NITROGEN RESOURCE GUIDE

BECK'S

WHAT'S INSIDE

NITROGEN RESOURCE GUIDE

Nitrogen is one of the most critical inputs for a corn crop's success and is also one of the more challenging inputs to manage because every year we face a different set of environmental conditions that can change the response to different forms, timing, and placement of nitrogen on your farm.

Researching nitrogen proves challenging because so many external factors can impact the results. That's why Beck's agronomists and Practical Farm Research (PFR)® team continues to conduct multi-year and multi-location data on the key components of nitrogen management to gain a better understanding of the best timing, placement, and practices, in an attempt to solve the nitrogen puzzle.

THE GOAL OF NITROGEN MANAGEMENT IN CORN IS THREE-FOLD:

1. To have sufficient nitrogen available in the right form to meet crop demands throughout the growing season
2. To optimize nitrogen availability from a total rate/cost perspective
3. To minimize losses to the environment through denitrification, volatilization, and leaching

BUT IT'S IMPORTANT TO REMEMBER THAT, AS WITH ALL NUTRIENTS, NITROGEN STEWARDSHIP IS ABOUT MANAGING THE "4 RS":

1. Right source/form
2. Right rate to meet crop needs
3. Right timing for crop growth
4. Right placement to optimize source, rate applied, and crop growth

In the end, there is no "best" nitrogen program. Depending on multiple factors, one system can be the most profitable one year, while a different system may provide the highest return the following year. Other factors like logistics, cost, labor, soil mineralization, and, of course, weather will impact the decisions you make regarding nitrogen applications. Ultimately the key is to find the best system that works for your farm while at the same time maximizing profitability and minimizing loss into the environment.

WATCH NOW!

THE DIG, EPISODE 7 - NITROGEN MANAGMENT

Eastern Region Agronomy Manager, Steve Gauck, cohosts Episode 7 of The DIG to discuss nitrogen management. Join Steve as he shares all of his tips and tricks for nitrogen and how you can manage it to maximize profitability on your farm.

bit.ly/NitrogenPFR

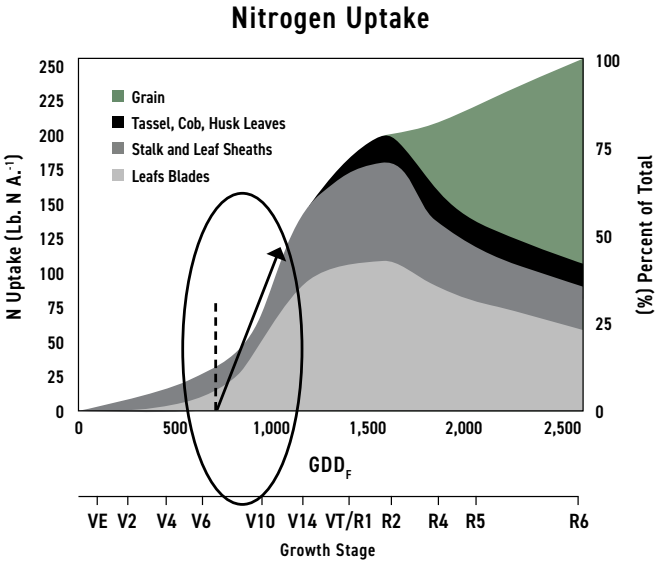
NITROGEN MANAGEMENT

First, understand corn nitrogen needs over time and growth. The figure at left is a depiction of when corn uses N. The key takeaway is that corn from V8 to VT needs 7-10 lb. N/day. In order to ensure N is available, apply prior to the rapid uptake stage.

Second, N management begins with a recommendation for N fertilizer needs. Although not perfect, the Economic Optimum N Rate (EONR) Calculator for Midwest Corn States **http://cnrc.agron.iastate.edu/** provides the best starting point available. Additionally, there are 120+ N studies conducted by the PFR Team available here: **beckshybrids.com/pfresearch/**

Third, a nitrogen recommendation accounts for all sources of N availability, including livestock manure, prior crop credits, soil nitrate tests (if applicable), and credit from nutrient sources that contain N, like DAP, MAP, and AMS. Consider climate conditions and the use of an N stabilizer where fall-applied anhydrous ammonia is included in the recommendation.

Finally, there are multiple methods to get N to a crop, so planting and weed control should take priority over N applications. Even if you are locked into an anhydrous purchase, you can still sidedress your corn with this product. Stick with the goal of supplying the crop with ample N throughout the growing season to maximize yields.



WHEN IS N USED? A corn plant uses a great deal of its N later in the growing season. In fact, over 75% of N uptake occurs after the V10 growth stage. The most rapid uptake usually occurs between V8 and VT when the corn plant takes up between 7 to 9 lb. of N each day. Ensuring that ample N is available in the correct form during the corn plant's growth is key to maintaining the potential in every field.

Chart adapted from Bender, et al., 2015

Split/Sidedress Nitrogen Applications

The advent of readily available sources of both granular and liquid sources of N and more flexible equipment to apply means it is no longer necessary nor agronomically recommended to have all N available at planting. However, applying the majority of recommended N as a late POST application is not recommended, either. In both cases, the risk is too great – the former, risk due to loss or positional unavailability; and in the latter, risk of crop needs and unavailability due to movement.

A split or sidedress N application can be planned, or added in response to weather-related losses early in the season. Applications made after the plants have emerged allow you to maintain more available N during key growth stages like ear development (V4 to V8), and the late vegetative and early reproductive stages from V12 to R1. By minimizing losses, you can see yield increases and minimize the negative environmental impact of N applications which.

Sidedressing is a PFR Proven™ practice that has become the standard in our N programs across our PFR locations. Our standard N program is 2x2x2 up front followed by a sidedress application at the V3 growth stage. The split-application N program has proven to be the most efficient and most cost-effective way to fuel our corn for years at multiple locations.

Source: Beck's Agronomy Brief - Nitrogen Managnement

NITROGEN MANAGEMENT

Beck's PFR team has also conducted research on different N management products, practices, rates and hybrids to help farmers make the best decisions for their farms and analyze various options to maximize their return on investment. Since 2012, Beck's PFR has worked to determine the Economic Optimum Nitrogen Rate (EONR) in a corn-after-soybean and corn-after-corn rotation. As a mobile nutrient, the amount of N that is necessary each year varies due to environmental conditions and the cost of N inputs.

Do hybrids differ in their response to N rate? We have learned over time that some hybrids and hybrid families tend to have a higher likelihood of response to full-season N availability while others may have a lower level of response. It is important to know the N response of the hybrids you plant in order to place products in fields and situations that optimize yield within your N program. The Beck's Product and Program Guide contains ratings and information on our hybrids with regard to N response – high (H), medium (M), and low (L).

Our EONR for corn-after-soybeans rotations consistently comes in around 190 to 195 units of nitrogen/A. In any given year, we typically see a 25 to 50 unit of N difference in the EONR between the N efficient hybrid and the higher N response hybrid at a given site. In this rotation, it is traditionally 175 units for the N efficient user and 200 units for the higher N user. This has resulted in a long-term average EONR of 190 to 195 units nitrogen/A.

Do you need to stabilize your sidedress N? The sidedress stabilization decision is impacted by several factors including what level of N is in place or soil-available, whether or not you applied some N through the planter or a weed-and-feed program, and what growth stage the crop is at. Those systems would provide NO_3^- N to be available early in the season.Most anhydrous stabilizers on the market extend the length of time your N remains in the NH_4^+ form and reduce the potential for loss via denitrification or leaching. Stabilizers do what they say they will do. But keep in mind, you will want both NO_3^- and NH_4^+ forms in the soil during the rapid uptake phase to supply the current crop needs as well as the future crop needs. Delaying NO_3^- nitrogen availability at V8 or later is not desired.

Source: Beck's Agronomy Brief - Nitrogen Managnement

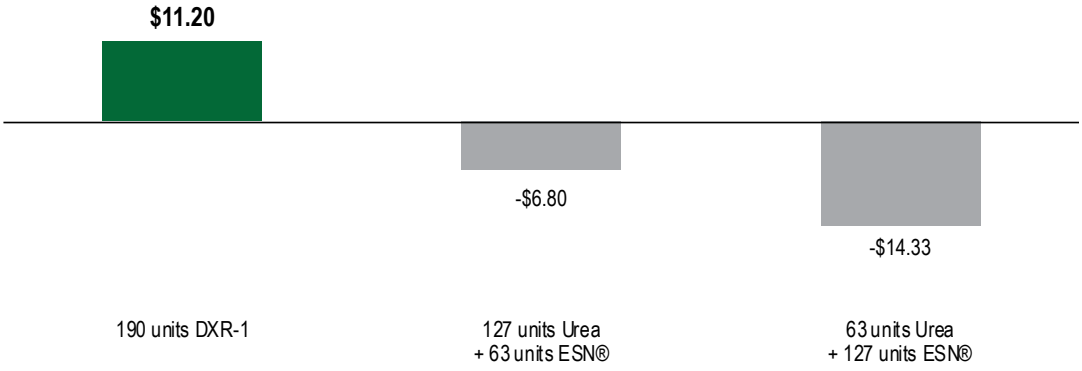
RIGHT SOURCE

A good nitrogen recommendation accounts for all sources of nitrogen availability, including livestock manure, prior crop credits, organic matter mineralization, and credit from nutrient sources that contain nitrogen, like DAP, MAP, and AMS. Having the right blend of nitrogen molecules available is also important when crop demands are high. Balancing Nitrate and Ammonium ratios relative to crop uptake and timing will drive the success of your nitrogen program.

NITROGEN COATING STUDY - UREA

DXR-1 is a unique prescriptive coating technology from Pursell that releases nitrogen more uniformly during the growing season, potentially reducing losses to leaching and volatilization.

2-YEAR MULTI-LOCATION NITROGEN COATING RETURN ON INVESTMENT (COMPARED TO 190 UNITS UREA)



Scan the QR Code to watch a video about this study!

Source: Beck's 2023 PFR Book: Pg. 130

NITROGEN FORM STUDY - SIDEDRESS

This study aims to evaluate different forms of nitrogen sidedressed at V3 and their impact on yield and profitability. Each nitrogen form has its own advantages and risks. Protecting against risks like volatilization with surface-applied urea will enable any program to be successful. Additional years of research are needed before determining which nitrogen form is the best.

2017 RESULTS

BRAND	NITROGEN RESPONSE	V3 TREATMENTS	PERCENT MOISTURE	BU./A.	NITROGEN COST/A.	NET RETURN
Hybrid One & Hybrid Two	N Efficient	**160 units NH_3**	**24.0**	**219.5**	**$48.00**	**$799.27**
		160 units UAN	23.2	215.4	$70.40	$761.04
		160 units Urea	23.3	207.7	$60.80	$740.92
Hybrid Three & Hybrid Four	Higher N Response	**160 units NH_3**	**22.3**	**223.6**	**$48.00**	**$815.10**
		160 units UAN	22.0	220.6	$70.40	$781.12
		160 units Urea	21.4	218.2	$60.80	$781.45
4-Hybrid Average		160 units NH_3	23.2	221.6	$48.00	$807.38
		160 units UAN	22.6	218.0	$70.40	$771.08
		160 units Urea	22.4	213.0	$60.80	$761.38

Corn $3.86/Bu. Anhydrous Ammonia $0.30/unit of nitrogen. Urea $0.38/unit of nitrogen. UAN $0.44/unit of nitrogen. Individual results may vary.

