had average to above average SDS tolerance ratings.

All varieties used in these studies had average to above average SDS tolerance ratings.

The Results

At 6 of the 7 sites, SDS symptoms (chlorotic mottling and leaf chlorosis) were present during the seed-filing period (R6) and these symptoms were almost always more severe in the control plots that did not have seeds treated with ILeVO (Picture 1). The yield increase from adding ILeVO to the base fungicides+insecticide seed treatments ranged from 3.2 to 15.4 bu per acre (Table 1) depending upon the site/location. Moreover, sites that had more severe SDS symptoms during the seed-filling period tended to have larger yield increases from adding ILeVO to the base fungicides+insecticide seed treatment package. The Clear Lake, IA site was an exception. At this site no SDS symptoms were visible during the seed-filling period but on average ILeVO increased yields 5 bu/acre.



Peoria, IL site in the growing season of 2016.

Table 1. Soybean yield and net returns from using base fungicide + insecticide or base fungicide+insecticide+ILeVO seed treatments at 7 Illinois and Iowa locations in the growing season of 2016. The price per bu of soybean used to calculate the net returns from using ILeVO was $9.50/bu. The cost of adding the ILeVO seed treatment package was assumed to be $12/ac.

Location	Fung + Insecticide	Fung + Ins + ILeVO	Yield Increase	Net Return
	Grain Yield bu/ac			$/ac
Walcott, IA	52.2	55.4	3.2	18.8
Peoria, IL	38.1	53.5	15.4	136.3
Roseville, IL	72.3	78.6	6.3	48.7
Walnut, IL	59.4	72.5	13.1	114.2
Clear Lake, IA	78.1	83.1	5	36.2
West Liberty, IA	48.4	53.2	4.8	34.1
Eldridge, IA	64.8	71.6	6.8	53.5
Average	59.0	66.8	7.8	63.1

Conclusion

Averaged across these 7 sites, adding ILeVO to a base fungicide+Insecticide seed treatment package increased yields 7.8 bu/acre and economic returns $63.1 per acre, suggesting that ILeVO may be a worthwhile insurance policy for farmers to purchase. Even though there is not a guarantee that ILeVO will provide a return on investment in every season, yield increases such as these in 2016 suggest that ILeVO could be bought for the next 5 growing seasons and net returns would still be north of break even. That being said, the odds are high SDS will again return in one or several of the next 5 growing seasons.

New Research Comparing Ortho/Poly-Phosphate Ratios
for In-Furrow Seed Safe Starter Fertilizers (5 Site-Year Summary)

authored by
Dr. Jake Vossenkemper

Article Summary

- Ortho-phosphates are 100% plant available, but a high percentage of poly-phosphates in starter fertilizers convert to ortho-phosphate within just two days after application.
- This quick conversion from poly to ortho-phosphate suggests expensive "high" ortho starter fertilizers are not likely to result in increased corn yields compared to conventional poly-phosphate starters.
- On-farm field studies conducted near Traer, IA and Walnut, IL in the 2016 to 2018 growing season found no statistical difference (Pr > 0.05) in corn yield between conventional and high ortho-phosphate starters.
- High ortho starters cost more per/ac than conventional poly-phosphate starters, but do not increase corn grain yields.

Poly-Phosphates Rapidly Convert to Plant Available Ortho-Phosphates

Given poly-phosphates are not immediately plant available and ortho-phosphates are immediately plant available, this gives the promoters of "high" ortho-phosphate starters ample opportunity to muddy the waters. Nevertheless, the facts are, poly-phosphates are rather rapidly hydrolyzed (converted to) into ortho-phosphates once applied to soils, and this hydrolysis process generally takes just 48 hrs or so to complete.

In Sept of 2015 I posted a blog discussing some of the more technical reasons why the ratio of ortho to poly-phosphates in starter fertilizers should have no impact on corn yields. For those that are interested in the more technical details, I encourage you to follow this link to the Sept 2015 blog post (liqui-grow.com/farm-journal).

While we were relatively certain that the ratio of ortho to poly-phosphates in liquid starters should have no effect on corn yields, I decided to "test" this idea with on-farm field studies conducted near Traer, IA and Walnut, IL in the 2016 to 2018 growing season.

How the Field Trial Was Conducted

In these field trials we used two starters applied in-furrow at 6 gal/ac. Each starter had a NPK nutrient analysis of 6-24-6. The only difference between these two starters was the ratio of ortho to poly-phosphates. One of these starters contained 80% ortho-phosphate and the other contained just 50% ortho-phosphate with the remainder of the phosphorous source in each of these two starters being poly-phosphate.

At the Traer, IA locations the plots were planted with a 24-row planter (Figure 1) and were nearly 2,400 ft long. At the Walnut, IL locations the research was conducted using small plot techniques. Plot dimensions there were 10 ft wide by 30 ft long. At both Traer, IA and Walnut, IL in each of the 3 growing seasons, the experimental design used was a simple randomized complete block with 4 or 5 replications.

