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Plant Nutrition TODAY
Better Crops, Better Environment...through Science

From Scientific Staff of the
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MANAGING CROP NUTRITION IN A CHANGING CLIMATE

Uncommon weather is becoming more common. Extreme weather has implications for managing crops and their nutrition. To adapt, what should you be considering in terms of strategies for managing plant nutrients?

The Intergovernmental Panel on Climate Change recently released a special report on extreme weather events. While its most confident prediction is a global increase in heat waves, it also states "It is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy rainfalls will increase in the 21st century over many areas of the globe." In particular it projects increased heavy rain events in winter months for most of the eastern and northern portions of the Corn Belt. The report also notes that while some areas of the world appear to be on a trend to longer and more severe droughts, central North America seems to be going the other way. Projections for floods, tornadoes and hail are acknowledged to be almost impossible to predict.

Adaptation is ongoing. As a producer you can adapt to increased temperature by choosing crops and cultivars that tolerate hot weather, and by planting crops earlier. With more intense rain events, the importance of conservation tillage to protect soil and nutrients from erosion and runoff will only increase. And there are also important considerations for managing crop nutrition. What happens to the choices for right source, rate, time and place when the weather becomes less stable?

Source. You have choices that influence the fate of the nutrients you apply, particularly N. You can slow the release of urea with coatings, or delay its conversion to ammonium with an inhibitor. Other inhibitors delay the transformation of ammonium to nitrate. These forms differ in how they move and are transformed in wet soil during periods of excess moisture. Some can also prevent salt injury in dry soil. Consider the weather in your choices of source.

Rate. If yield goals were hard to set in the past, they may be even more difficult to predict in the future. If you felt you needed a little extra for insurance with normal weather, the temptation may increase when weather becomes more variable. There are alternatives! Particularly for N, you can use crop sensors and/or weather-driven crop models as decision support tools. These tools can help you take into account and respond to the dynamic changes in weather.

Time. Splitting the dose into multiple applications can help minimize risk of loss and maximize nutrient supply to the crop. Does your equipment enable you to take advantage of narrow application windows that open up? Can you respond to short-term forecasts that assure that applied nutrients will stay in the soil? Can you fit your application timing to the growth stages of crops that might happen earlier than usual? These are questions to ask when reviewing your investment in application equipment.

Place. If rainstorms are more frequent and intense, leaving nutrients on the soil surface makes even less sense than before. Placing nutrients in the soil close to where the roots are growing adds resiliency to your crop management. Invest in equipment that can place the right nutrients in the soil at the right time, rapidly enough to fit application windows that might be shorter and at different times than in the past.

Experiment to adapt. This spring in Ontario Canada some farmers planted small areas to corn in March. Much earlier than generally recommended! But each time you try something new, provided you keep good records, you learn something, and it may turn out to be more valuable than you expected.

The adaptive management built into 4R Nutrient Stewardship emphasizes learning from results. Following 4R principles can help empower you to make the right choices in response to a changing climate.

– TWB –

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Abbreviations: N = nitrogen

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THE FEATURES OF THREE COMMONLY AVAILABLE FORMS OF NITROGEN FERTILIZER

In the Northern Great Plains (NGP) there are often questions on whether a farmer should preferentially use one N fertilizer form over another. A common statement is that "A pound of N, is a pound of N." If applied appropriately, all N forms can perform equally well, but the important thing to consider is what does "applied appropriately" mean.

Anhydrous ammonia (NH_3 or 82-0-0). When pressurized liquid NH_3 is released to the atmosphere it becomes gaseous NH_3. At the soil surface, NH_3 is volatile and can travel short distances (1 mi or 1.6 km) before settling back on the land. NH_3 must be injected into the soil to be effective—usually at about a 4 inch (10 cm) depth. Denitrification and leaching losses from NH_3 applications are usually low unless NH_3 is applied very early during a warm, long fall. Most of the N will be converted to nitrate (NO_3^-) under such conditions and if waterlogged conditions are experienced the following spring, denitrification losses of NO_3^- may be a problem. If NH_3 is applied later in the fall, or early spring, when soil temperatures are below 50 °F (10 °C) denitrification losses are normally small in the NGP.

