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

From Scientific Staff of the
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Summer 2010, No. 1

WHAT TO EXPECT FROM THE NITROGEN USE EFFICIENCY TRAIT IN CORN

The future demands crops that will produce more food using less N. Corn is one of the most productive cereals, producing a lot of carbohydrate per unit of N applied. Several plant breeding companies have set goals to substantially increase the N use efficiency of their future hybrids. How will these differ from the hybrids of today?

Corn producers have already improved N use efficiency. This doesn't necessarily mean less N per acre. In the past 40 years in the Corn Belt, the amount of corn produced per unit of fertilizer N applied has increased by 78%, while N rates went up 30%.

How has this improvement in efficiency been achieved? Mainly by increasing yields, associated with:
- Greater N uptake, extending later into the season;
- Increased internal efficiency in the plant, yielding more grain per unit of N taken up;
- Small reductions in the crude protein (N) content of the grain.

Plant breeding companies have ramped up efforts to continue genetic improvement. Both conventional and biotech approaches are being applied. What are the traits that might contribute?
- Further increases in yield and tolerance to stresses like high plant populations;
- Roots that explore the soil more quickly and thoroughly;
- Transporters that assimilate nitrate and enzymes that convert it to amino acids more efficiently;
- Altered patterns of storage and remobilization of N within the plant;
- Ultimately, symbiotic N fixation—but that's an unknown, and a long way off.

These traits may require changes to the way nutrients are managed for corn. What will the right choices look like for source, rate, timing, and placement?

Source – Corn will likely continue to take up N as ammonium and nitrate. Physiologically, it takes the plant less energy to make protein from ammonium than from nitrate (even though corn is efficient at using nitrate). Increasing ambient carbon dioxide also favors ammonium uptake. Corn may start showing more preference for ammonium. So perhaps we can envision using sources that slow or prevent the conversion of fertilizer into nitrate, keeping it as ammonium later into the growing season.

Rate – Plant breeding won't likely improve our ability to predict what the soil might provide, or what the weather might remove from the soil by leaching, denitrification or other loss routes. These factors will likely remain the main determinants of the optimum rate to apply, though when yields increase some account will have to be made for increasing plant demand for N as well.

Timing – The corn plant needs N from start to finish. European studies show that continued N uptake beyond even a typical silage harvest date can be important for grain yield. Can we find ways to split the dose or control release for effective N uptake over a more extended period of time?

Placement – Could we envision a root trait that changes the depth from which N is captured? Roots operate most efficiently within the topsoil. It will still be important to get the applied N into that zone. But could we place other nutrients—like P and K—in a way that helps express the full potential of a NUE trait? Can we envision a trait that proliferates roots in zones where nutrients have been banded in ways that minimize losses to water and air?

There are good reasons to expect more genetic improvement of N use efficiency in corn. To make the most of it will require more agronomic experimentation with plant nutrition as well.

—TWB—

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Abbreviations: N = nitrogen.

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Summer 2010, No. 2

HOW WILL CLIMATE CHANGE AFFECT CROP GROWTH AND FOOD PRODUCTION?

Recently, I was asked to attend and participate in two different climate change adaptation workshops. It was interesting to me that these workshops were centered on the topic of adapting to climate change and not how to reduce greenhouse gas emissions to mitigate global warming. It was discussed that even if there was concerted international action on reducing greenhouse gas emissions and if the atmospheric levels of those gases were significantly decreased to levels of pre-industrial times, the Earth's average temperature is still going to continue to rise for a period of a decade or two.

An increase in average annual temperature in a region can greatly affect what type of crops can be grown. In areas of shorter growing seasons, such as the Northern Great Plains (NGP), this could mean that we will be able to grow longer season, more heat-requiring crops. The northern edge of where corn and soybean crops are grown could possibly move north from where it has traditionally been. Conversely, the bottom edge of the area where cooler temperature crops—i.e. canola, field peas, lentils and spring-seeded wheat, barley and oats—will move north, with cropping moving into northern areas where limited heat and length of growing season did not allow successful cropping of these crops previously.