NITROGEN SYSTEMS - ANHYDROUS AMMONIA

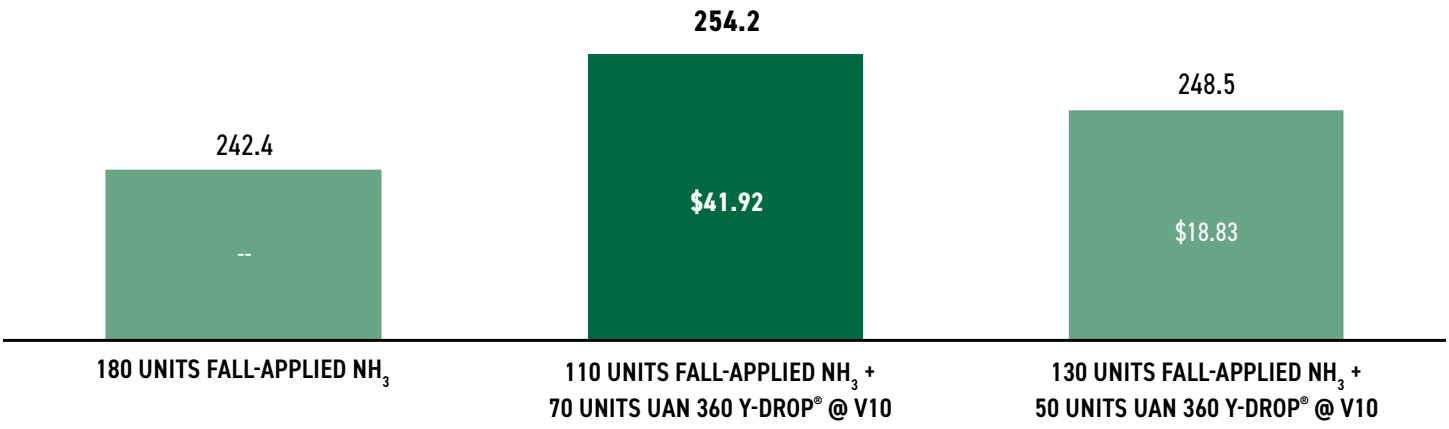
This study evaluates different nitrogen systems utilizing fall anhydrous and their effect on yield. Saving more nitrogen for the sidedress pass paid likely due to the heavier rainfall early in the growing season. The anhydrous was stabilized with N-Serve® in this study.

2024 RESULTS

FIRST APPLICATION	SECOND APPLICATION	BU./A.	BU./A. DIFFERENCE	NET RETURN	RETURN ON INVESTMENT
Control: 180 units Fall-Applied NH_3	--	233.3	--	$1,015.31	--
110 units Fall-Applied NH_3	**70 units UAN 360 Y-DROP® @ V10**	**254.5**	**+21.2**	**$1,102.99**	**+$87.68**
130 units Fall-Applied NH_3	50 units UAN 360 Y-DROP® @ V10	243.4	+10.1	$1,054.08	+$38.77

Corn $4.73/Bu. NH_3 $0.49/unit of nitrogen. UAN $.67/unit of nitrogen. These results are based on the disclosed study parameters and participating sites.

2-YEAR NITROGEN SYSTEMS YIELD AVERAGE & RETURN ON INVESTMENT



RIGHT RATE

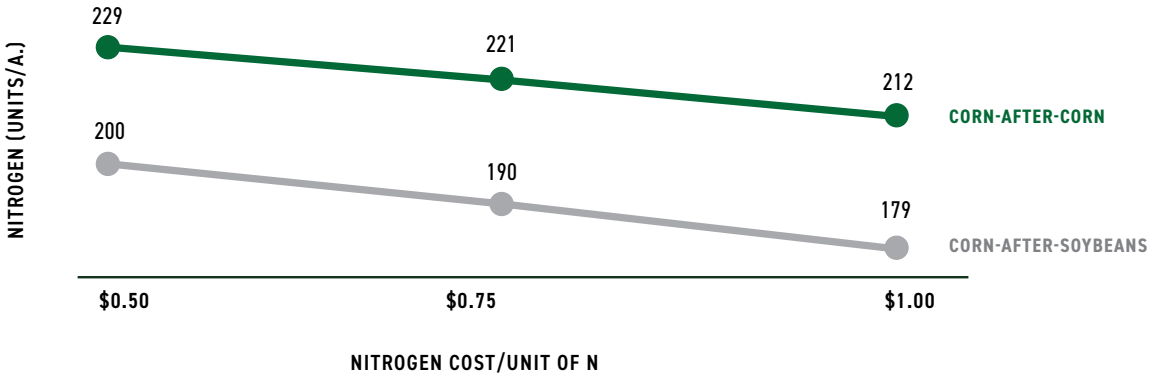
As a mobile nutrient, the amount of nitrogen that is necessary in a given year varies due to environmental conditions and the hybrid planted. Determining the economic optimum nitrogen rate (EONR) is difficult because of the variable weather, soils, nitrogen prices, and hybrids. However, Beck's nine-year, multi-location data indicates a range between 215 to 231 lb./A. for corn-after-corn and 183 to 202 lb./A. for corn-after-soybean rotations. It's important to keep in mind the carbon penalty when planting corn-after-corn as additional nitrogen will be required, especially during the early part of the growing season.

EONR FOR CAB AND CAC

ECONOMIC OPTIMUM NITROGEN RATE

Beck's nine-year, multi-location data indicates that the economic optimum nitrogen rate (EONR) for corn-after-corn rotations is between 212 and 229 lb./A. For corn-after-soybean rotations, the EONR is between 179 and 200 lb./A.

9-YEAR ECONOMIC OPTIMUM NITROGEN RATE (EONR) (BASED ON $5.50/BU. CORN)



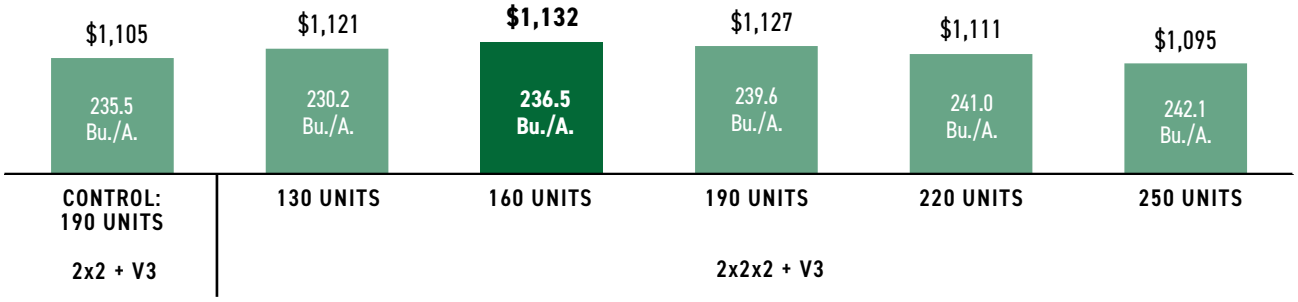
WHAT WE RECOMMEND: Due to the carbon penalty when planting corn-after-corn, additional nitrogen is required, especially during the early part of the growing season.

NITROGEN RATE - 2X2X2

2X2X2 ECONOMIC OPTIMUM NITROGEN RATE (EONR)

Placing more nitrogen up front on both sides of the row provides better efficiency. This could be explained by the more robust early-season root growth on both sides of the plant that enabled the roots to explore and access a greater volume of soil.

4-YEAR MULTI-LOCATION NITROGEN RATE - 2X2X2 NET RETURN

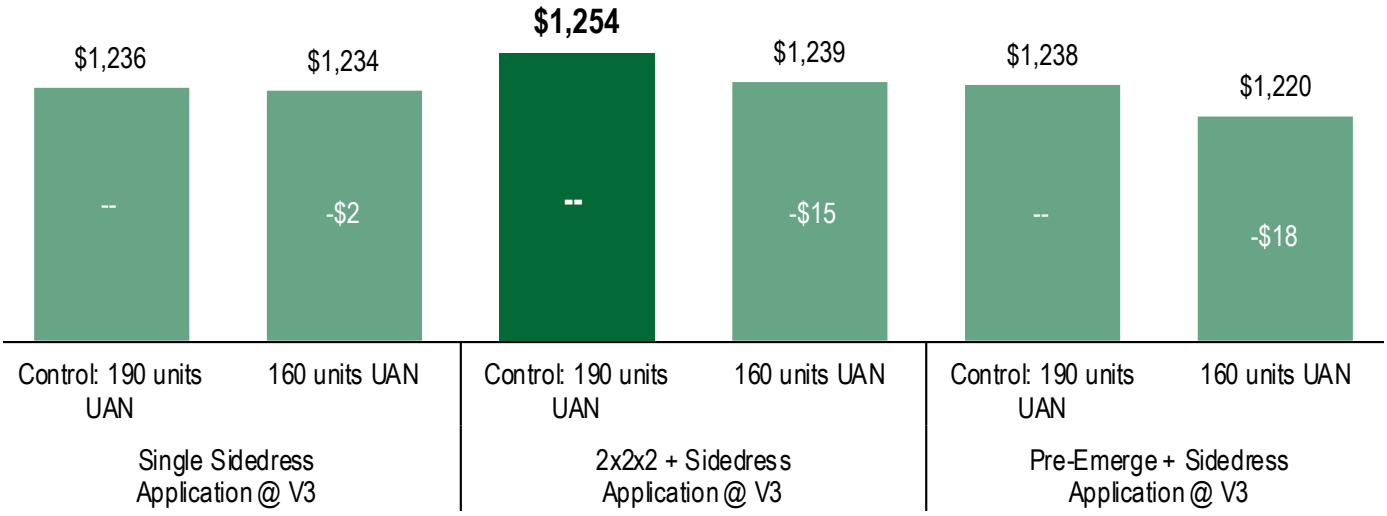


WHAT WE RECOMMEND: Moving to a 2x2x2 system increases nitrogen efficiency. Try testing 30 lb./A. less nitrogen on some strips to see what returns are possible on your farm.

NITROGEN RATE X SYSTEMS STUDY

The goal of this study was to compare different nitrogen systems and see if we could be more efficient with our rates by using a different approach. What we have learned after two years is that our PFR Proven™ system of applying 60 units upfront followed by 130 units sidedressed at the V3 growth stage is the most profitable compared to a single sidedress or pre-emerge application followed by a sidedress system.

2-YEAR MULTI-LOCATION NITROGEN RATE X SYSTEMS NET RETURN & ROI

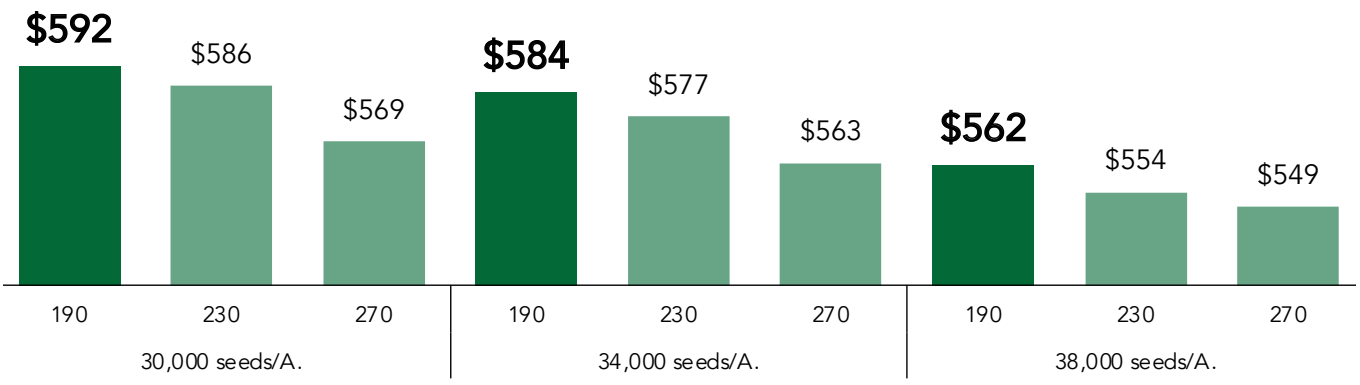


NITROGEN RATE VS POPULATION

DO I NEED TO ADD MORE NITROGEN IF I INCREASE MY PLANTING POPULATIONS?