Urea ($CO(NH_2)_2$ or 46-0-0). Urea is hydrolyzed in the presence of the naturally occurring urease enzyme in soil, or crop residues, to release free NH_3. When left on the surface after broadcast applications there may be some NH_3 volatilization losses. The risk of volatilization is smaller under cool, late fall or early spring conditions, but it increases under warm conditions during the late spring or summer and can range between 30 to 50% unless rainfall or irrigation soon follows application. A half-inch (13 mm) rainfall is usually sufficient to dissolve and move the soluble urea into the soil before much hydrolysis occurs. Once in the soil, any free NH_3 resulting from hydrolysis becomes NH_4^+ and losses are minimized. Volatile losses are minimal if urea is incorporated or banded in the soil. As is the case for all NH_4^+-based fertilizers, the NH_4^+ is eventually converted to NO_3^- through nitrification. Urea is less subject to denitrification in the short-term, because the conversion to NO_3^- takes time and the product can be a reasonable choice for surface applications in late fall or early spring. Once temperatures warm up, N top-dressing may be less subject to losses if urea ammonium nitrate solution is used instead of urea.

Urea ammonium nitrate solution (UAN or 28-0-0). This liquid fertilizer is a mixture of dissolved ammonium nitrate and urea in an approximate 50:50 blend and has loss properties that are typically half like urea and half like ammonium nitrate. The urea portion can be subject to NH_3 volatilization losses, while the ammonium nitrate portion is not. The NO_3^- portion of the ammonium nitrate can be subject to denitrification losses if waterlogged conditions are experienced soon after application. Surface applications are generally recommended to be surface-dribble-banded because much of the fertilizer may adhere to the surface residue and not move readily into the soil beneath the residue (e.g. established forage crop or a no-till seeded crop) if sprayed evenly over the surface of the soil into a thatch cover. If banded into the soil it will perform well compared to banded urea or banded ammonia. This pre-dissolved liquid form of N has similar plant availability compared to NH_3 or urea. However, liquid fertilizer storage, distribution, metering and field application systems do have some convenience advantages. UAN is a popular N fertilizer in areas where retail fertilizer dealers sell the product, and transportation distances are shorter [e.g. 20 mi (30 km)]. If transportation distances are great, transportation costs for NH_3 and urea tend to be less per unit of N.

In most cases all three of the N fertilizers above can adequately fill the N requirements of a crop if applied in a way to minimize losses and maximize crop uptake. The fertilizer industry encourages farmers to follow the 4R Nutrient Stewardship approach by applying the Right Form of fertilizer, at the Right Rate, Right Time, and Right Place. Generally the cost per pound of N is least for ammonia, then (in order of increasing cost) urea and UAN. There are exceptions in different local markets where the comparative cost between these three N fertilizers can change in order. The common statement "A pound of N, is a pound of N" is valid as long as consideration of the movement and potential loss mechanisms are understood, and timing and placement of a specific N fertilizer is appropriate.

– TLJ –

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Abbreviations: N = nitrogen; NH_3 = ammonia; NH_4^+ = ammonium; NO_3^- = nitrate

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IS IT ALL ABOUT THE APPLICATION RATE?

It seems that discussions by government regulators to minimize nutrient impacts immediately turn to reducing the rate of fertilizer application. While this approach has the advantage of simplicity and being easy to measure, a narrow focus on fertilizer application rate alone will consistently fall short of achieving the desired environmental and economic goals.

Selecting the Right Rate of fertilizer application is only one of the 4R's that must be considered when making nutrient decisions. In addition to selecting the Right Rate, it is also essential to choose the Right Source, the Right Time, and the Right Place to get the maximum value. When one of these 4R's is changed, it is necessary to evaluate how it impacts the remaining 4R factors.

Here are a few examples of how only modifying the fertilizer application rate may not achieve the desired results:

- It is important that growing crops have the right combination of all nutrients present in the rootzone, especially during periods of peak demand. If the nutrient supply during these critical times is not adequate to support growth then crop yields and quality will suffer.

- Nutrient applications should be made as close to the time of plant uptake as feasible. Some nutrients can be placed in the soil in advance of plant uptake because of their limited mobility; however other nutrients are at risk of loss if they remain in the soil for an extended period of time.

- When organic materials are used as a plant nutrient source, a period of mineralization is required before the nutrients are converted to a form that can be taken up by roots. Sufficient time is required for mineralization to synchronize nutrient release with plant uptake.