One of the great unpredictable aspects of climate change is what will happen to the amount of annual precipitation and how that precipitation will be distributed throughout a year, especially during the growing season. There are numerous climate change models used to predict precipitation amounts and patterns for different regions. At one climate change workshop I attended, the majority of available climate prediction models discussed indicate that in Saskatchewan there will probably be more precipitation received, but it will shift somewhat more into the fall and winter and less during the growing season. This could affect how well different crops grow and yield. For example, this may mean that fall seeded winter wheat may grow more successfully in areas where spring seeded wheat was previously the dominant crop. Another possibility is that the development and reliance on irrigated areas may increase as precipitation received in the fall and winter may be successfully stored in irrigation reservoirs to be utilized in the warmer and drier summers to irrigate crops. Among other potential trends in precipitation is that there may be an increased chance of periods of drought, but also times of potentially higher than normal precipitation. My understanding of this is that there will be more variability and perhaps more extreme weather events.

One of the more predictable effects of increased levels of carbon dioxide (CO_2) in the atmosphere along with slightly higher temperatures is that crop growth will increase due to the increased efficiency of photosynthesis. This is known because the greenhouse industry uses artificially elevated CO_2 concentrations and temperatures to increase the growth of horticultural crops such as ornamentals, flowers, and the growth and yield of vegetable crops. While CO_2 is an atmospheric greenhouse gas, it is also a plant nutrient taken in through crop leaves and is a vital building block of photosynthesis. If crop growth and yields increase, then nutrient application rates will need to increase to supply crops with the needed nutrients. This will mean that fertilizer demand may also increase.

I was asked to attend the climate change workshops as an IPNI scientist, but also as an agricultural industry and fertilizer industry representative. At one meeting I was asked if the agricultural industry was capable and ready to adapt to climate change. In answering this question I could confidently respond that, yes agriculture will be able to adapt to climate change … it always has and always will. Agriculture has survived periods of cooling or warming, moisture deficits or excess, needed changes in crops grown sometimes due to climate change, but also adapting to changing market needs. Admittedly, the unprecedented rate of climate change we are presently experiencing will demand a timely and effective response by the agriculture industry to continue growing the food and fiber needs of humankind. Scientific knowledge, research, and adoption of new proven technologies will be important to successfully adapt to climate change.

—TLJ—

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Summer 2010, No. 3

MAINTAINING HIGH QUALITY ALFALFA: DON'T IGNORE THE NUTRIENTS

Alfalfa is one of the most important crops grown in North America, with its value ranked behind corn and soybeans. It is most commonly grown for hay, but is also harvested for silage. Maintaining a high quality alfalfa stand results in higher yields and enhanced quality forage. This requires a careful combination of plant nutrition, weed control, pest management, and skill in harvesting.

Alfalfa growers face the challenge of balancing achieving top yields with the price premium for early-harvest high quality hay. Alfalfa leaves regrow rapidly after mowing and the leaves are where the majority of the valuable plant protein is located. The stems continue to develop as the plants mature. The stems are lower in protein and high in fiber and indigestible lignin compared with the leaves.

Alfalfa places the highest demand on soil nutrient reserves of any of the commonly grown crops. Every ton of harvested alfalfa removes the fertilizer equivalent of approximately 12 lb of P_2O_5, 50 lb of K_2O, and 5 lb each of Mg and of S. When multiple alfalfa harvests are accounted for, it is clear that large amounts of nutrients are drained from the soil each year.

In addition to supporting the growth of high yields of hay, there are several less obvious benefits to maintaining adequate supplies of soil nutrients.

Quality – Nutrient deficiency hurts more than alfalfa yield. For example, studies have demonstrated that an adequate K supply in the soil improves stand persistence and increases the number of shoots per plant. An adequate K supply also increases the number and the activity of rhizobia bacteria, a prerequisite for a healthy N fixation symbiosis. Leaf drop from the alfalfa plants also is minimized with adequate K, resulting in a better leaf to stem ratio and higher quality animal feed.

Adequate P in the soil has been shown to support higher nodule numbers and nodule health essential for protein production. Plant regrowth and recovery after cutting is more rapid with adequate P, compared with deficient P conditions.

Plant Disease Control – Attention to plant nutrition can also benefit alfalfa profitability in less obvious ways. Careful nutrient management can also bring improved resistance to plant disease.