Although it seems logical that increasing your seeding rate would require additional nitrogen (N), three years of PFR data and research from multiple universities indicates that increasing your planting populations does not necessarily mean you need to increase your N rate. Individual growing seasons vary in rainfall amounts and timing, leading to increased N loss, but all things being equal, higher seeding rates do not necessarily require higher N rates.

3-YEAR MULTI-LOCATION POPULATION VS. NITROGEN RATE NET RETURN (CORN-AFTER-SOYBEAN)



NITROGEN RATE VS THIN STAND

THIN STAND NITROGEN RESPONSE

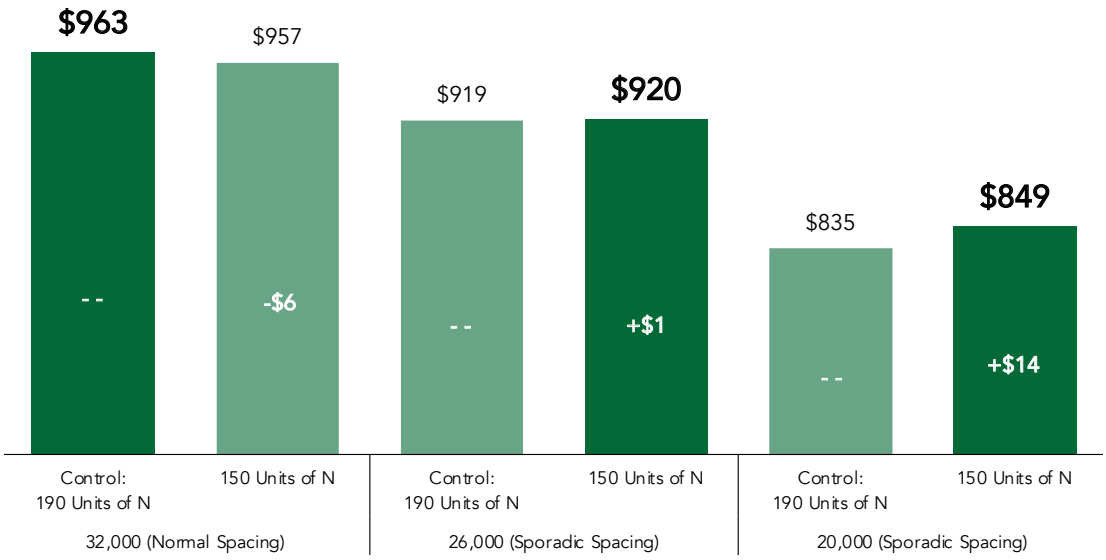
Every year, many areas of the country face challenging conditions at emergence that have the potential to reduce their final stands to anywhere from a few thousand to 10,000 or more plants/A. This creates many difficult decisions for farmers, including whether nitrogen (N) rates should be decreased. Because many growers assume thin stands equate to lower yields, the natural inclination is to cut N rates.

However, our PFR data indicates that if you experience a stand loss in the range of 6,000 plants/A. (sporadically placed with a final stand of 26,000 plants/A.), there is minimal benefit to cutting N rates, but this decision ultimately depends on the growing season. Therefore, cutting rates may have little benefit but could end up being a costly decision.

Our data is less clear when final stands are reduced to 10,000 to 12,000 plants/A. PFR studies show a financial benefit to reducing N rates, but this benefit has more to do with the price of N. One variable to consider is that this data factors in an initial at-planting application with a 2x2x2 system. Why is that important? Other studies indicate that when moving to a 2x2x2 system, our nitrogen efficiency increased, and we utilized less total N overall.

The bottom line is that many variables can impact the data, so be sure to consider all the different potential outcomes. All other things being equal, it may be beneficial to trim your N rates when faced with reduced stands; just understand that every year is different, and you need to adjust to the growing season when making these decisions.

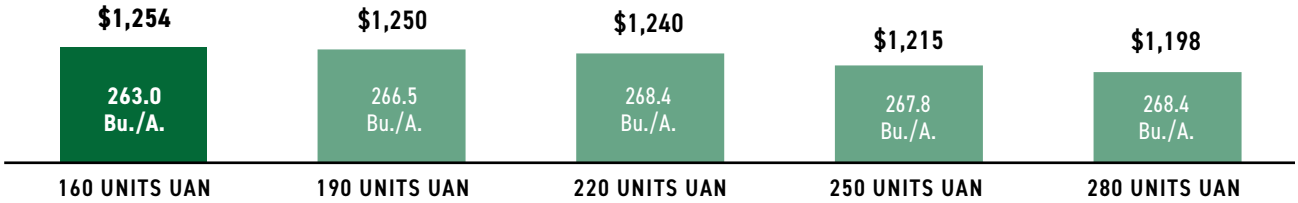
3-YEAR MULTI-LOCATION THIN STAND MANAGEMENT - NITROGEN RESPONSE NET RETURN & ROI



NITROGEN RATE- FURROW-IRRIGATION

To determine the Economic Optimum Nitrogen Rate (EONR) when applying in a furrow irrigated environment. These results are surprising given that we don't expect large amounts of mineralized nitrogen (N) from these soils. This could indicate a higher efficiency of utilization of the applied N with this system. Additional years of research are required before we can draw any conclusions.

2-YEAR NITROGEN RATE - FURROW IRRIGATION NET RETURN



LATE SEASON NITROGEN - AERIAL

This study evaluates different sources of nitrogen and sulfur applied at the VT growth stage and their impact on yield and profitability. Corn plants utilize a large amount of nitrogen after flowering; however, much of it is remobilized from other parts of the plant. Supplemental nitrogen applications at the VT growth stage can provide a benefit, but conditions must be right. In 2023, this site received 0.47 in. of rain on the evening of the aerial application, which was crucial.

2023 RESULTS

TREATMENTS	BU./A.	BU./A. DIFFERENCE	RETURN ON INVESTMENT
Control: 60 units UAN Dual Dribble + 190 units UAN @ V3	221.1	--	--
Control + 46 units Urea @ VT	**228.0**	**+6.9**	**+$11.66**
Control + 23 units Urea + 50 lb. AMS @ VT	227.5	+6.4	+$8.87
Corn $5.69/Bu. Urea $0.60/unit of nitrogen. AMS $550.00/ton. These results are based on the disclosed study parameters and participating sites.			

ECONOMIC OPTIMUM NITROGEN RATE

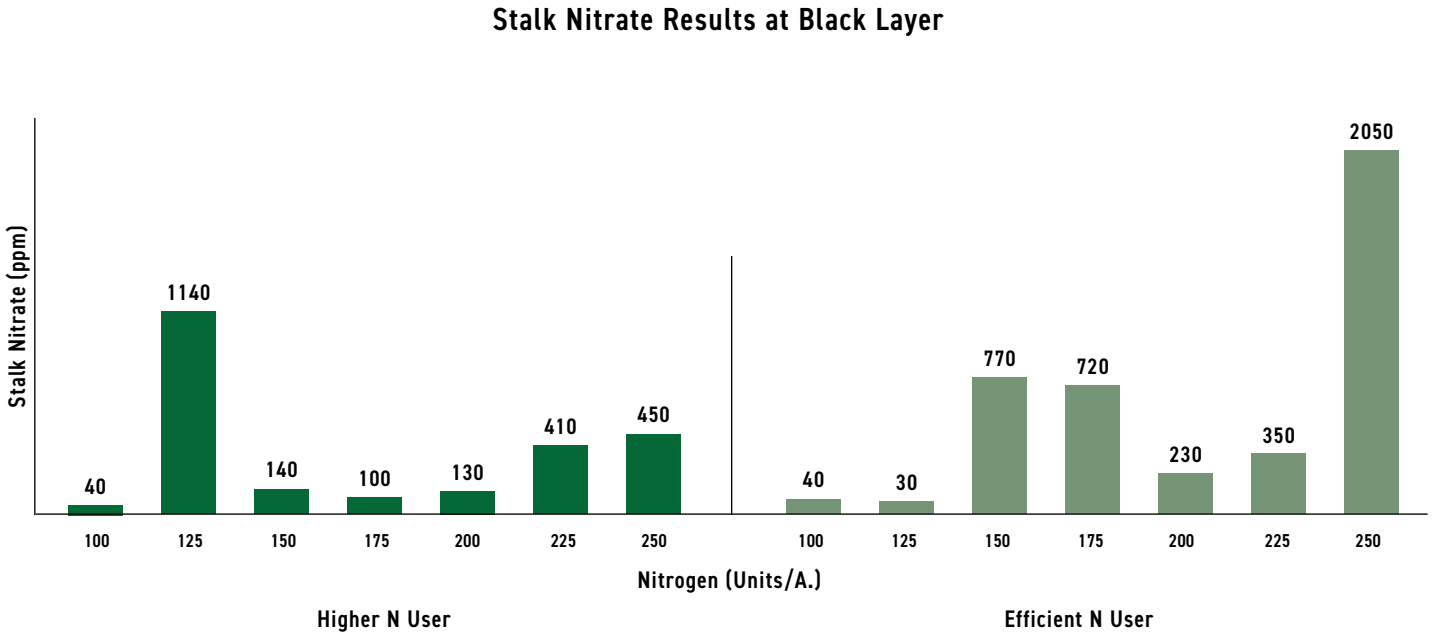
Nitrogen (N) is a critical input for a corn crop's success. It is also one of the more challenging inputs to manage as every year brings a different set of environmental conditions that can change the response to different forms, timing, and placement of N on your farm. Researching N is equally challenging because so many external factors can impact the results. That's why multi-year and multi-location data are key components to gaining a deeper understanding of N results. Through Beck's PFR, we will continue to evaluate different timing and placement methods as we strive to help solve the puzzle that is N management.

DO HYBRIDS DIFFER IN THEIR RESPONSE?

We have learned over time that some hybrids and hybrid families tend to have a higher likelihood of response to full-season N availability while others may have a lower level of response. It is important to know which category the hybrids you're planting fall into so they can be placed in fields and situations that may provide the best opportunity for full-season N availability. The Beck's Product and Program Guide contains ratings and information on all Beck's hybrids in regards to N response.

STALK NITRATE (NO_3^-) SAMPLES

Stalk nitrate samples illustrate the genetic differences between hybrids in a given year. Below are stalk nitrate samples taken at black layer from the 2017 Indiana N Rate Corn after Soybeans study. Genetic differences are apparent as the more efficient N user consistently has greater nitrate content in the stalk compared to the higher N user. It's clear that at this point, when the N has moved from the stalk to the ear for grain fill, more N is required with the higher N users when compared to the efficient N users.