- Adequate soil moisture is needed for dissolved nutrients to be taken up by roots. Uncertainties in rainfall patterns make the prediction of fertilizer rate an ever-changing target each year. When crops are irrigated, nutrient loss is closely associated with water distribution and irrigation uniformity across the field.

- There are numerous examples to show that when plants are not supplied with a balanced and appropriate supply of all the essential nutrients, none of them will be fully used to their potential. For example if a soil is low in K, then nitrate will not be properly taken up and may be more prone to leaching loss.

- Some fertilizer sources are more suitable for placement close to the seed than other sources, which may cause damage to germinating seedlings. Placing fertilizer close to the seed can provide some early-season growth stimulation in some circumstances.

- Technology can be used to help keep nutrients in the proper place. For example the use of a nitrification inhibitor may reduce both nitrate leaching and denitrification losses from some N fertilizers. Similarly, a urease inhibitor can minimize ammonia loss and improve nutrient recovery from urea applied to the soil surface.

- Controlled-release technology can reduce the risk of nutrient loss and eliminate the need for multiple trips through the field to apply fertilizer. Enhanced nutrient recovery by plants is often reported when these nutrient sources are used.

- Custom blends of fluid fertilizers allow a precise combination of nutrients to be delivered to the soil in each drop. Each droplet provides uniform and consistent nutrition to the plant. Some compound fertilizers and additives are formulated to control the soil environment around the granule to enhance plant nutrient recovery.

These few examples illustrate how an overly narrow focus on fertilizer application rate alone can cause growers to miss their overall objective—that is growing a high yielding and high quality crop that is both economically profitable and environmentally sound. When the 4R Nutrient Stewardship approach is implemented on each field, it is clear that no one of them can dominate nor be excluded. It is NOT all about the fertilizer application rate, because the source, time, and place decisions must all be considered to get the rate right.

– RLM –

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Abbreviations: N = nitrogen; K = potassium.

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CORN AND SOYBEAN PRODUCTION IN 2011

Since about 1998, the planted acres of corn and soybean have been varying inversely. As harvested corn acres increase, soybean acres decrease and vice versa. The trends have been particularly striking since 2004 (**Figure 1**). In 2011, harvested corn acres were the highest they have been since 1944. Soybean acres decreased to levels comparable to those in 2004.

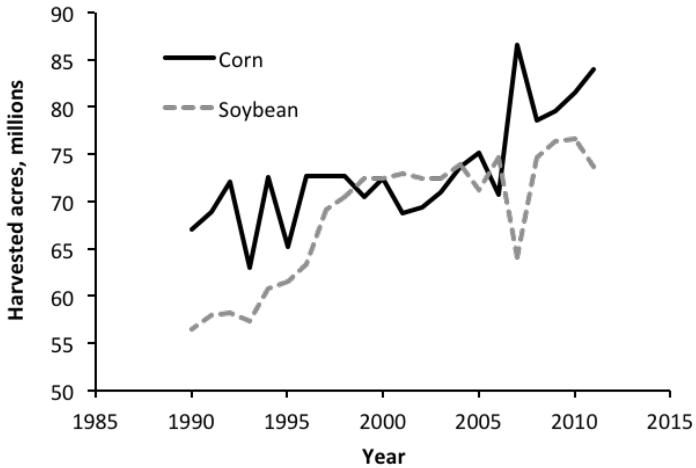

Figure 1. Harvested acres of corn and soybean from 1990 to 2011 (millions of acres).

Total corn production in 2011 of 12.4 billion bushels was up slightly from the average production of the previous 5 years. Although greater total production occurred, yield was lower in 2011 than the average of the previous 5 years, coming in at 147.2 bu/A.

U.S. corn statistics

	Year	Harvested acres, millions	Production, billion bu	Average yield, lb/A
	2011	**84.0**	**12.4**	**147.2**
5-yr. average:	**2006 to 2010**	**79.3**	**12.2**	**154.2**

The 3.06 billion bushel total soybean production represented a small decrease in 2011 compared to the average production of the previous 5 years. Yield was also down slightly, decreasing from an average of 42.4 bu/A in 2006 to 2010 to 41.5 bu/A in 2011.

U.S. soybean statistics

	Year	Harvested acres, millions	Production, billion bu	Average yield, lb/A
	2011	**73.6**	**3.06**	**41.5**
5-yr. average:	**2006 to 2010**	**73.3**	**3.11**	**42.4**

Source: National Agricultural Statistics Service, USDA. Available at http://quickstats.nass.usda.gov/ (verified 2 May 2012).