In many cases, K-deficient alfalfa is more susceptible to disease than when adequately fertilized. For example, alfalfa leaf spot is decreased with adequate K. Zinc deficiencies make alfalfa more susceptible to fungal diseases such as rhizoctonia and phytophthora. These two root rot diseases can cause major problems in alfalfa. Proper varietal selection, water management, and attention to plant nutrition all work together to minimize root damage.

A key to maintaining high yields and healthy alfalfa stands includes providing an adequate nutrient supply. Soil analysis prior to establishing the stand is the best way to get young alfalfa off to a healthy start. Tissue testing in subsequent years is a good way to track nutrient trends over time and spot encroaching problems. There are well-established methods for testing alfalfa nutrient concentrations in the plant tissue. A newly developed test from the University of California to sample hay bales also shows considerable promise as an easy and convenient way to track nutrient sufficiency.

Proper plant nutrition is fundamental to successful alfalfa production. Use only those nutrients that are needed to achieve your production goals. Remember that not all yield-robbing deficiencies are visible to the eye. Keep track of your nutrient use and select the right source and rate to protect the investment in your alfalfa stand.

—RLM—

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Abbreviations: K = potassium; N = nitrogen; Mg = magnesium; S = sulfur; P = phosphorus.

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Summer 2010, No. 4

A TREATMENT FOR MY GRAINS

That's right — my grains, not migraines. What treatment are we talking about? Some new inoculant or seed coating? Guess again. Here's a hint: it's a proven technology that tells you the nutrient content of your grain. Okay, so it's time to fess up. We're really just talking about grain nutrient analyses. So why the fuss? Haven't soil testing and plant analysis labs always offered these tests as a service? You bet. And that's the story. They have always offered them, but few people take advantage of them or make full use of the information they provide. So here are a couple of things to consider.

First, there's sustainability. Yes, this is an over-used and ill-defined term, but I'd hazard a guess that when most of us hear the word "sustainability," we think about managing our land responsibly so that it remains productive for generations to come. Nutrients are an important part of that vision. If we don't put back the nutrients we take out, soil fertility declines, leading to a host of problems if it gets too low. Knowing how much of each nutrient is removed in the grain is the first step in calculating how much to put back.

The gene pool keeps changing. If you've ever wondered why specific nutritional needs of hybrids or varieties aren't studied more at universities, you need only reflect on how long a specific genetic offering stays on the market. By the time a solid university investigation has taken place, the hybrid or variety has been replaced by the next generation. Is the nutrient content in the grain changing if there is more starch and less protein? Is drought tolerance affecting more than just yield? You can answer these questions for yourself just by taking a few samples and sending them to a quality lab.

Interested in grabbing a grain sample? Make sure it's done correctly. There are many university Extension publications with good advice. If you want a resource that can help you earn some Certified Crop Adviser (CCA) continuing education units for reading, go to this website: >https://www.certifiedcropadviser.org/<. Look for the self study quiz "Measuring Nutrient Removal, Calculating Nutrient Budgets."

Become familiar with published nutrient removal rates. These are commonly referred to as "book values." They are average numbers that can be used when you don't have sample analyses of your own. The same university publications that provide nutrient recommendations often have these numbers in them. If you can't find them, go to: >http://nanc.ipni.net/articles/NANC0005-EN<. Average "book values" have been assembled there.

So if ever-changing genetics and sustainability have been giving you headaches, try this treatment for my grains and see if it helps. You've got nothing to lose and everything to grain.

—TSM—

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Summer 2010, No. 5

GETTING STARTED WITH PRECISION AGRICULTURE – STEPS FOR SUCCESS

Precision agriculture technologies are being utilized more and more frequently throughout the Southeast. Precision tools such as guidance systems, yield monitors, and variable-rate fertilizer applicators are resulting in higher productivity and profitability for many operations. However, some growers that stand to benefit from incorporating some aspect of precision agriculture into their farm management have been reluctant to get started. This article is for growers asking the question: "How do I get started in precision agriculture?"

