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

From Scientific Staff of the
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LIMITING NUTRIENT LEAKS

Natural ecosystems are often nutrient-limited. They support flora and fauna adapted to specific nutrient limitations. With a diversity of species competing for a limited supply of nutrients, little leaks out of the system.

Cropping systems are different. Agricultural management adds nutrients to boost productivity. While the higher yields save land for nature, nutrient leaks can perturb the natural balance .

Nitrogen is a nutrient that leaks in many ways. It can leach away as nitrate, causing issues for water immediately below the field and as far away as the ocean. It can leak to the air in the form of nitrous oxide, depleting the ozone layer in the stratosphere and warming the climate through the greenhouse effect. Or it can leak to the air as ammonia, possibly affecting air quality and smog, and potentially disturbing nearby natural ecosystems.

The nutrient P leaks in small amounts. But even the small concentrations in surface runoff or tile drain water can stimulate blooms of algae in rivers and lakes.

Best management practices limit the leaks. Applying the right source at the right rate, time and place—to the extent that is practical—ensures that crops take up the largest possible portion, limiting the amount available to be leaked.

Best management practices are specific to the soil and cropping system. They often include:

- Soil and plant analysis.
- Placement for maximum plant availability.
- Nutrient budgeting to match crop removal.
- Mapping and managing soil variability among and within fields.
- Timing applications and controlling release to synchronize with plant demand.
- Selecting genetics and managing for higher yield and nutrient uptake.
- Maintaining a buffer zone between the fertilized field and watercourses.
- Growing cover crops to retain nutrients for the next growing season.
- Conservation tillage to minimize runoff and erosion.

Even with best management, some leakage continues. Going further in limiting leaks requires further research and technology. Current technologies include inhibitors and coatings that control nutrient release from fertilizers. Future technologies may include nutrient-need forecasts related to weather. All technologies require on-farm testing to validate their effectiveness.

Are some crops leakier than others? Some consider corn to be particularly so, and worry that the biofuel-demand-driven increase in corn production will lead to larger leaks. However, nutrient leaks can occur before, during and after the growth period of any particular crop. It is important to consider the management of the full crop rotation. Extensive research in the Chesapeake Bay watershed has shown that cover crops following corn reduce nitrate leaks.

Increasing global demand for food, fiber, and fuel increases expectations for crop productivity. Best management of both cropping systems and nutrients gives the best chance of preserving natural ecosystems and limiting the nutrient leaks that might affect them.

—TWB—

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

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

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FALL SOIL SAMPLING — A GREAT WAY TO BEGIN PLANNING FOR NEXT YEAR'S CROP

Each crop year has unique weather and the crop year of 2007 is no exception. Some areas of the Northern Great Plains have experienced drier than normal moisture conditions and warmer than normal temperature conditions. In some of these areas ample soil moisture conditions early in the growing season resulted in excellent early crop growth, but ran short because of the lower than normal growing season precipitation...this caused crops to ripen earlier and yield less than what was expected. Lower yields due to dry conditions usually means there is a higher than normal carry-over of NO_3-N in the soil. If you were fortunate enough to live in an area where growing season moisture has been adequate and not excessive, the excellent crops grown will have removed most of the NO_3-N in the soil and soil test N levels will be less than normal for the area. Either way, if the warm weather has encouraged the crops to mature faster, the early harvest does open up the possibility to take soil samples sooner in the fall.

Generally, fall soil sampling on fields in the Northern Great Plains has been delayed until early October, but there are some advantages to start soil sampling soon after crops are harvested. First, there is more time to take soil samples to allow informed decisions for overall fertilizer recommendations…especially if fall N applications are considered. Fall N applications in this region are usually economically advantageous over spring applications because of lower N fertilizer prices in the fall compared to the spring. Secondly, poor weather later in the fall may interfere with taking of soil samples, especially if winter weather comes early. Thirdly, sampling is completed before use of residual soil N by volunteer crop growth. Much of the N used by volunteer growth in the fall is leached out of the frozen and dead volunteer crop residues and becomes available to next year's crop.