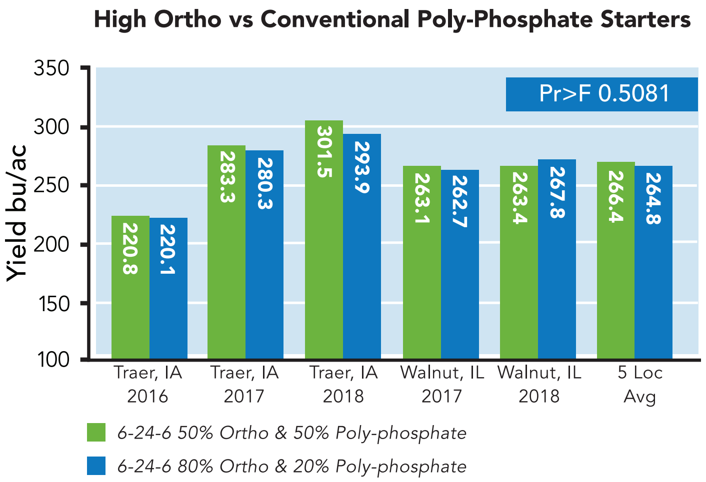


Figure 1. Average corn yield from field trials comparing high ortho vs conventional poly-phosphate in-furrow seed safe starter fertilizers. Yields at each location/year are averaged over 4 or 5 replications.

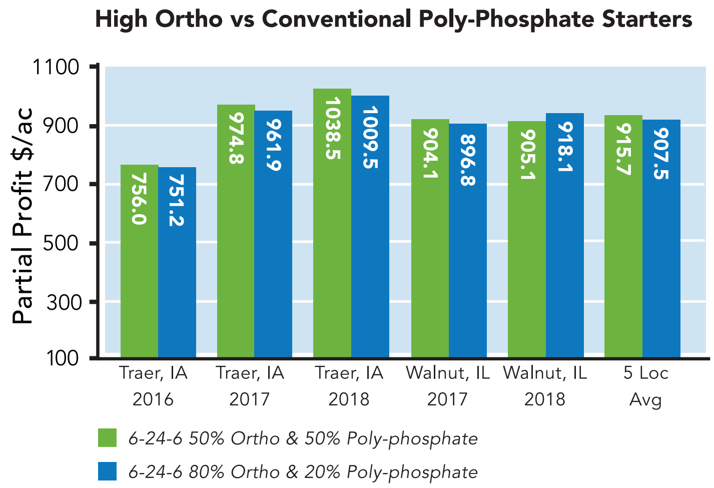


Figure 2. Partial profit from field trials comparing high ortho vs conventional poly-phosphate in-furrow seed safe starter fertilizers. Yields at each location/year are averaged over 4 or 5 replications. Partial profit was calculated using a grain sale price of $3.50 bu. Cost per gal used to calculate partial profit for the 6-24-6 50% ortho & 50% poly-phosphate and 6-24-6 80% ortho & 20% poly-phosphate was $2.80 and $3.20/gal.

Field Trial Results

Averaged over the 5 site-years there was only about 1.5 bu/ac yield difference separating the high ortho and the conventional poly-phosphate starter (Figure 1). Moreover, this small yield difference was not statistically significant ($Pr > 0.05$). In addition to finding no differences in grain yield between these two starters, the high ortho starter cost about $0.50 more per/gal (so $3/ac difference in price at a 6 gal/ac rate) than the lower ortho starters.

So the more expensive high ortho starter clearly did not "pay" its way in our multi-location field trials (Figure 2). Lastly, our observations in these studies agree with previously published university findings (Frazen and Gerwing. 1997).

References

Franzen D. and J. Gerwing. 2007. Effectiveness of using low rates of plant nutrients. North Central regional research publication No. 341. http://www.extension.umn.edu/agriculture/nutrient-management/fertilizer-management/docs/Feb-97-1.pdf (accessed 8 of Sept 2015).

Join Our Team

Retail Sales/Applicator Position

This job involves application of chemical and fertilizer to fields from spring to fall. Spring will be very busy, weekends may be involved. Field scouting and meeting with customer/prospects are needed when application is not occurring.

Benefits

- 401K
- Health Insurance
- Dental Insurance
- Tuition Reimbursement Program
- Continuous Paid Training in Sales/Marketing and Agronomy
- Paid Licensing like CDL
  CCA + a bonus when passed

Additional Opportunities with Liqui-Grow

Agronomy Research Internship

Liqui-Grow is seeking a qualified intern/interns to work with our Agronomy Research Lead, Dr. Jake Vossenkemper, on the development of new, novel fertilizers and agronomic practices. The intern will work closely with our agronomy research lead assisting him with day-to-day research operation activities, but the intern must also be able to work independently with little supervision.

Seasonal Nurse Truck Driver Position

Drivers will be delivering liquid fertilizer to applicators in the fields. Applicants must be 18 years or older, hold a valid CDL with a good driving record, and willing to work overtime.

For more information on the open positions, visit **https://www.liqui-grow.com/employment/**

Please email your resume to info@liqui-grow.com and specify which job you are applying for.

As agriculture continues to rapidly change, Liqui-Grow strives to provide innovative crop solutions, quality nutrient products, knowledgeable staff, and dependable service to satisfy our growers' needs. We sell only the best liquid fertilizers and starters under the Liqui-Grow brand. We are wholly committed to the 4 R's and provide farmers with the right fertilizer, at the right rate, in the right place, at the right time.

Employees are vital to the continued growth and success of Liqui-Grow. To achieve that goal, we seek individuals who recognize opportunities, are prepared to find solutions to meet challenges they encounter, and look for ways—without exception—to help every customer maximize their earning potential.

- Scott, Hov, & Bruce Tinsman

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