Step one is to determine your individual need. Just as precision agriculture allows growers to address site-specific production issues, the reason for getting into precision agriculture will also vary from grower to grower. Do you want to be more efficient with inputs? Do you want better on-farm record keeping? Do you have ideas for management changes that require additional knowledge about your farm? Loading up with a bunch of new toys without first establishing a well-defined need can be costly and counter-productive.

Once you have established a need, you must identify the tools that can help meet that need. Determining what you need is only part of the process. Figuring out which of the numerous models or styles of the tool you are shopping for is right for you can be challenging. Just like televisions or washing machines, precision agriculture tools that appear to do the same thing can vary greatly in quality and price. Hopefully, you wouldn't buy a new tractor without knowing what it offered compared to the other brands; the same is true for guidance systems and software packages. Consultants and university extension personnel can often help determine which specific tool is right for you.

Third, an understanding of what is required to implement the new tool and how it will be used will help ensure success. Several questions can and should be asked regarding implementation: Can this tool be used on multiple crops? Is it going to be used on the entire farm or only certain acres? Who is going to run it? Will operator training or technical support be needed? Plans for implementation can also affect which specific tools are selected to meet a defined need. Establishing an implementation plan early in the process can go a long way toward what would be considered successful adoption of a precision agriculture technology.

Finally, be patient. Adding new technologies to the farming operation will inevitably take some adjustment. Even the most "operator-friendly" tool will have its moments. Your adoption timeline might need to extend over a few growing seasons, not just to work out the kinks and get comfortable with the new tools, but to fully establish the system needed to obtain the desired results. If your need is to increase crop yield, then a yield map is a good place to start, but really of little value unless the information leads to a change in management that can increase yield, like a change in variety or planting density in certain areas of the field. Successful adoption of precision agriculture will in many cases be more of an evolving process rather than a quick-fix that will show immediate results. Multiple tools might be needed to address some needs. There is so much reliable information and so many experienced growers to learn from that there really is no reason to be hesitant to explore the opportunities that exist in adopting precision agriculture technologies.

To learn more about precision agriculture technologies, consider attending the 9th International Conference on Precision Agriculture (ICPA) in Denver, CO, July 18-21. The ICPA will provide a forum for presentations on the current state of precision agriculture research and applications. Also, dedicated sessions for practitioners entitled "Precision A to Z Tracks" will offer practical advice from international authorities on key topics of precision agriculture for producers and professionals. For more information, visit >www.icpaonline.org<.

–SBP–

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Summer 2010, No. 6

FIELD GREENHOUSE GAS EMISSIONS AND FERTILIZER NITROGEN: THE FACTS

Fact: In the U.S., agriculture contributes less than 7% of the collective gases which are thought to aggravate the global "greenhouse" effect and contribute to climate change. Yet agricultural soil management, which includes N fertilization and manure application, is estimated to contribute about two-thirds of the U.S. nitrous oxide (N_2O or "laughing gas") emitted to the atmosphere. Nitrous oxide emissions are no laughing matter (sorry for the pun) since N_2O has a radiative warming effect which is about 300 times that of carbon dioxide, the dominant greenhouse gas.

We are learning that getting the fertilizer N source, rate, timing, and place correct (4R Nutrient Stewardship) can increase crop recovery of N and reduce direct N_2O emissions, as well as indirect emissions that result from ammonia volatilization, and nitrate leaching, drainage, and runoff losses. Important recent research by scientists with the USDA-Agricultural Research Service (ARS) and some leading land grant universities is showing that use of enhanced efficiency fertilizers (e.g. fertilizer N with urease and/or nitrification inhibitors, slow and controlled release fertilizer N) and altered management of more conventional water-soluble N fertilizers can help reduce direct N_2O emissions by as much as 30 to 50% in some cropping and tillage system environments.

The potential for such large reductions in direct N_2O emissions should catch our attention. We need, however, to be reminded that in many soil and crop environments, the total direct N loss as N_2O represents only a small fraction (often less than 1%) of the total N applied … often below 2 to 4 lb/A. In many cropping systems and soil environments, N loss via other pathways is larger and of greater agronomic and economic significance. Nitrogen loss can exceed 10 to 20 lb/A/year — as nitrate-N in drainage from some tiled fields; as surface runoff on strongly sloping lands; or as ammonia from surface-applied urea-containing fertilizers, where incorporation does not soon (within about 48 hours) follow application.