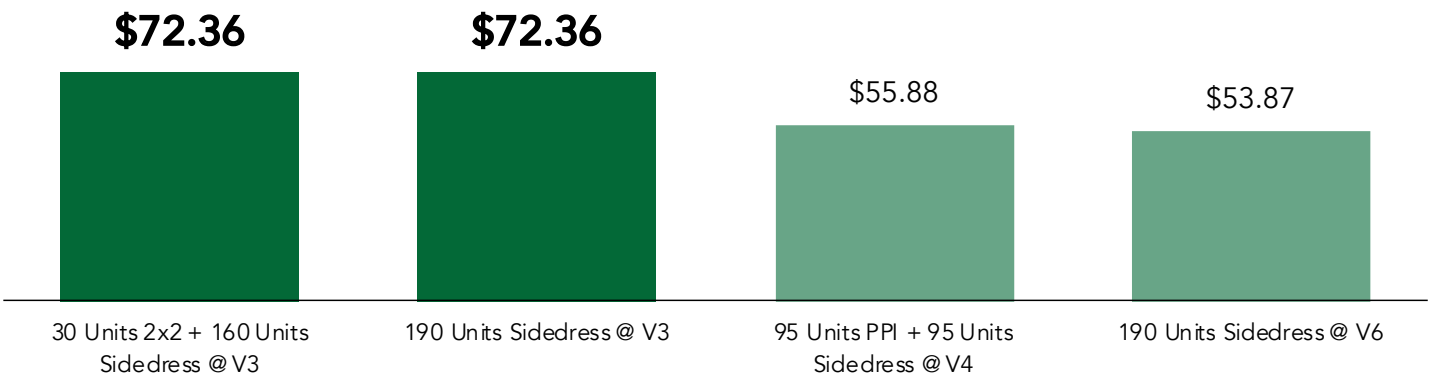
RIGHT TIME

Understanding a corn crop's nitrogen needs over time and growth stages is key to a successful season. Corn takes up most of its nitrogen between the V8 and VT growth stages and needs 7-10 lb. of nitrogen per day for optimal growth. To ensure enough nitrogen is available, applications should be made before the rapid uptake stage, as corn plants use a great deal of nitrogen later in the growing season. In fact, over 75% of uptake occurs after the V10 growth stage. Ensuring that ample nitrogen is available in the correct form during the corn plant's growth is key to maintaining the potential in every field.

NITROGEN TIMING

There is not a perfect nitrogen program due to the the fact that much of its effectiveness is determined by the weather. But two things that we have routinely found to be impactful and profitable is banding your early-season nitrogen with the planter beside the row and sidedressing a bulk of the nitrogen at the V3 growth stage.

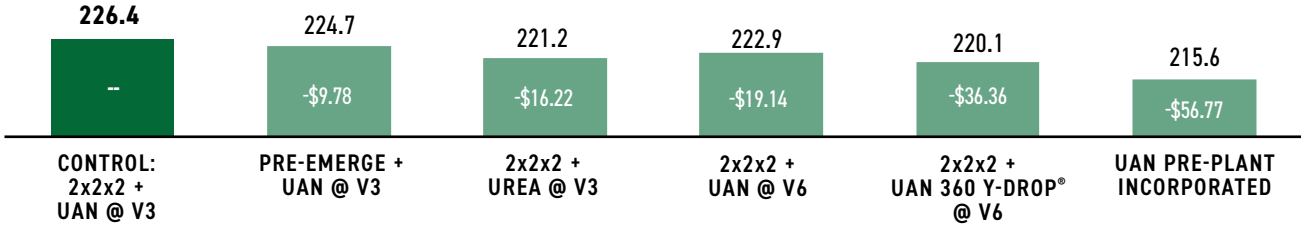
4-YEAR MULTI-LOCATION NITROGEN TIMING ROI (190 TOTAL UNITS OF UAN)



NITROGEN SYSTEMS STUDY

There are many different methods to apply nitrogen, and weather can certainly impact which system performs best in any given year. However, for multiple years, we have continued to see the best profitability by moving more nitrogen up front in a 2x2x2 system and applying the remaining portion at the V3 growth stage via a UAN application.

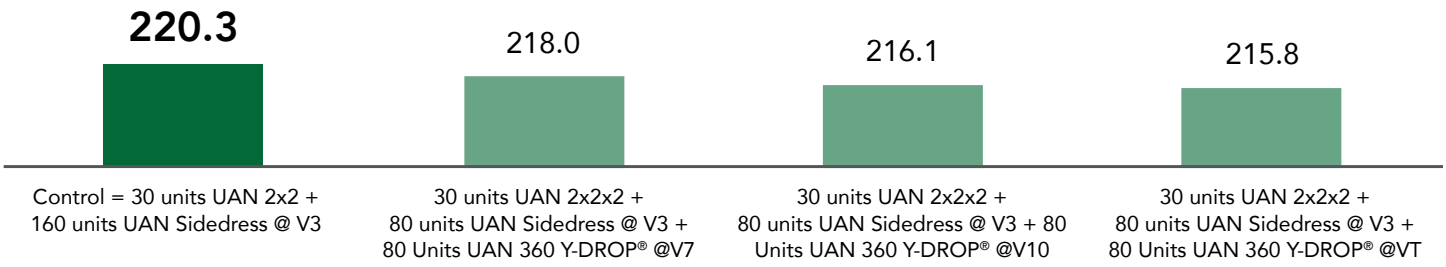
3-YEAR MULTI-LOCATION NITROGEN SYSTEMS YIELD AVERAGE & RETURN ON INVESTMENT



NITROGEN TIMING STUDY

This study evaluated various nitrogen (N) application timings and their effects on N uptake and yield. Each treatment in this study received a total of 190 units of N as UAN. Nitrogen (N) applications when corn N requirements are the highest (V6 to VT) consistently improves fertilizer nitrogen recovery efficiency (FNRE). Treatments where N is applied at later corn growth stages (up to tassel) almost always result in greater FNRE. However, these treatments do not consistently result in higher yields and/or return on investment over pre-plant and early sidedress application timings. This is because the landscape and soil variability in soil N mineralization and loss over the season result in variable N availability and corn N uptake.

3-YEAR MULTI-LOCATION NITROGEN TIMING YIELD AVERAGE



NITROGEN MANAGEMENT - DRIP FERTIGATION

The purpose of this study is to evaluate utilizing a drip-irrigation system to apply nitrogen and sulfur compared to our standard sidedress application. The only difference in the treatments is the method of application. The control received the same amount of water and total pounds of N. The drip line is on 30 in. centers directly beneath the corn row.

3-YEAR NITROGEN MANAGEMENT YIELD AVERAGE

CONTROL
60 units UAN & 2 gal. Thio-Sul (12-0-0-26S) 2x2x2 +
190 units UAN & 6 gal. Thio-Sul (12-0-0-26S) Sidedress @ V3

DRIP-FERTIGATION
60 units UAN & 2 gal. Thio-Sul (12-0-0-26S) 2x2x2 +
47.5 units UAN & 1.5 gal. Thio-Sul (12-0-0-26S) Drip-Fertigated
(4 Applications of Drip-Fertigation V4-VT)

*All treatments recieved a total of 260 units of nitrogen + 23 units of sulfur

*All treatments were watered as needed through the drip-irrigation system

NITROGEN TIMING - FALL VS SPRING ANHYDROUS

The purpose of this study is to compare an anhydrous ammonia application in the fall vs. the spring and its effect on yield. The testing locations experienced weather conditions that were not conducive to nitrogen (N) loss from denitrification in the fall and early spring. Mineralization was good at these locations, so N was not a yield-limiting factor.

2021 RESULTS

PRE-PLANT INCORPORATED TREATMENTS	APPLICATION TIMING	PERCENT MOISTURE	BU./A.	NET RETURN
190 units Anhydrous Ammonia + 1 qt. N-Serve®	Fall	16.3	244.8	$1,070.97
	Spring	16.4	244.4	$1,069.06

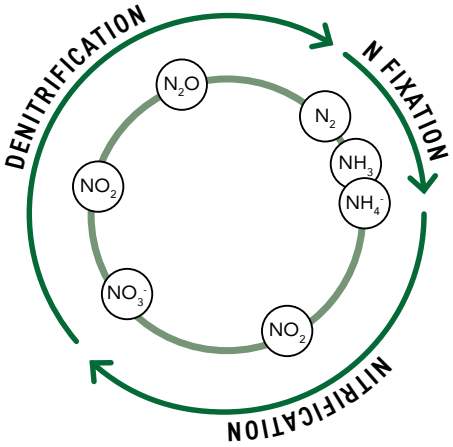
Corn $4.78/Bu. Anhydrous Ammonia $0.46/unit of nitrogen. N-Serve® $47.12/gal. These results are based on the disclosed study parameters and participating sites.

		SOIL NITRATE-NITROGEN PPM NO3-N @ V5							CORN STALK NITRATE-NITROGEN PPM NO3-N @ BLACK LAYER				
PRE-PLANT INCORPORATED TREATMENTS	APPLICATION TIMING	IA	IA	CIL	CIL	CIL	CIL	AVERAGE	IA	IA	CIL	CIL	AVERAGE
190 units Anhydrous Ammonia + 1 qt. N-Serve®	Fall	38	69	32	35	51	32	43	10,160	7,650	2,040	2,880	5,683
	Spring	18	16	71	44	35	24	35	11,090	7,290	4,670	2,960	6,503

CENTRAL ILLINOIS CORN

FALL APPLICATION	SPRING APPLICATION
	

NITROGEN TIMING AND PLACEMENT



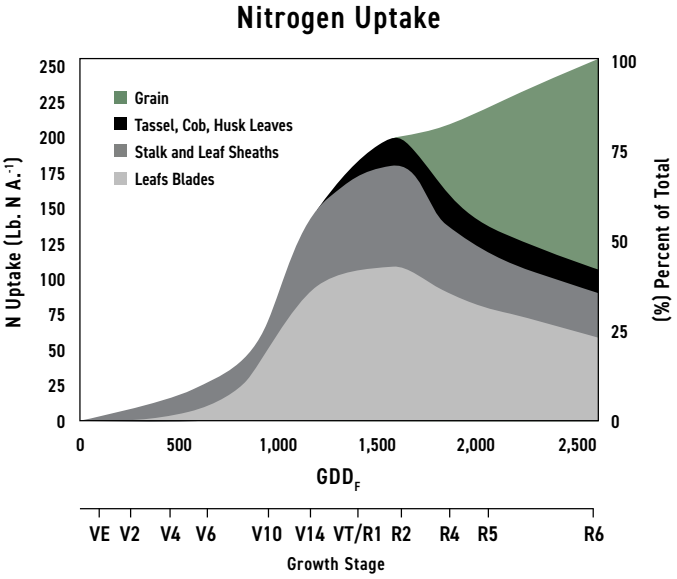
Nitrogen (N) is a mobile nutrient. When we look at the N cycle, we think of NO_3^- is the N form most readily taken up by the plant, followed by NH_4^+. Loss of N when applying urea or UAN can occur as ammonia volatilization (lost in gaseous form). In the case of UAN applications, N loss can also occur in the form of NO_3^- leaching if a heavy rain follows or denitrification. Two ways to prevent N loss are more accurate timing and more precise placement. If we can supply N to the plant when it needs it, this allows less time for N loss. If we supply N near the base of the plant where it can more easily access the nutrient, this could increase N use efficiency.

WHAT HAPPENS WHEN N IS APPLIED?

A number of things can happen to N once it is applied as a mobile nutrient. Regardless of the N form you apply, once it's in the ground it will either be taken up by the plant, be immobilized (tied up by soil microbes in the soil), or be lost via one of four methods:

1. Surface Displacement
2. Volatilization
3. Denitrification
4. Leaching

Utilize the 4R approach to N management to maximize crop productivity while minimizing N loss. This includes: considering the right form, at the right rate, at the right time, and in the right place.



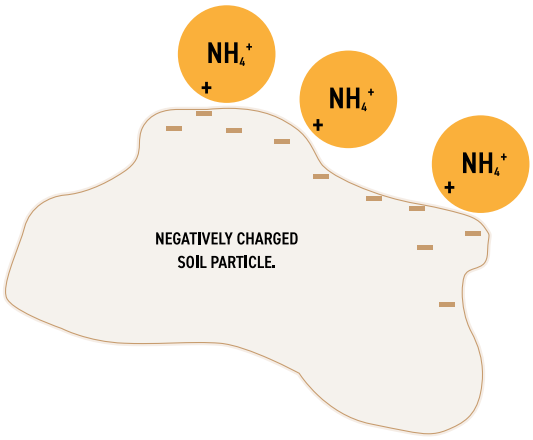
Charts adapted from Bender, et. al., 2015

WHEN IS N USED?

A corn plant uses a great deal of its N later in the growing season. In fact, over 75 percent of N uptake occurs after the V10 growth stage. The most rapid uptake usually occurs between V8 and VT when the corn plant takes up between 7 to 9 lb. of N each day. Ensuring that ample N is available in the correct form during the corn plant's growth is key to maintaining the potential in every field.

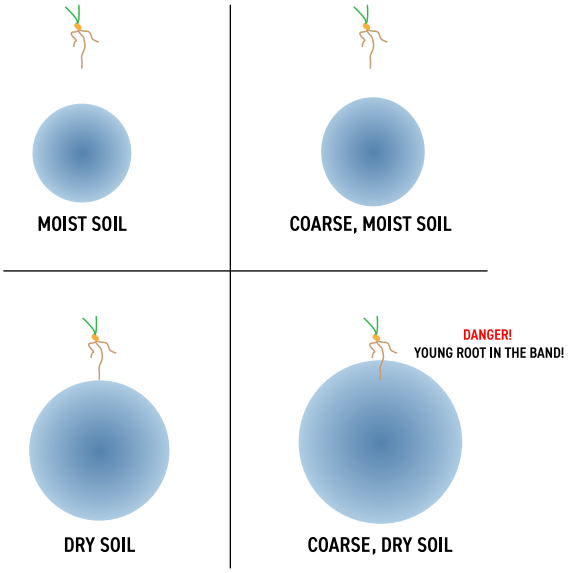
SPRING-APPLIED ANHYDROUS RISKS

Often, farmers find themselves pressed for time in the spring and are forced into tight windows of operation. One operation that many farmers need to carefully consider is the spring application of anhydrous ammonia. Although it's possible to apply anhydrous before planting, there are strategies to reduce the risk of injury. Keep in mind that there are many ways to apply nitrogen to a crop in-season, so planting should always take precedence to nitrogen applications. Even if you have pre-paid for your anhydrous, you can still sidedress anhydrous with great success.



What Does Anhydrous Do When Applied to Soils?

When anhydrous is applied to soils, it will diffuse out in a circular pattern, creating a cylindrical band in the soil. Soil type, texture, organic matter and moisture at the time of application will heavily influence the diameter of the band. When the ammonia (NH_3) is applied to the soil, it grabs a hydrogen ion from water to become NH_4^+. This positive charge allows the anhydrous molecule to attach to negatively charged soil particles and limits its movement within the soil profile. Therefore, soils with good moisture can reduce the anhydrous band diameter whereas in very dry soils, the band will likely expand to a greater distance.



Soil texture and organic matter can also affect the size of the anhydrous band, and coarse-textured soils will likely have a larger band. In most cases, the band is around three to four inches in radius from the point of injection, and the ammonia is more concentrated in the center of the band. The band size is why the depth of application in the spring is so important, especially as application timing nears planting. Farmers who are applying anhydrous close to their planting date should place their application deeper, at 8 in. if possible, in order to keep the anhydrous band away from the immediate vicinity of germinating seeds and the seminal root system.

From a timing perspective, applying anhydrous more than three days prior to planting is ideal, but that is not always possible, and there is no hard and fast rule regarding the timing of application prior to planting. In those cases where you are applying anhydrous shortly before the planting pass, depth of application and soil moisture become bigger factors than timing. Always shoot to apply anhydrous at a depth in which soil moisture is available.

SPRING-APPLIED ANHYDROUS RISKS

Anhydrous Injury

Ammonia in the band of anhydrous can damage seedling roots. If the damaged roots appear desiccated and brown, the seedling likely will not survive. Applying anhydrous at an angle relative to the row reduces the risk that the whole row of seedlings will be damaged as a result of being planted too close to the band.

What Else Can Be Done to Reduce the Risk of Injury?

- Do not apply to soils that are too wet as it will cause smearing and a lack of closing. This can lead to upward migration of the ammonia gas that moves it closer to the seed and the immediate loss of nitrogen.
- Cloddy soils at the point of application will also allow the movement of the ammonia gas up through the soil profile and result in loss or even seedling injury.
- Split your application if possible as full rates at planting create a greater risk for injury. Sidedressing anhydrous is indeed an extra pass across the field, but so is replanting. See graph below.
- Try to apply at a slight angle to reduce intersection with the row if possible.

ABOVE: Anhydrous burn to seminal root system; this seedling will not recover.

NITROGEN TIMING STUDY

Nitrogen Timing vs. Pre-Plant Incorporated (4-Year Multi-location)

Split applying nitrogen (N) decreases your risk from various N loss mechanisms. Ensuring adequate supply at key growth stages is critical. Beck's PFR recommends split applications of N.

RESULTS: Optimum - Nitrogen 2x2 followed by V3 sidedress.

Should I Stabilize my Pre-Plant Anhydrous?

The process of converting the NH_4^+ to NO_3^- can take many weeks. Depending on your soil health, drainage, temperature, soil structure, and rainfall post application (among other factors), it can take longer than that to convert. You want to have adequate NO_3^- nitrogen available when the corn plant hits the rapid N uptake phase (about V7) because nitrate N is mobile in soil water and thus, the form of N that is more available for uptake. Keep the following in mind when trying to decide if you should stabilize or not.

- Nitrogen stabilizers extend the length of time your nitrogen remains in the NH_4^+ form and can reduce the potential for loss via denitrification or leaching.
- Using a stabilizer can be beneficial depending on your drainage and soil types. Heavier clay soils and/or soils with limited drainage can benefit from the use of a stabilizer.

NO FALL NITROGEN? NO PROBLEM

There are different methods to apply anhydrous in front of planting to minimize seedling injury. Having said that, there is no guarantee that this spring will be a smooth planting season. So, what should you do if you have a tight planting window this spring?

First, Beck's experts emphasize that planting is more important than applying nitrogen (N) prior to planting. There are multiple ways to get N to a crop, so planting should take priority over N application. If you are locked into an anhydrous purchase, you can still sidedress your corn.

If you are going to apply anhydrous sidedress and have not done it before, one common question is whether or not to stabilize. Let's examine this question. Once the corn plant hits that V7 or V8 growth stage, it begins to take up N at a high rate, estimated to be 7 to 10 lb. of N per day. With that in mind, the corn will have large N requirements within four or five leaf stages of application (assuming a V3 to V4 sidedress timing).

Anhydrous is in the ammonium form (NH_{4+}) once it takes up a hydrogen ion from water in the soil and binds to negatively charged soil particles. The ammonium ion must go through a process called nitrification in order to be converted to the nitrate form. Nitrate (NO_{3-}) has a negative charge, so it is more mobile in the soil. Nitrate is the main form of N taken up by the plant simply because it is mobile in the soil through soil water. The process of converting the NH_{4+} to NO_{3-} can take weeks. Depending on your soil health, drainage, temperature, soil structure, and rainfall post application (among other factors), it can take longer than that to convert. You want to have adequate NO_{3-} N available when the corn plant hits the rapid N uptake phase. Keep that in mind when trying to decide if you should stabilize or not.

The sidedress stabilization decision is impacted by other factors as well. Are you able to apply some N through the planter? Did you use any N in a weed-and-feed program? Those systems would make NO_{3-} N available early in the season. Most anhydrous stabilizers on the market extend the length of time your N remains in the NH_{4+} form and reduce the potential for loss via denitrification or leaching. They do what they say they will do. But keep in mind that you want both NO_{3-} and NH_{4+} forms in the soil during the rapid uptake phase to supply the current crop needs as well as the future crop needs.

Bottom line: there is no right answer as to whether or not to stabilize. That question can really only be answered post mortem, but here are some things to consider. The odds of stabilizers paying off are much higher if you have poorly drained soil, heavy clay content, and/or if you plant fuller season hybrids. Of course, those odds are swayed by rainfall during the season. If you are able to apply NO_{3-} N in other forms through the planter or with other methods and have poorly drained soils, then stabilizing your anhydrous may make sense.

Ultimately, many factors outside of your control impact your decision. If you do decide to stabilize your sidedressed anhydrous, make sure you are supplying the plant with adequate NO_{3-} nutrition early as well. Remember, the ammonium form is held tightly by your soil and will not move readily through soil water; it is somewhat unavailable until it encounters roots. Roots only intercept one to two percent of your soil by volume, so root interception is a limited method of N uptake to the corn plant.

There are multiple new methods to apply N to a growing corn crop in-season. Focus on planting the crop first, then utilize one of the many avenues available to apply N post planting. Make sure you supply the crop with ample N throughout the growing season to maximize yields.

Source: Agronomy Journal. Nutrient Uptake, Partitioning, and Remobilization in Modern, Transgenic Insect-Protected Maize Hybrids. 105:161-170 (2013)

RIGHT PLACE

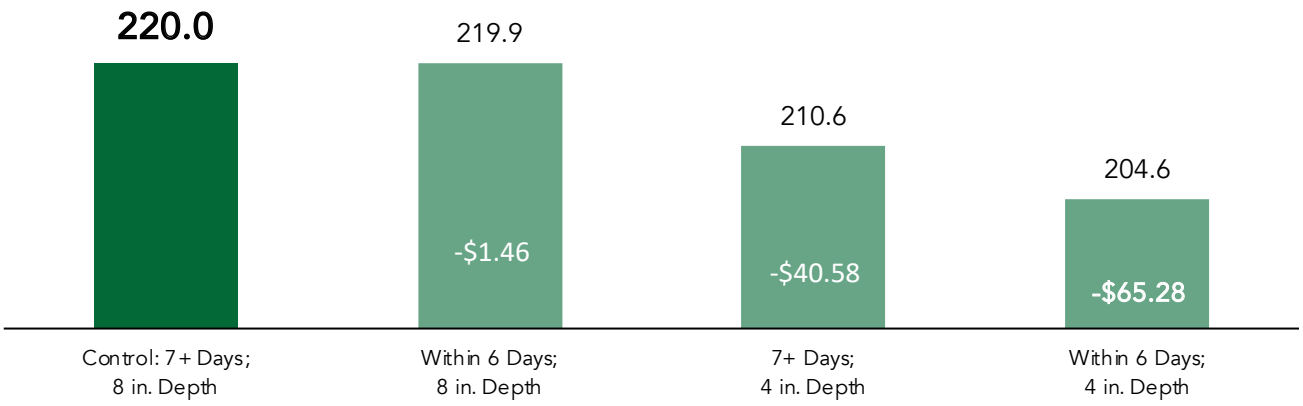
Getting the nitrogen closer to the plant without injuring it has been beneficial, especially early in the season, with a 2x2x2 system at planting. Placement will affect the availability of the nitrogen to the plant and the potential for loss, thus impacting your nitrogen use efficiency.

NITROGEN PLACEMENT

WHERE AND WHEN DO I APPLY AMMONIA NH_3?

The popularity of NH_3 varies from year to year, and it can be a great source of nitrogen (N) for corn. There are, however, concerns with seedling safety. Three strategies tested in PFR are horizontal placement, vertical placement, and the time between placement and planting. Placing NH_3 between the rows is a PFR Proven™ strategy that reduces the negative effects by moving the band horizontally away from the seed. Next, looking vertically, three years of consistent testing shows a yield increase when placing the band 8 in. deep compared to 4 in. deep. Finally, time can play to our advantage if the band cannot be placed deeper than 4 in., allowing for seven or more days between application and planting. In summary, the more time or soil that is placed between the applied band of NH_3 and the seed, the better the return.

3-YEAR MULTI-LOCATION NITROGEN DEPTH & TIMING - NH_3 YIELD AVERAGE AND ROI



3-YEAR MULTI-LOCATION NITROGEN PLACEMENT - NH_3 NET RETURN

NITROGEN - 2X2X2 SYSTEMS

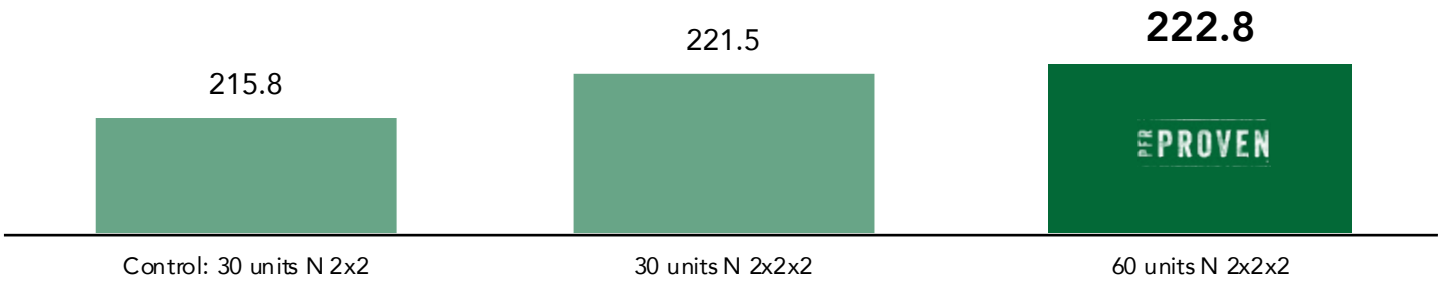
We know that roots will proliferate in the presence of ammonium and nitrate nitrogen. Feeding and building the roots on both sides of the plant will provide a more stable anchor and allow it to access more of the soil profile. In addition, there are limits on salt loading near the seed, but by utilizing this system, our data shows that farmers can increase their early-season nitrogen and increase yield.

2X2X2 SYSTEM	PFR PROVEN ACRES TO PAY OFF	YIELD ADVANTAGE (BU./A.)	WEIGHT (LB.)	MOUNTING POSITION	COMPANY
YETTER DUAL 2968 SERIES	224 Acres	7.0	58.0	Rear of Row Unit	Yetter Manufacturing Company, Inc.
DUAL CONCEAL®	429 Acres	6.1	26.0	Front of Row Unit/ Inside Gauge Wheels	Precision Planting, LLC.
MARTIN-TILL® DUAL UMO	430 Acres	7.0	90.0	Front of Row Unit	Martin Industries, LLC.

PFR PROVEN ACRES TO PAY OFF = (16-Row Planter at $5.50/Bu. Corn)

YETTER DUAL 2968 SERIES	MARTIN-TILL® DUAL UMO	CONCEAL® (DUAL SIDES)
		

4-YEAR MULTI-LOCATION NITROGEN PLACEMENT YIELD AVERAGE



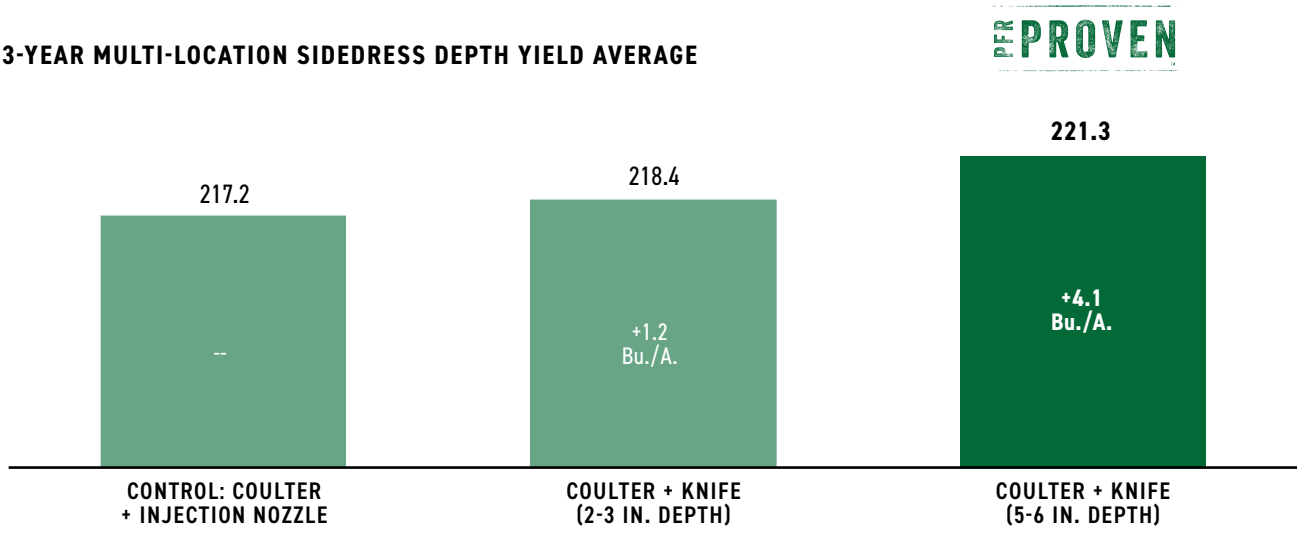
NITROGEN PLACEMENT - 2X2X2 VS DRIBBLE

4-YEAR MULTI-LOCATION 2X2X2 VS. DUAL DRIBBLE YIELD AVERAGE

SIDEDRESS DEPTH STUDY

Deeper applications of sidedressed nitrogen reduce surface exposure and place the nitrogen closer to the root system, which could be a benefit in drier growing seasons. Additionally, shallow applications can lead to increased volatility loss if the slot remains slightly open.

3-YEAR MULTI-LOCATION SIDEDRESS DEPTH YIELD AVERAGE

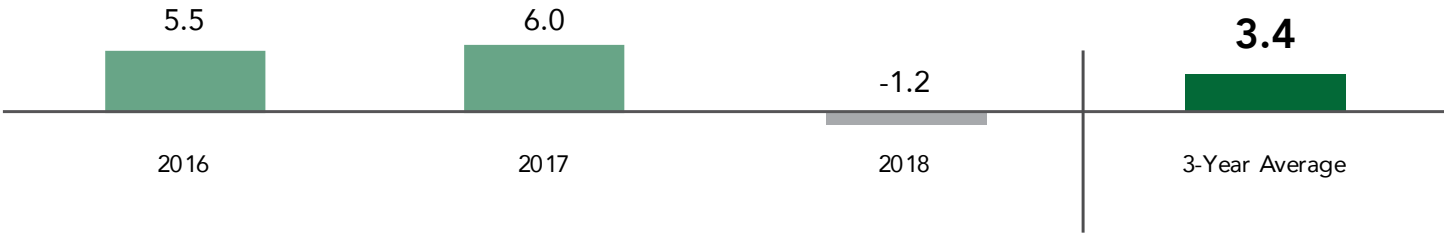


NITROGEN APPLICATION STUDY

COULTER + KNIFE VS 360 Y-DROP

The 360 Y-DROP® system places nitrogen at the base of the plant and allows for a wider application window. The disadvantage of the system is that it places the nitrogen on top of the ground, where it can be lost through volatilization. Timely rain is critical for incorporation and will have a significant impact on its success each year.

3-YEAR MULTI-LOCATION 360 Y-DROP® YIELD ADVANTAGE

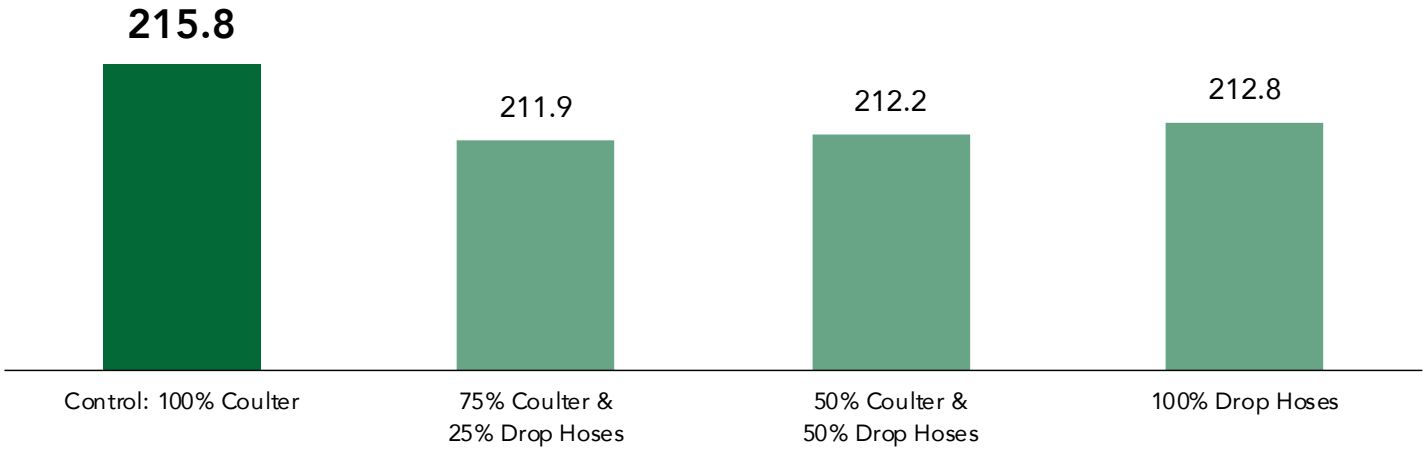


Source: Beck's 2018 PFR Book - pg. 23

NITROGEN APPLICATION STUDY

This study compares Unververth's Nutrimax® Dual Delivery System's different delivery methods at V5 sidedress and their effects on yield and profitability. The system allows you the option of placing nitrogen in the middle of the row, at the base of the plant, or any combination of the two. The time of application and weather will impact which placement excels in any given year.

2-YEAR MULTI-LOCATION NITROGEN APPLICATION YIELD AVERAGE



ROOT ARCHITECTURE

Our theory behind this study is that hybrids with a horizontal root architecture would respond more to nitrogen (N) in the middle of the row. In contrast, the vertical roots might respond better to N beside the row. However, our results this year were different. One thing to note is that the horizontally-rooted hybrids displayed a greater response to sidedressed N vs. pre-emerge applications. This data also validates the PFR Proven™ practice of applying N 2x2x2 vs. pre-emerge applications.

2024 MULTI-LOCATION RESULTS

LOCATION	ROOT ARCHITECTURE	FIRST APPLICATION	SECOND APPLICATION	PERCENT MOISTURE	BU./A.	BU./A. DIFFERENCE	RETURN ON INVESTMENT
CIL, OH, IA, MN	Horizontal	60 units UAN Pre-Emerge	130 units UAN @ V5	22.0	218.4	--	--
		60 units UAN 2x2x2	130 units UAN @ V5	21.8	224.2	+5.8	+$27.44
		60 units UAN 2x2x2	**130 units UAN 360 Y-DROP® @ V5**	**21.8**	**227.3**	**+8.9**	**+$42.10**
CIL, SIL, IA, MN	Vertical	60 units UAN Pre-Emerge	130 units UAN @ V5	20.9	233.1	--	--
		60 units UAN 2x2x2	**130 units UAN @ V5**	**20.9**	**236.6**	**+3.5**	**+$16.56**
		60 units UAN 2x2x2	130 units UAN 360 Y-DROP® @ V5	20.5	236.0	+2.9	+$13.72
SIL, OH	Balanced	60 units UAN Pre-Emerge	130 units UAN @ V5	20.2	194.9	--	--
		60 units UAN 2x2x2	130 units UAN @ V5	20.0	198.0	+3.1	+$14.66
		60 units UAN 2x2x2	**130 units UAN 360 Y-DROP® @ V5**	**20.6**	**198.3**	**+3.4**	**+$16.08**

Corn $4.73/Bu. UAN $0.67/unit of nitrogen. These results are based on the disclosed study parameters and participating sites.

ROOT DIG PICTURES - IOWA

HORIZONTAL	VERTICAL	HORIZONTAL	VERTICAL	HORIZONTAL	VERTICAL
PRE-EMERGE + SIDEDRESS		2X2X2 + SIDEDRESS		2X2X2 + 360 Y-DROP®	

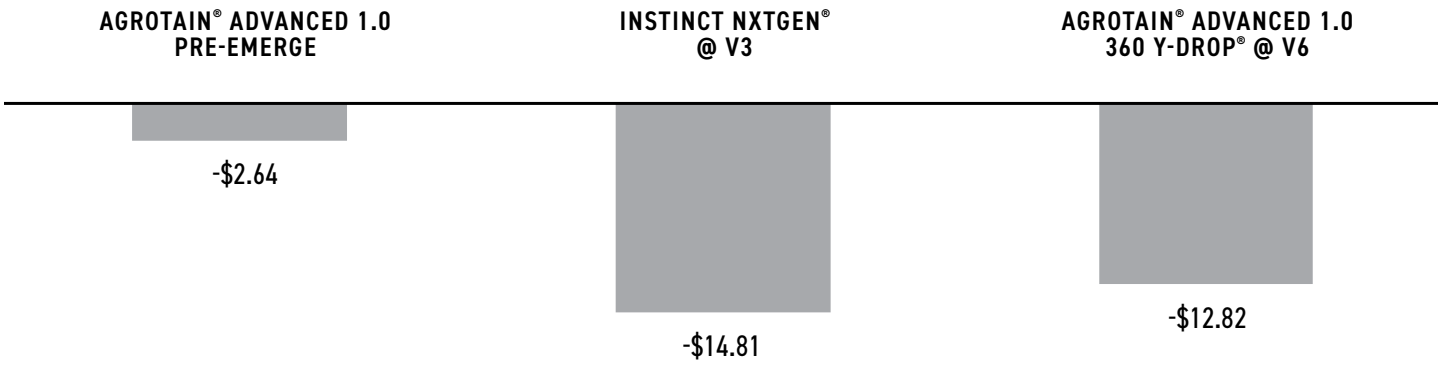
NITROGEN PRODUCTS

Beck's PFR team has conducted research on different nitrogen management products and equipment to help farmers make the best decisions for their farms and analyze various options to maximize their return on investment.

NITROGEN STABILIZER TIMING

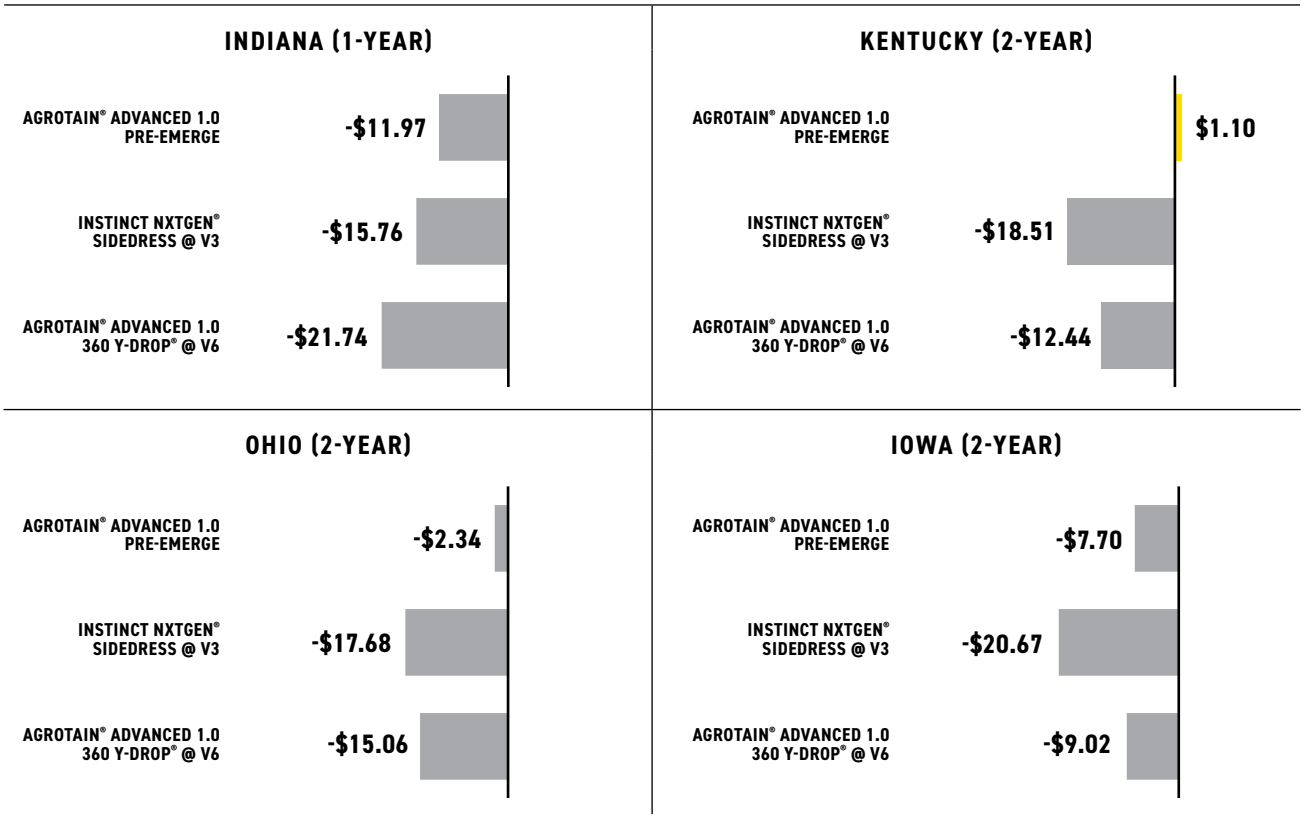
Most of the sites experienced a rainfall event after the nitrogen application. This helped incorporate the UAN into the soil and reduced the opportunity for volatility loss. Additionally, none of the sites experienced heavy rainfall events that led to soil saturation and denitrification, so nitrification inhibitors were unnecessary. Every year is different, and we will continue to conduct this study to learn more.

2-YEAR MULTI-LOCATION NITROGEN STABILIZER RETURN ON INVESTMENT



Scan the QR Code to watch a video about this study!

MULTI-YEAR NITROGEN STABILIZER TIMING RETURN ON INVESTMENT



PFR PROVEN PRODUCTS

Humic substances (those containing carbon, such as humic acids) are the primary organic compounds found in humus, the major organic fraction of soil. The addition of humic acids can be beneficial for soils and plants by doing two primary things; improving the soil's nutrient-holding capacity and helping the plant roots receive water and nutrients. Because of the high level of organic compounds found in organic matter, humic acids tend to work better on lower soil organic matters or where increased water and nutrient holding capacity is desired.

SIDEDRESS ADDITIVE	PFR PROVEN ROI	ROI WIN %	YIELD ADVANTAGE (BU./A.)	YIELD WIN %	APPLICATION RATE & TIMING	COMPANY
HUMIKA™	$6.88	64%	3.5	82%	1 pt. @ V3 Sidedress	Max Systems, LLC.
CARBON WORKS CETAIN®	$5.71	69%	3.2	85%	1-2 oz./4 gal. UAN @ V3 Sidedress	Carbon Works, Inc.
FEAST® SIDE-KICK® 0-0-25 W/17S	$3.41	67%	3.4	78%	1.5 gal. @ V3 Sidedress	Conklin Company, Inc.

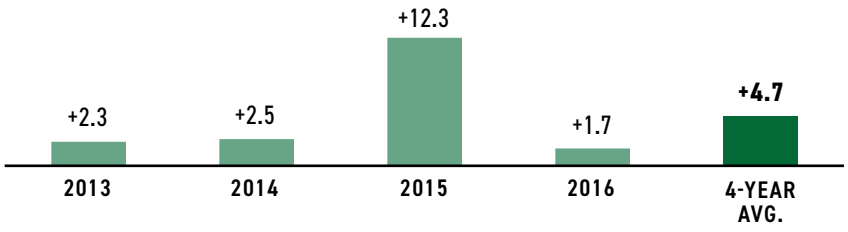
NITROGEN VOLATILIZATION

Nitrogen Sealers' double rolling coulter system covers the slot made by the injection knife, ultimately reducing the chance of nitrogen volatilization.

EQUIPMENT	PFR PROVEN ACRES TO PAY OFF	YIELD ADVANTAGE (BU./A.)	YIELD WIN %	APPLICATION TIMING	COMPANY
NITROGEN SEALERS	164 ACRES	4.7	88%	V3-V6 Sidedress	Nitrogen Sealing Systems

PFR PROVEN ACRES TO PAY OFF = (17-Row Toolbar at $5.50/Bu. Corn)

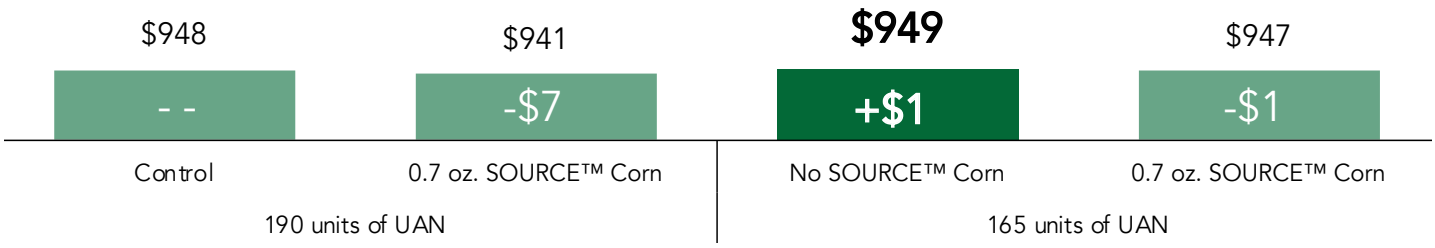
4-YEAR MULTI-LOCATION NITROGEN SEALERS YIELD ADVANTAGE



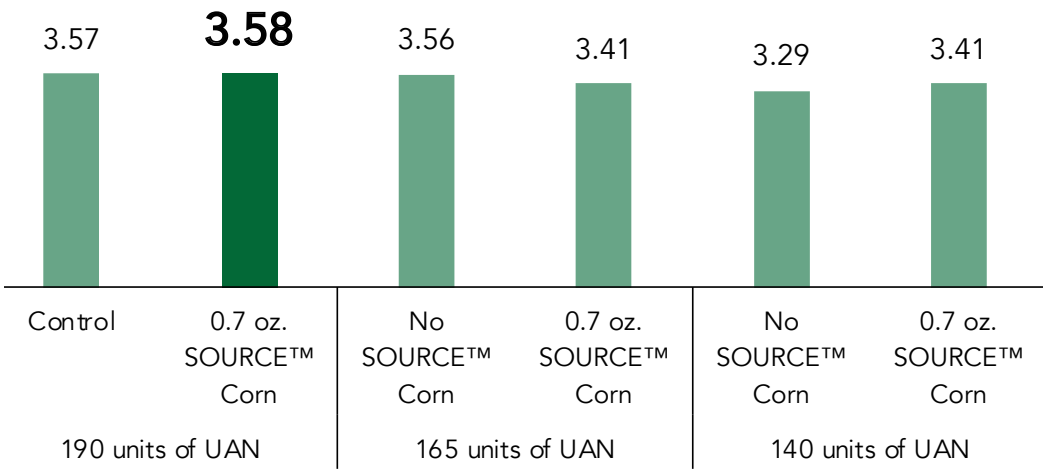
MICROBIAL ACTIVATION STUDY - SOURCE

The purpose of this study was to evaluate SOURCE™ Corn and its impact on microbial activation, nitrogen use efficiency, yield, and return on investment. Foliar applications of SOURCE™ Corn move into the root zone, stimulate nitrogen-fixing microbes, and (potentially) increase phosphorus availability. Our three-year data indicates that the best yield performance is seen when the N rate is reduced by 25 lb.; however, the return on investment was slightly negative.

3-YEAR MULTI-LOCATION MICROBIAL ACTIVATION STUDY NET RETURN & ROI



MUL (IN, KY, OH, IA) AVG. NITROGEN TISSUE TEST RESULTS @ V10



Source: Beck's 2022 PFR Book: Pg. 85

NUTRIENT EFFICIENCY STUDY - PIVOT BIO PROVEN 40

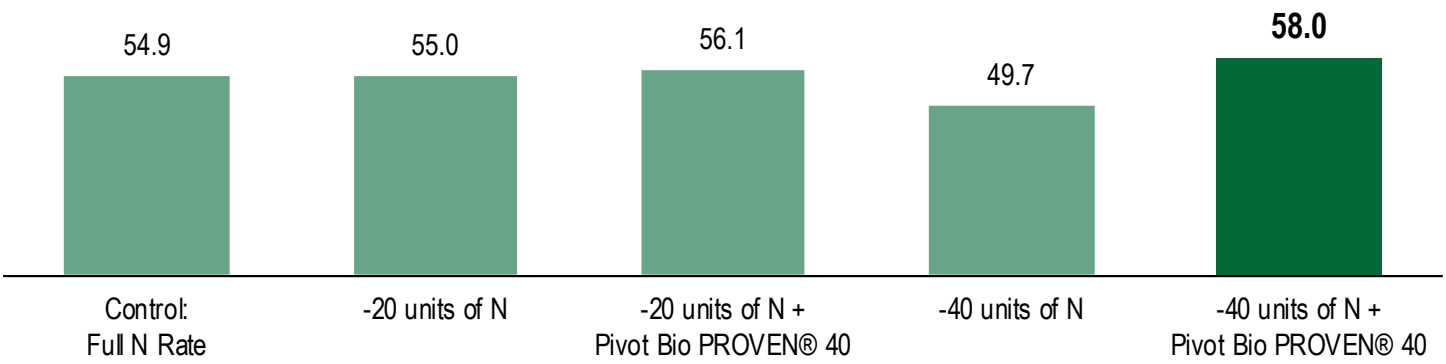
Pivot Bio PROVEN® 40 was tested in corn-after-soybean and corn-after-corn systems. Interestingly, at the reduced nitrogen rate of 40 lb./A., it slightly improved yields in both rotational systems to nearly identical levels. Pivot Bio PROVEN 40 improved plant biomass at both reduced rates. The yield improvements were not more profitable than the reduced nitrogen rates. Multiple sites experienced extended dry spells during the growing season, and we theorize this could have impacted the performance of biological additives.

2023 MULTI-LOCATION RESULTS

LOCATION	TOTAL NITROGEN (UNITS/A.)	IN-FURROW TREATMENTS	EMERGED POPULATION	POPULATION DIFFERENCE	BU./A.	BU./A. DIFFERENCE	NET RETURN	RETURN ON INVESTMENT
IN, KY, OH (CAB)	190	Control: No Pivot Bio PROVEN® 40	32,605	--	222.4	--	$1,130.56	--
	170	No Pivot Bio PROVEN® 40	32,473	-132	218.7	-3.7	$1,123.70	-$6.86
		12.8 oz. Pivot Bio PROVEN® 40	31,676	-929	219.7	-2.7	$1,108.39	-$22.17
	150	No Pivot Bio PROVEN® 40	32,209	-396	207.3	-15.1	$1,073.04	-$57.52
		12.8 oz. Pivot Bio PROVEN® 40	32,250	-355	209.4	-13.0	$1,063.99	-$66.57
CIL, IA, NE (CAC)	215	Control: No Pivot Bio PROVEN® 40	32,889	--	246.5	--	$1,249.94	--
	195	No Pivot Bio PROVEN® 40	33,222	+333	244.5	-2.0	$1,252.76	+$2.82
		12.8 oz. Pivot Bio PROVEN® 40	33,389	+500	244.8	-1.7	$1,233.46	-$16.48
	175	No Pivot Bio PROVEN® 40	32,982	+93	244.3	-2.2	$1,265.82	+$15.88
		12.8 oz. Pivot Bio PROVEN® 40	32,722	-167	246.1	-0.4	$1,255.06	+$5.12

Corn $5.69/Bu. UAN $0.71/unit of nitrogen. Pivot Bio PROVEN® 40 $21.00/A. These results are based on the disclosed study parameters and participating sites.

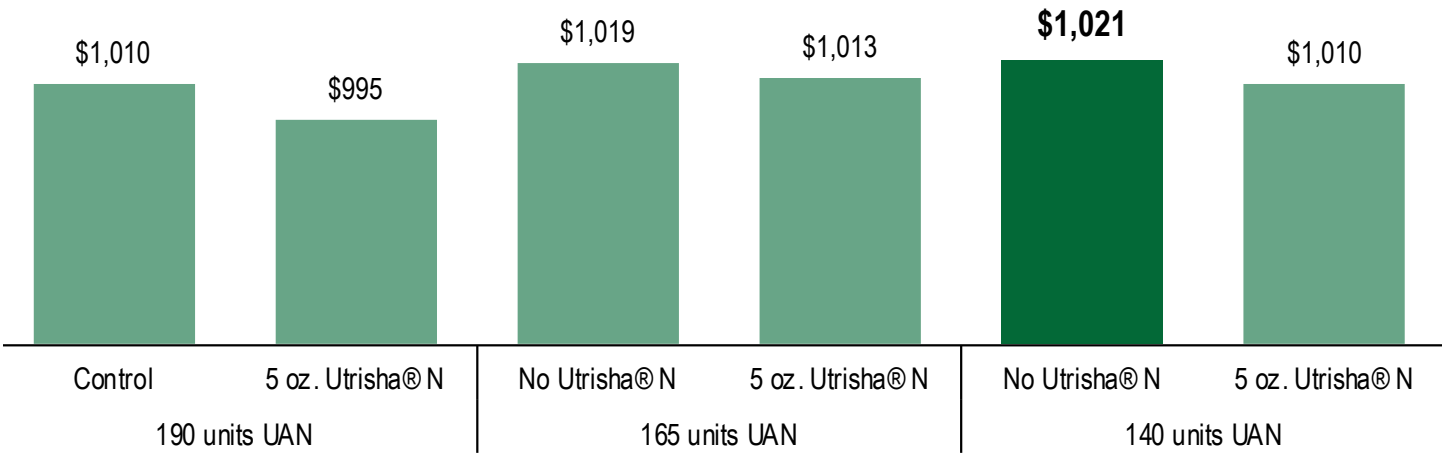
2023 MULTI-LOCATION PLANT BIOMASS @ V8 (POUNDS OF NITROGEN/A.)



NUTRIENT EFFICIENCY STUDY - UTRISHA® N

Dry weather suppressed yields at these sites in 2023, and the lower yield levels did not require as much overall nitrogen as in previous years when nitrogen loss was elevated. A few interesting observations were gleaned from this study; the first was that slightly lowering nitrogen levels overall was profitable. The second was that the applications of Utrisha® N improved yields at the lowest nitrogen level but not enough to be profitable.

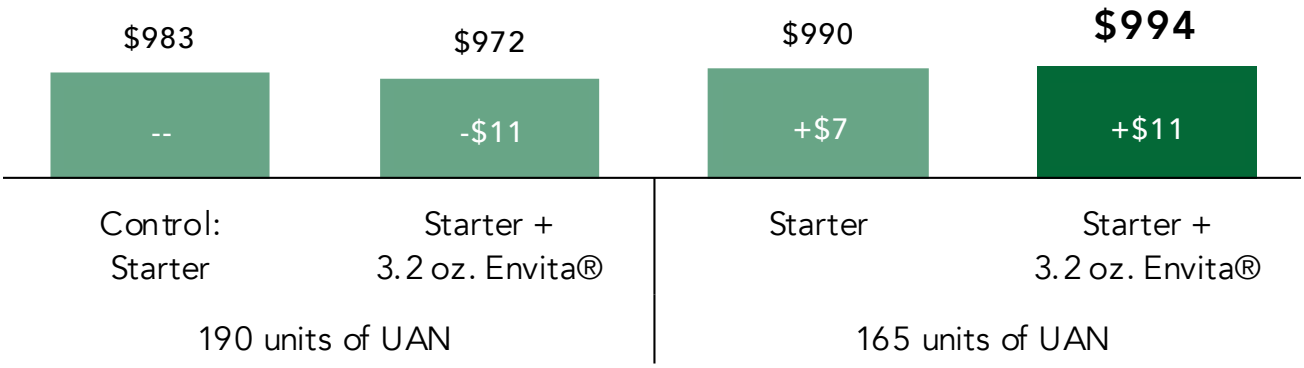
2-YEAR MULTI-LOCATION NUTRIENT EFFICIENCY - UTRISHA® N NET RETURN



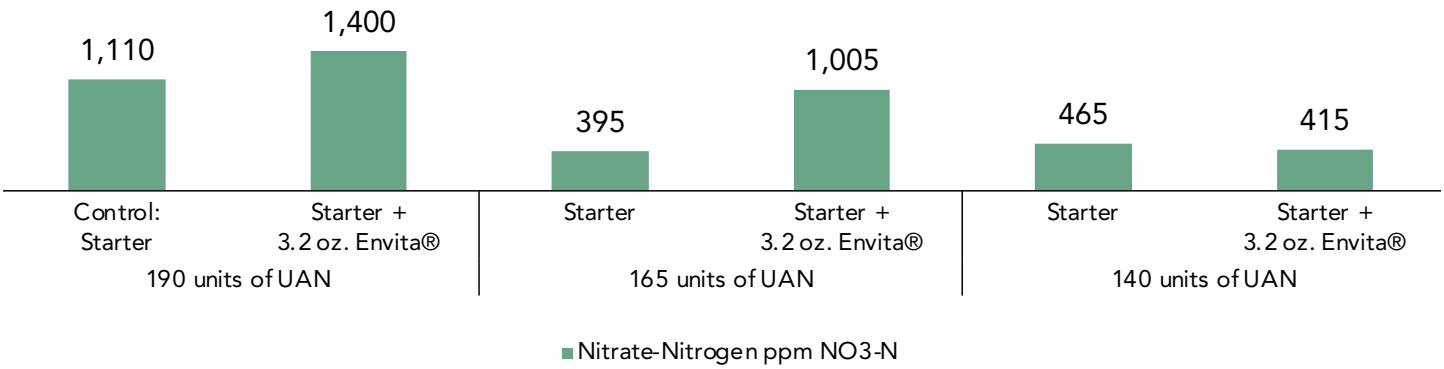
MICROBIAL INOCULANT STUDY- ENVITA (IN-FURROW)

This study evaluated Envita® in-furrow and its impact on nitrogen use efficiency, yield, and return on investment. Envita® is a bacteria that, once taken up by the plant, helps fix atmospheric nitrogen (N) in the cells. Our three-year data favors Envita when N rates are reduced by 25 lb.; however, because we saw a yield loss in one of the three years of testing, it is not PFR Proven™.

3-YEAR MULTI-LOCATION MICROBIAL INOCULANT (IN-FURROW) NET RETURN & RETURN ON INVESTMENT



MUL (KY, CIL) AVG. STALK NITRATE RESULTS @ BLACK LAYER



Scan the QR code to learn more about interpreting stalk nitrate results.


BECK'S