The only disadvantage of early fall soil sampling is in a year when ample early fall precipitation is followed by warmer than normal conditions well into the fall. This type of moist and warm condition can allow extra mineralization of N from soil organic matter. This extra soil mineral N will not have been present when the soil was sampled earlier, but will be available to the next year's crop. If such a fall season is experienced it may be beneficial to take some additional soil samples from selected fields early the following spring to determine the extent of fall N mineralization. It is often not more than 15 to 20 lb of extra N per acre.

Research over time has shown little if any need to delay soil sampling on perennial pasture and hay fields. This is because perennial forage stands tend to use up residual NO_3-N very effectively and little is left over and allowed to be subject to losses from leaching or denitrification. The exception may be recently seeded stands where the root systems of the forages may not be extensive enough to use the N present.

—TLJ—

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Abbreviations in this article: N = nitrogen; NO_3 = nitrate.

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AN OVERLOOKED NUTRIENT… ARE YOU KEEPING TRACK OF SULFUR?

Since S deficiencies are increasing in many areas, the use of this nutrient is becoming more common. The most common forms of S used in fertilizer are elemental S and SO_4. Thiosulfate forms of S are also commonly available in many regions. A review of how S behaves in the soil is useful to get top crop performance.

Sulfur plays two important roles in agriculture…as an essential nutrient required for proteins and enzymes…and as a soil amendment for improving alkaline soils.

Many crops require between 10 to 25 lb of S each year. While this is not as much as some other nutrients, the frequency of crop S deficiency has been steadily increasing since many fertilizers do not routinely contain S and deposition of air-borne S has decreased.

Although S exists in many different chemical forms in nature, plants primarily absorb it in the SO_4 form. The SO_4 molecule carries a negative charge, so it moves freely with soil moisture. As a result, SO_4 concentrations are sometimes greater with increasing depth in the soil below the rootzone. There are several excellent sources of plant-available SO_4 that will provide immediate crop nutrition. These include materials such as potassium-magnesium sulfate, ammonium sulfate, or potassium sulfate.

Elemental S is totally unavailable for plant uptake since it can not be directly taken up by roots. However, when elemental S is added to soil, it gradually becomes converted (oxidized) to the plant-available SO_4 form.

The transformation of elemental S to SO_4 is controlled by many factors. Since this conversion is done by soil microbes, several environmental and physical conditions govern how quickly this change takes place. In general, S oxidation takes place most rapidly in warm and moist soils. But field application should take place some time before the plants have a need for SO_4.

The physical properties of elemental S are also important. Small-sized particles have the most surface area and the most rapid reaction. However, fine particles of S can be difficult to apply. Fertilizer manufacturers have developed useful techniques where very fine S particles are clumped together with expandable clay to form a pellet which disintegrates in the soil.

Elemental S is highly acidifying after it is oxidized in the soil. It is commonly used to treat high-pH soils or to amend calcareous soils loaded with harmful concentrations of sodium. The specific S application rates should be calculated with the aid of a crop adviser.

Thiosulfate has also become a popular source of S nutrition for crops. Thiosulfate generally converts to SO_4 within a few weeks in typical summer growing conditions. Thiosulfate has also been shown to have beneficial effects on N transformations and may offer some unique benefits for plant metabolism.

There is no reason to risk yield loss from S deficiencies. When the need for S is suspected, there are many excellent materials that are available to meet crop needs.

—RLM—

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Abbreviations in this article: S = sulfur; SO_4 = sulfate.

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KEY NUTRIENT MANAGEMENT QUESTIONS WHEN SWITCHING FROM CORN/SOYBEAN TO CORN/CORN ROTATIONS

There are many questions producers and their advisers are asking as more corn is being incorporated into crop rotations. Following are a few key questions and comments related to switching from corn/soybean (CS) to corn/corn (CC) rotations.

How much do I need to change my N rate when moving from CS to CC?

- **Soybean effect on N credit.** A previous crop of soybeans can enhance N mineralization from organic matter. This can lead to reductions in the N rates applied to corn. When soybean is omitted from the rotation, more N may be needed to make up for reduced mineralization.
- **Soil NO_3 level**. Soybeans are good scavengers of soil NO_3. When soybeans are omitted, residual soil NO_3 levels may increase, although levels are very dependent on the weather. Given such variability, it is usually a good practice to test for residual soil NO_3 before deciding how much N to apply.
- **Attainable yield**. University research has shown that there is a potential for CC systems to yield, on average, less than CS systems. If, over time, yields have in fact decreased, N rates will need to be adjusted downward in recommendation systems using yield goal as a factor.
- **Monitoring tools**. Incorporation of monitoring tools (e.g., chlorophyll meter, stalk NO_3 test, etc.) can be very helpful when the switch is first made from CS to CC.