–TSM –

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COTTON FERTILIZATION ON THE BLACKLAND PRAIRIE

Determining the right fertilizer rate for cotton production as part of 4R Nutrient Stewardship depends on several factors. Plant nutrient demand, soil nutrient supply, and fertilizer use efficiency are some examples of things that need to be considered when making a fertilizer rate decision. Following a 4R Nutrient Stewardship plan also requires that growers consider the interaction of rate with nutrient source, time of application, and placement. Thus, identifying the optimum fertilizer rate in a given season can be one of the most challenging aspects of cotton management.

One of the major cotton production areas in the South is the Blackland Prairie region in central Alabama and Mississippi. This region was once the heart of North American cotton production; however, growers in recent years have experienced fertility problems that have been difficult to explain. Growers are reporting K deficiencies in cotton in spite of the fact that these soils often test “high” or “very high” in K. One problem may be poor calibration of the soil test-based recommendations for these soils.

Auburn University researchers, Charles Mitchell and Gobena Huluka concur that “Soil test calibration for cotton on these soils is weak.” To address this concern, a fertilizer response study was conducted for six years on a Blackland clay soil in Central AL. The experimental site tested “low” in P and “very high” in K, and the treatment structure included multiple rates of N, P, and K. Lint yields were compared to that of a control treatment that received 90-100-100 lb N-P_2O_5-K_2O/A each year.

Despite the fact that this soil initially tested “very high” in K, there were significant increases in yield with rates up to 100 lb K_2O/A in five of the six years. These results provide credibility to growers’ claims that additional K seems to increase yields even though the soils are rated “high” or “very high” for K and none is recommended from the Auburn University Soil Testing Lab. There may be justification to change soil test K ratings for these soils and increase K recommendations for cotton.

Just as surprising a result was the lack of a significant yield response to added P. The “no P” treatment typically produced relative yields between 96 and 120% of the control treatment, which received 100 lb P_2O_5/A/yr. This result calls into question the current “low” rating for this soil test value for cotton. The definition of a “low” soil test rating indicates that the soil will produce less than 75% of its potential without fertilization of that nutrient and that clearly does not appear to be the case for the Blackland Prairie soils.

Soil testing remains our best tool for determining soil contributions to plant nutrient requirements. Fertility trial work shows current soil test recommendations to be accurate in determining required rates of P and K for cotton in other areas of Alabama and surrounding states. However, the results from this study demonstrate that periodic validation of the calibration accuracy is necessary and that re-calibration work is sometimes needed.

– SBP –

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium.

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WINNING THE NITROGEN GAME WITH TWO PAIR

In many respects, today's farmers and growers are in a high-stakes poker game; never really knowing how many cards are in the deck, or which cards they may be dealt by the seemingly unpredictable weather. Yet, unlike in a traditional poker game, "two pair" can lead to a winning game.

The "two pair" referred to are the "two pair" that form the '4 Rs' of superior N stewardship; matching the right source with the right N rate, in combination with the right time and place of application. The N source will often dictate the time and the place of application (e.g. beneath the soil surface). The right N rate is often influenced by the anticipated affects of the other three 'rights' on crop N uptake and use efficiency. The time and place of N application depend heavily on knowledge of the soils and cropping system response, and the in-season uptake demands, in the prevailing climate and environmental conditions.

At some retail fertilizer suppliers, the N source choice may be limited for many growers. With such limited choices among N sources, growers are compelled to make even greater efforts to properly place and time their N applications.

Most growers would readily admit that as they approach each new cropping season, they weigh many risks and benefits, while constantly monitoring and anticipating weather outlooks. Some are recognizing that as realistic achievable yields increase, and crop and fertilizer prices fluctuate less predictably, they must hone their N management skills to optimize net returns and the efficient use of all cropping system management inputs and expenses: from planting and tillage systems, to seed purchases and crop protectants, to other fertilizers and any manures used. Good N management can help improve the returns from many other crop inputs.

If you have not seriously evaluated your N management program recently, in view of all available '4R' options ….in consultation with your crop adviser, fertilizer dealer, or extension agent ….now would be a great time. Track the crop yield per unit of N applied this year and in previous years, to see if improvements are occurring in your fields. Also determine if there are opportunities to adjust your N management in-season, to respond to high yield environments or to the damages of drought. Ask yourself, does my N source provide flexibility in timing, rate, and place of application? Do I have a precision technology platform that provides broader options in site-specific N management than I am currently taking advantage of?

