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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 1

EFFECTIVE NUTRIENT USE EFFICIENCY IMPROVEMENT

The world's population growth is projected to continue increasing demand for food, fiber, and fuel. Fertilizer nutrients have helped spare millions of acres of land while sustaining crop production increases to meet the demand. Efficiency improvement is key, therefore, for cropping systems as a whole, and for nutrient use within them. Effective nutrient use improves both, minimizing risks of losses that potentially harm air and water quality.

Efficiencies are calculated as ratios of inputs to outputs in a system. A recent scientific review identified 18 different forms of nutrient use efficiency. Four of them are very commonly used, but are often misinterpreted.

1) **Partial factor productivity** (crop yield per unit of nutrient applied) answers the question: "How productive is this cropping system in comparison to its nutrient input?"
2) **Agronomic efficiency** (yield increase per unit of nutrient applied) answers a more direct question: "How much productivity improvement was gained by the use of this nutrient?"
3) **Partial nutrient budget** (nutrient in harvested crop per unit of nutrient applied) answers the question: "How much nutrient is taken out of the system in relation to the amount put in?"
4) **Recovery efficiency** (increase in above-ground crop uptake per unit of nutrient applied) answers the question: "How much of the nutrient applied did the plant take up?"

In the short term, all four of these ratios increase as rates of fertilizer application are decreased, even to levels well below the economic optimum. This might cause one to falsely conclude that the lowest fertilizer rate results in the most efficient cropping system. This is untrue.

Cropping systems depend on multiple inputs, including land, labor, seed, plant protection, capital, and more. At the rate where the net return to the use of a plant nutrient peaks, it is making its best contribution to increasing the efficiency of all other inputs involved. This most economic rate is also often associated with minimal nutrient loss.

Best management practices ensure effective use of fertilizers in improving the efficiency of all inputs used in cropping systems. The goal of their use is to apply the most appropriate sources at the right rate, time, and place. Opportunities abound for improving nutrient use efficiency effectively:

- Genetics and management practices assuring maximum economic yields.
- Enhanced-efficiency fertilizer products using controlled-release technologies.
- Precision agriculture technologies to sense crop needs and improve application.
- Increased use of on-farm measures evaluating nutrient use efficiency.
- Decision support tools applying science at the farm level.

Yield improvement has increased partial factor productivity for N use on U.S. corn by 50% in the past 30 years. A partial nutrient balance reveals, however, that removal is less than 80% of the amount applied. For non-legume crops in general the figure is 64%. Room for further improvement exists.

Nutrient use efficiency improvements must always be evaluated in terms of their effectiveness in supporting cropping systems with both increasing yields and diminishing nutrient losses.

—TWB—

For more information, contact Dr. Tom Bruulsema, Northeast Director, IPNI, 18 Maplewood Drive, Guelph, Ontario N1G 1L8, Canada. Phone: (519) 821-5519. E-mail: Tom.Bruulsema@ipni.net.

Abbreviations in this article: N = nitrogen.

Note: ***Plant Nutrition TODAY*** articles are available online at the IPNI website: www.ipni.net/pnt

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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 2

POST-EMERGENCE NITROGEN APPLICATION…IS IT FOR YOU?

If your crops are short of N during the early season, in-season N application may be for you. Producers are interested in N management options that reduce risk associated with applying all the N fertilizer at seeding. Understanding the uptake of N by your crop, and the importance of timing N for yield production, are critical.

Early N helps boost yield in cereals, while late N may boost protein. Early N is critical for the development of cereal crop yields, especially during the first 3 weeks after emergence. If the crop was seeded with little N, any N applied during stem extension may miss the yield-building time and only impact protein. Canola is much more elastic in its response, meaning that N application later in the growing season can still boost yield by improving flower and pod formation.

How much N should be applied at seeding to avoid yield loss? Results from research in the northern Great Plains indicates that at least 50% of the targeted N rate should be applied at time of seeding to reduce the risks of post-emergent N applications. For individuals with low tolerance to risk, they may want to apply 66% of their target N at time of seeding. Nitrogen fertilizer can be managed more precisely with post-emergent N applications providing that some starter N is provided.

How do we define target N rates for crops? The target N rate is that rate of fertilizer N required by the crop, in addition to the soil test determined N, to achieve the desired yield goal. For example, say you have a 40 bu/A wheat yield goal. Using 2.5 lb N/bu as your guide, you would want to have soil test N plus fertilizer N add up to 100 lb/A in total (40 bu/A x 2.5 lb N/A). If you opted to use post-emergence N application, and had a soil test N of 25 lb N/A, we would recommend a fertilizer N rate at seeding of 25 to 41 lb N/A to achieve the goal of 50 to 66% of the total 100 lb N/A.

How much post-emergence N should be applied? When the time comes to apply post-emergence N, you have a couple of options, based on growing conditions. One option is to not apply any more N in the event that the lack of rainfall has resulted in low yield potential. The second is to apply the remaining 34 to 50% of the desired N rate based on the previously established yield goal. And finally, some growers opt to apply more N than previously determined based on good to excellent growing conditions which will support yields higher than 40 bu/A. New technology using optical sensors, like the GreenSeeker®, have the potential to help apply the added N based on crop response to soil N supply across a field. Where soil N supply is low, more N would be applied, and where it is high, less would be used. Ongoing research with the sensors should give us a good idea of where they can best be used.

Making post-emergence N work requires good management skills. Be sure and prepare for post-emergence N application if that is an option you have selected on your farm. Timing will be critical for cereal crops, and having a good proportion of your N applied at seeding is the key to making the post-emergence application effective.

—TLJ—

For more information, contact Dr. Thomas L. Jensen, Northern Great Plains Director, IPNI, 102-411 Downey Road, Saskatoon, SK S7N 4L8. Phone: (306) 652-3535. E-mail: tjensen@ipni.net.

Abbreviations in this article: N = nitrogen.

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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 3

KEEPING A LID ON NITROGEN LOSSES

As fertilizer economics and supply change over the years, so do the most commonly used sources of nutrients. Farmers have changed from using guano, to ammonium sulfate, to anhydrous ammonia, and now to urea as the most common source of N fertilizer used in the world.

Each source of nutrient has unique properties that must be managed in order to get full benefit for the crop. Urea itself is commonly found in nature and can also be manufactured under controlled conditions using natural products. Considerable research and experience have shown that when urea and urea-containing fluids are managed properly, they are excellent nutrient sources.

Urea has the advantage of having a very high N content (46% N), making it much easier to transport and handle than many other sources. Urea is converted by naturally-occurring soil enzymes to ammonium within a few weeks after being added to soil. When urea changes to ammonium, it becomes susceptible to loss as ammonia gas. There are many soil and environmental factors that determine how much is lost. A few of the most important are reviewed here.

- **Placement: If urea is placed or incorporated at least one inch beneath the soil surface, ammonia losses are virtually eliminated.** Similarly, if one-half inch (or more) rainfall or irrigation occurs very shortly after surface application, the urea will move deep enough into the soil to virtually eliminate ammonia loss. The ammonium that is released from the urea will be retained on the soil particles to be used by plants, instead of being lost to the air.
- **Soil pH: When urea begins the change to ammonium, the soil around the granule or droplet becomes more alkaline.** This natural process makes ammonium more susceptible to the loss of ammonia gas to the air. As the ammonium later becomes converted to nitrate by soil microorganisms, the soil pH will drop again. Ammonia loss from soils receiving surface applications of urea becomes a greater concern as the soil pH increases above 7.
- **Crop Residue: The presence of crop residues on the soil surface can increase ammonia loss from surface applications of urea in two ways.** The enzyme that converts urea to ammonium is very abundant in crop residues and high organic matter soils. Additionally, when surface residue is present, the urea may remain trapped on the residue and not interact with the soil.
- **Soil Properties: Soils with a higher cation exchange capacity retain more of the ammonium released from urea than soils with a lower cation exchange capacity.** Similarly, soils that can resist a rapid change in pH usually have less ammonia loss from surface urea applications. This generally translates to higher ammonia loss from coarse-textured soils than from more clayey soils.
- **Coatings and Additives: Various coatings have been developed to control the solubility of urea and improve crop nutrient recovery.** A coating of S or a polymer can be used to protect the urea from soil reactions and prolong its persistence. The rate of N release from the coated urea should be closely matched to the nutrient demand of each particular crop. Chemical compounds are also available for dry or liquid urea to inhibit the enzymes responsible for the conversion to ammonium. This inhibition typically lasts for 2 to 8 weeks, during which time rainfall or irrigation should move the urea into the soil, protecting it from volatile losses.

Several soil and climate factors need to be considered when using surface-applied urea. In general, incorporate the urea into the soil whenever possible using equipment, rainfall, or irrigation. When this is not possible, consider using a coated fertilizer or an additive to keep the ammonia from being lost to the air.

—RLM—

For more information, contact Dr. Robert Mikkelsen, Western North America Director, IPNI, 4125 Sattui Court, Merced, CA 95348. Phone: (209) 725-0382. E-mail: rmikkelsen@ipni.net.

Abbreviations in this article: N = nitrogen; S = sulfur.

Note: ***Plant Nutrition TODAY*** articles are available online at the IPNI website: www.ipni.net/pnt

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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 4

BIOFUELS' POTENTIAL IMPACT ON NUTRIENT USE IN THE U.S.

Biofuels. They are changing agriculture in the Midwest so rapidly that no one can really say for sure just what the future holds. One thing is sure, though. We had better get it right. We need to feed the hunger for energy with responsible crop production. That means making sure approaches used are sustainable for the long term.

A substantial increase in corn production has been forecast for 2007. Predictions are a 10 to 15% increase over the 2004 to 2006 average. Much of this increase is expected to come from corn-soybean systems in the Corn Belt. That means more acres of corn following corn.

So what's the potential impact on fertilizer use? Let's assume that 5 million more acres of corn will be planted on acres that used to be grown to soybean following corn. Considering average fertilizer use per acre of corn surveyed by the USDA, fertilizer N use could increase by 3.8% in the U.S., compared to 2004 to 2006 average levels. Increases of P and K are projected to be 1.7 and 1.3%, respectively.

Now many are asking about harvest of crop residues. Currently, ethanol is made from corn grain, but commercialization of cellulose-based ethanol production is being researched. In this other type of production, corn stover, or the plant parts other than the grain, is expected to be a major feedstock early on. When stover gets harvested as well as the grain, some significant changes in the amount of nutrients removed from the soil occur.

So let's consider what would happen for a 150 bu/A corn crop where 40% of the stover is successfully harvested. The biggest news for nutrient removal is K – a 110% increase in removal. This is expected, since most of the K is found in corn stover. Phosphorus is less severe, with only a 14% increase projected. Unlike K, most of the P is contained in the grain, so stover harvest doesn't produce as large an increase in removal of that nutrient.

The projections here are tentative, and other assumptions would produce different numbers. But the trend is revealed – more nutrients will be used when more corn is grown, and the effect of crop removal on soil nutrient levels will need to be watched closely when stover comes online as a feedstock.

With more nutrient use comes more responsibility. This is indeed an opportune time for agriculture. But we must realize our opportunities not only for profit, but for the role we can play in producing fuel in a way that protects the environment.

—TSM—

Dr. T. Scott Murrell is Northcentral Director, IPNI, 2422 Edison Dr., West Lafayette, IN 47906. Phone: 765-463-1012. E-mail: smurrell@ipni.net.

For more information on this topic, see the article in *Better Crops with Plant Food*, issue No. 2, 2007, entitled "Potential Biofuels Influence on Nutrient Use and Removal in the U.S.," written by Dr. Paul E. Fixen, Senior Vice President, Americas Group Coordinator, and Director of Research for IPNI. Access the article as a PDF file at this URL: >www.ipni.net/bettercrops<

Abbreviations in this article: N = nitrogen; P = phosphorus; K = potassium.

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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 5

PREVENT ROOT PRUNING WITH PROPER NITROGEN PLACEMENT AT SIDE-DRESSING

As corn growers prepare to supplement their pre-plant programs with side-dressed N, an understanding of several important points may help improve the efficiency of crop response and N uptake.

- Prior to the 6th or 7th leaf (~25 to 30 days after emergence, or V6-V7), corn roots tend to grow nearly parallel to the soil surface, and in well-drained soils, more than 70% of the roots may be present in the top 10 in. Nitrogen shortage at this time can reduce the number of kernel rows on the ear.
- By 7 to 8 weeks after emergence (after V12), roots extend completely to the row middle and 4 ft. below the base of the corn stalk.
- Research on sandy, irrigated soils has shown consistently higher corn yields with side-dress applications than with N applied before planting.
- About 40 to 50% of the total N uptake usually occurs after tasseling (VT), but uptake accelerates rapidly between V8 and V10 (~30 to 40 days after emergence). Any limitation of root activity and nutrient uptake during this critical period can seriously short-change growth (e.g. leaf area expansion) and cause yield losses (especially the number of kernels along the length of the ear).
- In many systems, applying N to alternating row middles has proven as efficient as application to each row middle – provided that soil compaction, leaching, and water-logging are not limiting effective N use in the application row middle.
- Placing urea-containing products (e.g. urea, urea-ammonium nitrate solutions) into the soil, beneath surface residues, helps minimize the gaseous loss (volatilization) of ammonia from urea-containing N fertilizers. Yield benefits of 8% or more compared to broadcast or surface dribble applications have been measured in research.

Many farmers strive to place side-dressed N near the actively-feeding roots of young plants, especially where plants have not achieved much top growth. Where plants may be 14 to 16 in. tall (i.e. after V6-V7), placement of N mid-way between rows should be adequate. All too often, in an effort to stimulate greater root uptake, application rigs get within 6 to 8 in. of the corn stalks. This “too-close-to-the-row” application may be injuring roots and taking a toll on plant vigor...and yield. When making side-dress N applications, unnecessary root injury can be avoided by spacing application knives or coulters closer to the centers between rows.

With increased N costs, reports of some regional supply/distribution challenges affecting access to N sources, early-season crop stresses…and the current opportunities to capture desirable corn market prices …can one risk impairing nutrient and water uptake by allowing unnecessary root injury and root pruning by N application equipment? Growers should adjust the spacing of coulters and knives on N applicators before side-dressing this season to improve N use efficiency and effectiveness.

—CSS—

For more information, contact Dr. Cliff S. Snyder, Nitrogen Program Director, IPNI, P.O. Drawer 2440, Conway, AR 72033-2440. Phone: (501) 336-8110. E-mail: csnyder@ipni.net.

Abbreviations in this article: N = nitrogen.

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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
655 Engineering Drive, Suite 110
Norcross, Georgia 30092-2837 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

Summer 2007, No. 6

DON'T NEGLECT BERMUDAGRASS NUTRIENT NEEDS THIS SUMMER

Warm season forage growth and production is upon us. Among the most important warm season hay and pasture forage crops in the southern U.S. is bermudagrass, whether hybrid or common. The predominance of bermudagrass can be attributed to its high yield potential, drought resistance, and tolerance of acidic soil conditions. It can be produced for grazing, hay, or a combination of the two. Hay is generally cut at about 30-day intervals with from two to as many as six cuttings per season, depending on climate and moisture. In hay production, nutrient uptake is essentially the same as removal, so whatever is taken up by the crop is exported from the field in the product. In a grazing scenario some nutrients are returned to the soil (recycled) via animal urine and feces. How much to credit to this recycling depends on distribution of animal waste which is a function of several factors such as grazing intensity and water and shade distribution. **Maintaining adequate and balanced nutrition is fundamental to profitable bermudagrass production.** Skimping on needed fertilizer inputs can reduce yield and forage quality, as well as stand density and longevity. Additionally, reserves of soil nutrients such as P and K can be rapidly depleted in hay production where inputs are insufficient. Following are a few basic facts to keep in mind when fertilizing bermudagrass this season.

Adequate N nutrition is associated with improved shoot and root growth, stress tolerance, resiliency, and higher protein content. Bermudagrass will take up about 50 lb of N per ton of hay harvested. Tissue levels of N should be maintained at about 2.2% of dry matter. Basic recommendations call for the application of 100 lb N/A in the spring, with the remainder applied in split applications just after, or between harvests. Of course, as with any general recommendation this should be adjusted to specific conditions.

Phosphorus fertility is commonly associated with increased root growth and branching, increased N use efficiency, and improved drought tolerance and recovery. Bermudagrass will take up about 12 lb P_2O_5/ton, thus a top-yielding hay crop can remove as much as 100 lb P_2O_5/A. In a rapidly growing, high-yielding crop, uptake can equal 1.2 lb P_2O_5/A per day. Fertilizer P applications should be based on soil test results, but crop removal can also be useful information in crafting recommendations.

Adequate K fertility is associated with increased disease resistance, improved winterhardiness, maintenance of good stand density, and better N use efficiency. Maintenance of adequate K levels through the summer months to the onset of dormancy is important in the manufacture of carbohydrates for root growth and carbohydrate storage. Bermudagrass will take up about 50 lb of potash (K_2O) per ton with uptake reaching as much as 4 lb K_2O/A per day in a rapidly growing crop. Consequently, reserves of soil K may be reduced rather rapidly under intensive bermudagrass production. Soil testing is useful in developing K recommendations for bermudagrass. However, removal should be considered as well, especially in sandy soils with limited cation exchange capacity (CEC).

Secondary elements and micronutrients can also be important in achieving optimal bermudagrass production. A good example of this was shown in a recent east Texas study on Tifton 85 bermudagrass where in the fourth year of production yield was increased one ton, or 17%, with the application of S fertilizer (*Better Crops with Plant Food*, No. 2, 2007).

We started this season with excellent soil moisture in many areas. Thus, the stage is set for a good bermudagrass production year. Let's make sure that fertility doesn't limit that potential. Complete and balanced nutrition helps ensure optimum yield and forage quality, improved stand longevity, and maximum profit.

—WMS—

For more information, contact Dr. W.M. (Mike) Stewart, Southern and Central Great Plains Director, IPNI, 2423 Rogers Key, San Antonio, TX 78258. Phone: (210) 764-1588. E-mail: mstewart@ipni.net.

Abbreviations in this article: N = nitrogen; P = phosphorus; K = potassium; S = sulfur.

Note: ***Plant Nutrition TODAY*** articles are available online at the IPNI website: www.ipni.net/pnt