What happens to soil pH when I apply N more often? Switching from CC to CS means applying N every year, rather than biennially. Most N fertilizers have an acidifying effect on soils. In some cases, the initial reaction may be alkaline, but over the long run, the ultimate reaction is acid. Whether or not soil acidification rates will increase with CC compared to CS will depend a lot on the soil. The possible influence of rotation and the known impact of N fertilization upon soil acidification reinforce the need to regularly monitor soil pH, especially in the first few years when switching from one rotation to the other.

How does nutrient removal change? A CC sequence at a given yield level will remove more P, Mg, and S, but less N and K) than a CS sequence. For example, with 180 bu/A corn and 60 bu/A soybean the removal difference (CC-CS) in a sequence is -66 lb N, 18 P_2O_5, -29 K_2O, 4 Mg, and 4 S. To estimate this for yourself, multiply your corn and soybean yields by per bushel removal values (see www.ipni.net/northcentral/nutrientremoval).

Do I need to consider applying starter fertilizer? Several factors affect response to starter fertilizer (e.g., soil temperature, moisture, compaction, hybrid, etc.). In a 4-year Minnesota study, starter fertilizer produced equally beneficial responses (8 bu/A average) for CC and CS under a variety of tillage systems: no-till, zone till, strip till, and conventional tillage. The need for starter fertilizer for corn, regardless of rotation, may arise from the rapid influx of nutrients by corn roots early in the season and the positive effect of N and P on root proliferation.

An expanded version of these observations is available in the fall article series at the IPNI website: **www.ipni.net**.

—TSM/WMS—

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Abbreviations in this article: N = nitrogen; NO_3 = nitrate; P = phosphorus; K = potassium; Mg = magnesium; S = sulfur;

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PRECISION FERTILIZER TECHNOLOGY – GETTING THE RATE RIGHT

Remote sensing-based precision fertilizer technologies (PFT) are gaining popularity. Growers have long recognized that fields and areas within a field respond to fertilizer differently, but haven't always had the means to feasibly address these differences. The arrival of more affordable technologies along with the potential benefits being shown through university research studies have resulted in more growers moving toward site-specific, precision fertilization. There are several remote sensing systems available that use various strategies to collect information including, satellite imagery, aerial photography, and ground-based sensors. Regardless of information source, the end goal is the same for all PFTs – identifying the optimum fertilizer rate.

Remotely-sensed information is correlated with variables commonly used to determine fertilizer rates. In some PFTs, direct measurement of a soil or plant characteristic is involved, such as generating a variable-rate fertilizer map based on grid soil sampling. However in most remote sensing-based systems, the only thing "directly" measured is reflected light. The reflected light is correlated with plant characteristics like chlorophyll content, nutrient concentration, or yield potential to provide an "indirect" measurement of some variable that can be used to calculate fertilizer requirement.

Optimum fertilizer rates are calculated using algorithms constructed to consider a variety of factors. Many different algorithms (stepwise procedures for solving a problem) have been developed for PFTs to convert remotely-sensed data into fertilizer rates, but most will contain similar basic components:

- **Target measurements** that can be either directly or indirectly related to some variable that can be used to estimate plant nutrient requirement
- **In-field reference measurements** that are usually collected from "non-limiting" or "nutrient-rich" strips established earlier in the growing season to compare with the target measurements at the time of fertilization
- **Consideration of temporal (weather) conditions** that affect crop growth, soil nutrient availability, and overall yield potential
- **Estimates of crop responsiveness to applied fertilizer** that account for other nutrient sources such as manures or early-season mineral fertilizer applications
- **Estimate of nutrient use efficiency**

No precision fertilizer technology is perfect and improvements continue to be made. However, many PFTs are available that use reliable data collection methods and well-constructed, rigorously-tested algorithms to generate accurate fertilizer recommendations.

Getting the right rate of fertilizer in the right place in the field at the right time of the growing season using PFT can improve nutrient use efficiency and profitability by optimizing crop yields and minimizing nutrient losses.

—SBP—

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