The key to maximizing crop N uptake, while minimizing both direct and indirect emissions of N_2O via the dominant loss pathways, is to implement best management practices (BMPs). Fertilizer and cropping system BMPs are site-specific and sensitive to different crop, soil, tillage, and moisture conditions. Often, soil testing lab, university, and government N recommendations fall somewhat short in addressing variations in individual farmer skills, landscape attributes, market access to different N sources, logistical labor and equipment challenges, and other important management factors.

The professional guidance of Certified Crop Advisers, professional agricultural consultants, skilled Extension agents, and experienced fertilizer dealers is becoming increasingly important to proper N management. Perhaps that helps to explain the support for expansion of certification programs in Argentina, India, and elsewhere as announced by Luther Smith with the American Society of Agronomy. Science-based advice of certified agronomic experts can make a big difference in the effectiveness of your fertilizer N applications and improve economic returns. Implementation of such expert advice in your nutrient management plans will help give you confidence that food, fiber, and biofuel production per unit of greenhouse gas emitted is being optimized.

—CSS—

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Abbreviations: N = nitrogen.

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Spring, 2010, No. 7

SULFUR—THE 4TH MAJOR NUTRIENT

Sulfur is an essential nutrient in crop production. It is classified as a secondary element, along with Mg and Ca, but it is sometimes called "the 4th major nutrient". Some crops can take up as much S as P. Sulfur has become more important as a limiting nutrient in crop production in recent years for several reasons. These include higher crop yields that require more S, less S impurities in modern fertilizers, less use of S-containing pesticides, reduced industrial S emissions to the atmosphere, and a greater awareness of S needs.

Sulfur serves many functions in plants. It is used in the formation of amino acids, proteins, and oils. It is necessary for chlorophyll formation, promotes nodulation in legumes, helps develop and activate certain enzymes and vitamins, and is a structural component of two of the 21 amino acids that form protein.

The crop's need for S is closely associated with N. The relationship between S and N is not surprising since both are components of protein and are involved in chlorophyll formation. They are also linked by the role of S in the conversion of nitrate to amino acids. Crops having high N need will usually also have high S needs.

The majority of S in most soils is contained in organic matter. Organic S must be mineralized to the inorganic sulfate anion before it can be taken up by crops. Organic matter decomposition and the resulting S release is affected by temperature and moisture, and generally conditions that favor crop growth also favor mineralization and release of S, although this may be less likely with cool season crops. Sulfate, like most anions, is somewhat mobile in soils and therefore subject to leaching. Soil conditions where S is most likely to be deficient are low organic matter levels, coarse (sandy) texture with good drainage, and high rainfall conditions. But, these are generalizations and S can be deficient under other conditions as well.

Several factors should be taken into account when making S fertilization decisions. Among these are crop and yield goal, soil and plant analysis, organic matter content, soil texture, and contribution from other sources such as irrigation water and manure. High yielding forage crops such as alfalfa and hybrid bermudagrass remove more S than most grain crops and tend to be relatively responsive. Soil test S is usually a measure of sulfate-S, and as with nitrate-N samples should be taken deeper than normal (0 to 2 ft.) because of sulfate mobility in the soil. Soils containing less than 2% organic matter are most commonly S deficient; however, deficiencies do occur in soils with higher organic matter. Coarse textured soils are more apt to need S, but finer textured soils can also be deficient. Sulfur content of irrigation water should be determined since in some cases it can deliver significant amounts of S.

There are several S fertilizer sources available. Most soluble S fertilizer contains sulfate, but others such as bisulfites, thiosulfates, and polysulfides are also available. The most common insoluble S fertilizer is elemental S, which must be oxidized to sulfate before plants can use it. This is a biological process and is affected by temperature, moisture, aeration and particle size. This process also produces acidity, and elemental S can be used in some instances specifically to acidify soils.

Sulfur is an important component of complete and balanced crop nutrition, and has justifiably gained more attention in recent years. Several factors should be considered to make the best decision regarding S need and fertilization.

—WMS—

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Abbreviations: Mg = magnesium; Ca = calcium; P = phosphorus; N = nitrogen; S = sulfur.