Hopefully, you have developed a crop N nutrition strategy for a winning game this year …and every year. A winning strategy starts with an expanded understanding of the fertilizer N sources that may be available at your retailers, and an implemented plan developed in consultation with knowledgeable experts. Explore what leading farmers in your area are doing, weigh your management options, and don't be hesitant to try something new in your fields. Use the technology tools that are available to measure crop nutrition and yield differences in replicated N management comparisons in your individual fields. Maximize the power of the "two pair" that make the '4Rs" of excellent N stewardship and implement changes on your farm; for greater profits and field nutrient retention.

– CSS –

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SOYBEANS AND N FERTILIZER - DO THEY GO TOGETHER?

Soybean is a nutrient dense, high protein seed. Consequently, nutrient requirements of a good soybean crop are rather high. Although numbers can vary, IPNI recently assembled values that indicate that on average one bushel of soybeans contains 3.25 lb N, 0.73 lb P_2O_5, and 1.18 lb K_2O.

A question that sometimes arises is "do soybeans benefit from N fertilization, and if so under what conditions?" To begin to answer this question it is instructive to first consider sources of N for soybean uptake.

Soybeans get their N from three sources: 1) N_2 fixation by Bradyrhizobium, 2) nitrate and ammonium in the soil, and 3) fertilizer N. An evaluation of technical studies done by scientists at the University of Nebraska showed that on average, 50 to 60% of the N in soybeans comes from N_2 fixation. Normally, the remainder comes from the N in the soil. The maximum amount of N_2 that can be fixed was considered by the authors of the review to be 300 lb N/A. When excessive fertilizer N is applied it can substantially reduce N_2 fixation, making N fertilization of soybeans an even more delicate consideration. Typically, seasonal N demand peaks just after growth stage R3 (beginning pod).

Soybeans can be responsive to N fertilizer under certain conditions, whether in high or low yield environments. High yielding environments may have a greater chance of responding to fertilizer N, but at lower yields, there are still several situations the review authors listed where responses to N were more likely. These included poor establishment of the nodule system, extremely low soil N supplies at planting, plant water stress, soil pH problems, low soil temperature, or an absence of native Bradyrhizobium resulting from a cropping history with infrequent or no legumes.

Specific examples of some of these conditions have been reported on in *Better Crops* Magazine >www.ipni.net/bettercrops<.

Lamond and Wesley (2001) evaluated N treatments at four irrigated soybean sites over two years. Nitrogen fertilizer was applied at the R3 growth stage at 0, 20, and 40 lb N/A. Sources were UAN, urea, urea+NBPT and ammonium nitrate. All sites were in corn-soybean rotation and had high P and K levels. Nitrogen fertilizer increased yield in six of the eight site years. Sources of N fertilizer performed similarly, except the highest UAN rate where yield was reduced due to leaf burn. Yield in the control treatment averaged 55 bu/A and ranged from 72 to 35 bu/A. Yields with N fertilizer averaged about 62 bu/A—11% (7 bu) over the control average. There was no advantage to applying over 20 lb N/A. The authors ultimately stated that "Results suggest that soybeans with high yield potential (greater than 55 bu/A) may not be able to supply enough N during peak demand via atmospheric N (N_2) fixation."

Mengel et al. (2012) reported soybean yield response to N under much different conditions. In 2009 and 2010 fields were planted into "virgin" ground with no history of soybean production. Both sites were rainfed, thus average yield potential was considerably lower than expected under irrigated conditions. Observations indicated that plants were poorly nodulated, even though seed was commercially inoculated. Nitrogen was applied to each field during the growing season (R1 to R2) in 30 lb increments up to 150 lb N/A. The two site years of this study showed that N fertilization increased yields where nodulation was less than ideal. Applying just 30 lb N/A on average increased yield from 23 bu to 30 bu/A.

Nitrogen fertilization of soybeans requires careful evaluation of conditions, and even then carries some financial risk. Nevertheless, it can sometimes be beneficial and should be considered where appropriate. Review of publications, and consultation with CCAs and extension specialists can help in determining whether N and soybeans go together in your field.

– WMS –

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium.