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

From Scientific Staff of the
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Spring 2008, No. 1

CHANGING TILLAGE, CHANGING NUTRIENT MANAGEMENT

Crop producers have increasingly shifted to conservation tillage systems over the past few decades, but several issues are emerging that may modify the trend. There are important implications for nutrient management. A change in tillage is an opportunity to change application methods to improve nutrient use efficiency.

Last year the area planted to corn in North America increased by more than 15 million acres. This year (2008) again it is likely that more corn will follow corn, a situation in which it is more difficult to plant without tillage. Some soils that have been in no-till long-term may be tilled for the first time in many years.

Continuous no-till has numerous benefits. It often improves soil aggregate stability and increases water infiltration. However, it can also lead to accumulation of P at the soil surface causing higher P concentrations in runoff. This is suspected to be happening in some of the watersheds draining into Lake Erie, where the declining trend in particulate P is possibly starting to be overshadowed by a more recent trend of increasing dissolved P.

Recent research in Nebraska found that a one-time moldboard plowing reduced dissolved P loss from soils that had been managed as no-till for many years. The plowing increased total P loss at one site, but decreased it substantially at another. It had no effect on soybean and sorghum yields, but increased yields of corn planted a year later.

Similar research in Indiana found that rotational tillage reduced runoff volumes and concentrations of dissolved N and P, compared to a no-till field. For soils that have accumulated extremely high levels of available nutrients at the surface, plowing once in 10 years may benefit both yield and water quality.

Research on K needs in Ontario soils managed no-till for many years also found that a one-time fall moldboard plowing boosted corn yields. Corn responded more strongly to K, however, in soils that remained no-till.

Starter fertilizers have long been recognized as important for no-till corn. However, many studies also find similar responses to starter fertilizers—and similar total N requirements—for tilled and no-till corn. One recent study in central Illinois did find a difference, where no-till increased both yields and N requirements of corn.

Maintaining soil aggregate stability…and maintaining or increasing soil organic matter… remain important goals in tillage management. The results above encourage on-farm experimentation with different approaches to rotational tillage, testing opportunities to improve nutrient use efficiencies at the same time.

Considerable research points to practices that provide more efficient use of N by corn than surface-applying urea or urea-ammonium-nitrate around planting time. These practices include soil-incorporation, applying sidedress in late spring, or using controlled-release forms or inhibitors. There's no "one-size-fits-all" solution for either tillage or nutrient management. Consult your crop adviser, look for local research results, and test to find which efficiency-enhancing practice suits best.

—TWB—

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

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IS PROMOTION OF ORTHOPHOSPHATES AS MORE PLANT-AVAILABLE COMPARED TO POLYPHOSPHATES JUSTIFIED?

A common question from agronomists and growers in the Northern Great Plains is whether or not P fertilizers containing orthophosphate are more readily available to and better used by crop plants compared to P fertilizers containing polyphosphates. The simple answer is that there is very little difference under most field conditions. It is first important to understand how P fertilizers are manufactured, and the chemical and physical characteristics of these two general types of P fertilizers.

Most P used to make fertilizer originates from rock phosphates that are natural deposits of apatites. These materials are mined in different areas of the world, and are igneous or sedimentary in origin, with sedimentary deposits constituting the majority of world reserves. The mined rock phosphate is treated to increase solubility and availability of the P for crop use. The most common method used is called "Wet-Process Phosphoric Acid" and is simply the acidulation of finely ground rock phosphate with sulfuric acid in the presence of water.

In this method, dilute orthophosphoric acid (28% P_2O_5 equivalent) is separated from the other reaction end-products and normally concentrated by evaporation of water to a 42% P_2O_5 equivalent content. This material can be used to formulate P fertilizers by reaction with ammonia (NH_3) to form mono-ammonium phosphate (11-52-0), or with a K containing solution to form mono-potassium phosphate (0-51-34). Further heating of phosphoric acid causes more loss of water to the point that the P concentration can be increased to around 50% P_2O_5 equivalent and is commonly called "merchant grade" phosphoric acid. The phosphoric acid molecules exist in the singular orthophosphoric form.

Polyphosphoric acid (also called superphosphoric acid) is made when the merchant grade acid is heat-treated until orthophosphoric acid molecules begin linking together with a corresponding loss of water as steam. The water in the steam originates from a combination of a hydroxyl ion (OH^-) and a hydrogen ion (H^+) off the ends of adjoining orthophosphoric acid molecules. There is a loss of one molecule of water for every two orthophosphoric acid molecules that link together.

Ammonium polyphosphate (10-34-0) is a common liquid fertilizer. This product is made by reacting a 68% P_2O_5 polyphosphoric acid with NH_3 under controlled conditions. When the NH_3, a strong base, mixes with the acid the resulting exothermic reaction produces a large amount of heat. This heat produces a high amount of linking of phosphoric acid molecules into polyphosphoric acid. For example, 70% of the P in 10-34-0 is in polyphosphate form.

Plants can absorb P into their roots in both the orthophosphate and polyphosphate forms. In the soil, polyphosphate converts to orthophosphate by hydrolysis (reaction with water). The time required for polyphosphate hydrolysis to occur varies with soil conditions and temperature, and is accomplished by both chemical and biological reaction of polyphosphates with water. Temperature has a great effect on increasing the rate of hydrolysis with the amount of hydrolysis being 42%, 63%, and 84% after 72 hours, respectively, at 5°, 20°, and 35° C (41°, 68°, and 95° F). Under cool, dry conditions, hydrolysis may take longer. The efficiency of polyphosphates with more than 80% water solubility is considered to be equal to, but not better than, orthophosphates.

Polyphosphate-containing fertilizers are generally as effective as orthophosphate fertilizers.

—TLJ—

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Abbreviations: P = phosphorus; NH_3 = anhydrous ammonia.

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WHERE DOES FOLIAR FERTILIZATION FIT IN?

A portion of a plant's nutritional needs can be met by applying soluble fertilizer directly to the foliage. Foliar fertilization can result in rapid nutrient absorption and utilization to correct deficiencies or to merely prevent nutrient shortages during critical periods of growth. However, unlike roots, plant leaves are not adapted to assimilate large amounts of nutrients and meet the bulk of the nutrient requirement. Foliar nutrition has several potential benefits, such as:

- Supplying nutrients during peak periods of demand when an immediate response is needed
- Providing plants with certain nutrients, such as zinc and iron, that may not be readily available for root uptake
- Allowing flexibility in supplying nutrients related to improving the quality of the harvest
- Controlling nutrient losses in conditions with high potential loss
- Providing a nutrient source during periods of stress when soil applications are not practical
- Giving a nutritional boost to plants at the same time that other foliar chemicals are being applied, thereby minimizing application expenses

For some crops, foliar nutrition may be the most economical and reliable method of providing some nutrients, especially with micronutrients. However, there can be a large difference in the effectiveness of various fertilizer sources in actually penetrating into the leaf surface and providing the desired nutritional benefit. A local expert should be consulted to select the source of foliar nutrition that will best achieve the desired result with the least expense on specific crops.

There are many environmental factors that also impact the effectiveness of foliar nutrient application. Generally, application during early morning or evening is most effective. Air temperatures less than 85 ºF and high humidity conditions favor nutrient adsorption into the leaf. Wind speed should be low to avoid missing the target plants and minimize drift. Nutrient application to young, actively growing tissue and buds is generally more effective than application to mature tissue.

Foliar application of macronutrients, such as N and K, can also be beneficial for meeting the complete plant nutritional requirement. For example, foliar application of K has been shown to help cotton meet the demand of the rapidly developing bolls when roots may not be capable of completely meeting demand. Additionally, foliar sprays of N fertilizer onto small grains such as wheat are sometimes beneficial in increasing the protein content of the seed.

Foliar fertilization can provide an important supplement to the nutritional program of farmers. However, this practice should be considered an additional management technique and not the primary means of nutrient delivery. Plant roots have evolved to be the major pathway for nutrient uptake and their health and function is the primary goal. Appropriate soil fertility levels in the rootzone should be monitored with regular soil testing and maintained with nutrient replacements. However during critical growth stages, a foliar application of nutrients might be just what the plants need to reach goals for yield and quality.

—RLM—

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Abbreviations: N = nitrogen; K = potassium;

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2007 CORN AND SOYBEAN HARVEST IN THE NORTHCENTRAL REGION

Nationwide, corn yields in 2007 were up 1.3% over 2006 levels. In 2007, Illinois had the highest average corn yields of the six states in IPNI's Northcentral Region. State average corn yields in 2007 ranged from 121 to 175 bu/A. Average P removal rates were 42 to 75 lb P_2O_5/A and quantities of K removed were 28 to 51 lb K_2O/A. In 2007, half of the states in the Northcentral Region showed increased corn yields and quantities of nutrients removed. South Dakota was the most remarkable, with a 24.7% increase over 2006 levels.

Average corn yield per acre, state average P and K removal per acre, and yield and removal percentage change from 2006.

State	2007 avg. yield, bu/A	2007 avg. removal, lb/A		Change in yield and removal from 2006, %
		P_2O_5	K_2O	
IA	171.0	64	51	3.0
IL	175.0	75	49	7.4
IN	155.0	57	42	-1.3
MN	146.0	50	28	-9.3
SD	121.0	42	36	24.7
WI	135.0	51	39	-5.6
U.S.	151.1			1.3

Sources: USDA National Agricultural Statistics Service and state Extension publications

Soybean yields nationwide were down 3.5% from 2006 levels. Four states in the region followed this downward production: Illinois, Indiana, Minnesota, and Wisconsin. Iowa's 51.5 bu/A average yield was the highest in the region and was up 2% from the previous year. South Dakota again had the most remarkable increase over last year's production, at 23.5%. Quantities of P removed by soybean harvest ranged from 32 to 41 lb P_2O_5/A. Potassium removal was 39 to 77 lb K_2O/A.

Average soybean yield per acre, state average P and K removal per acre, and yield and removal percentage change from 2006.

State	2007 avg. yield, bu/A	2007 avg. removal, lb/A		Change in yield and removal from 2006, %
		P_2O_5	K_2O	
IA	51.5	41	77	2.0
IL	43.0	37	56	-10.4
IN	45.0	36	63	-10.0
MN	41.0	34	41	-6.8
SD	42.0	32	59	23.5
WI	39.0	34	39	-11.4
U.S.	41.2			-3.5

Sources: USDA National Agricultural Statistics Service and state Extension publications.

—TSM—

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POTASSIUM NUTRITION FOR COTTON

Grower interest in K fertility of cotton is very high heading into the 2008 growing season. This interest was evident at the recent Beltwide Cotton Conference, when a special session on K fertility was standing-room-only. The increased concern is likely because growers are reporting K deficiency showing up in fields where it had never been a problem before. Higher-yielding varieties, earlier-maturing varieties, and recent weather patterns have been cited as possible explanations for the increased frequency of K deficiency in cotton.

A 2-bale cotton crop will take up approximately 140 lb K_2O/A (70 lb/bale), 40 lb (20 lb/bale) of which will be removed at harvest. As yields have increased across the region due to new varieties and better management, growers that have typically applied 30 to 50 lb K_2O/A annually may be surprised to find their soil test levels dropping. Heavier boll loads have increased the demand for K even more, with uptake rates being as high as 3 lb K_2O/A/day during fruiting. Research in Tennessee demonstrated that the recommended rate of 60 lb K_2O/A was adequate for late-maturing varieties, but lint yield was reduced in an early-maturing variety. Increasing the K rate to 120 lb K_2O/A increased the yield of the early variety to that obtained using the later-maturing variety. The lint yield of the later-maturing variety was not affected by increasing the K rate. These results suggest that yield of early-maturing cotton varieties may not be maximized at recommended K rates and that increased K fertilization may be necessary for optimal yield response.

Although K is bound to soil surfaces, it can be lost through leaching. This potential for loss has led many states growing cotton on coarse-textured soils to investigate splitting K applications. Work in Virginia on a sandy Coastal Plain soil demonstrated a 138-lb lint/A yield increase when K was split between planting and early square. Recommendations from Mississippi also suggest that there are situations where splitting K applications might be beneficial; however, research in Georgia resulted in a yield decrease when K was split. The Georgia researchers did note that deep sands (no subsoil clay within the top 20 in.) might be more responsive to split applications. The consensus recommendation appears to be to apply the recommended K rate at planting on low to medium K-testing soils then follow with a petiole or leaf analysis later in the season.

Responses to foliar K applications throughout the cotton belt have been variable. Researchers agree that foliar applications should be used as a supplement to…not a replacement for…a good soil-based fertilization program. The most common conditions where a yield response to foliar K applications is likely to occur include deep, sandy, low organic matter soils, low soil K at planting, high-yield, irrigated conditions, and during periods of limited soil moisture. Work in Tennessee indicates that responses may also differ among tillage systems.

By the time K deficiency symptoms appear in the leaves, all other plant parts have been affected. Potassium affects lint quality (micronaire, length, and strength), water use efficiency, enzyme functions, and reduces the incidence and severity of wilt diseases. Petiole or leaf analysis can identify K deficiencies up to two weeks in advance of any yield reductions and can also be used to determine the need for sidedress or foliar K applications. The best defense against K deficiency in cotton is a combination of soil testing, tissue testing, and proper fertilization.

—SBP—

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Abbreviations: K = potassium.

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THE NEW GEOGRAPHY OF PLANT NUTRITION

Farmers today have a new set of tools to help them deal with the challenges of nutrient management decisions. Substantial fluctuations in prices for fertilizer and other inputs, and in prices received for crops sold, have made these tools even more valuable. Beyond the economic incentives, these tools also help optimize agronomic plans for the crop production system and make important contributions to improving our stewardship of soil, water, and air resources.

GIS-based record keeping. Good records serve to document past and current cropping practices and help design plans for future seasons. Building records into a Geographic Information System (GIS) allows for more details to be kept about the variability within fields, important to fine-tuning inputs for the future.

Soil testing. While a good soil sampling program has been a recommended practice for many years, new developments in sampling strategy, GIS records, and new application options enhance the value of traditional soil tests. Systematic geographically-referenced sampling provides ability to map spatial variability in soil nutrient supply and guide variable-rate application to efficiently distribute fertilizers precisely where they are needed.

Variable-rate application. The value of variable-rate application is increased as fertilizer prices and grain prices increase. Being able to put fertilizer dollars where they will be most effective is always a good idea, but with higher prices the economic incentive is much greater. When a uniform rate is used, parts of the field get nutrient levels built beyond where there is an economic response and/or other parts do not get enough to reach optimum levels. And there are the added potential benefits to the environment of applying nutrients only where they are needed.

Digital soil survey. The soil is the most basic resource for production, and the main manageable source of variability within the field. Geo-referenced digital soil surveys are now available for almost every field and contain a great wealth of information about each soil type in a field. This information can be incorporated into the field's GIS records and used with numerous analytical and decision-aid software tools to help make management decisions.

Yield monitors. Yield monitors are now available for most major commodity crops, providing an accurate measurement of yield and its variability across the field. With GIS analysis tools, yield data can be related to the geo-referenced data on inputs, weather, pests and other scouting observations, remote sensing imagery, and digital soil survey. Compared over time, yield maps can identify yield trends and profitability of different areas of the field. Analyzing the various databases may help identify areas of a field that should be taken out of production, and others that may warrant more intensive management. Yield variability means variability in nutrient uptake and removal, and can help better define variability in maintenance fertilizer needs.

Better-informed decisions. With a growing database of geo-referenced information to draw upon, a farmer and his advisers can fine-tune management decisions to move closer to optimum levels of inputs to produce the optimum yields for maximum profit. Embracing the technology to collect and manage information and to make better-informed decisions on nutrient management is the first step in keeping a production system profitable for each field. Similar technologies for other inputs can help further enhance profits.

These technologies for getting the right rate of the right inputs in the right place at the right time have demonstrated the increased value of better information. The cost of putting on too much fertilizer can be avoided. Perhaps more important, the greater cost (loss) from not putting on enough in parts of a field can be avoided. Using these geo-referencing tools and technologies also help farmers reduce their contribution to environmental problems and protect the production resources that will sustain productivity for future generations.

—HFR—

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Abbreviations: GIS = geographic information system

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TIPS FOR STRETCHING YOUR NITROGEN FERTILIZATION INVESTMENTS THIS YEAR

World demand for N fertilizers and increased energy expenses have caused N fertilizer costs to increase to ranges not seen before. Prices of grain, oilseed, and fiber crops have increased as a consequence of lower stocks of these crops, associated with increased global demand. These market forces and prices require farmers and their crop advisers to use every resource available to optimize the benefits of each unit of N fertilizer applied. Many farmers are seeking alternative sources of N, such as animal manures and biosolids. Whatever the chosen source, there are key principles that need to be considered in management decisions this year, to ensure good crop N use efficiency and optimized profits.

There are four major loss pathways to consider when applying N fertilizers and all other N sources to soils to meet crop requirements. They are: l) escape to the atmosphere as ammonia gas (termed volatilization); 2) surface runoff; 3) leaching through the soil; and 4) gaseous loss to the atmosphere as nitrous oxide (N_2O, a potent greenhouse gas) or stable di-nitrogen gas (N_2, which makes up 78% of the atmosphere)…this loss is termed denitrification.

Here are some tips to consider to minimize the risk of N loss via these four major pathways, and to improve N use efficiency on your farm this year.

Ammonia emission or volatilization losses — Ensure that anhydrous ammonia, urea-containing, and ammonium-based N sources are properly placed beneath crop residues and are incorporated below the soil surface; with urea-containing sources, urease inhibitors can be used that help delay or reduce the risks of loss as ammonia gas.

Leaching and runoff losses — These losses can occur with any N source applied to the soil, since all sources, including ammonium and urea-containing sources, will normally convert to the nitrate (NO_3^-) form in warm, moist soils in the course of several weeks. With NO_3^--based sources, and essentially all N sources, time the application to synchronize as closely as practical with crop uptake demand; avoid timing that may be subject to high intensity rainfall events within a few days to a few weeks after application that could rapidly accelerate movement off or through the soil; apply rates consistent with crop requirements and yield potential; consider split applications to minimize NO_3^- accumulations before crop uptake; and/or use nitrification inhibitors with ammonium-based N sources.

Denitrification losses — Once the applied N exists in the soil as NO_3^-, under warm, wet (near saturation) conditions, bacteria can convert it to N_2O and N_2 gases that can escape to the air. Take measures to prevent build-up of NO_3^- by using appropriate N rates and timing. Place N beneath the soil surface, but no deeper than necessary to prevent any potential ammonia losses from ammonium-based sources or those that convert to ammonium (often no deeper than 6 to 8 in., depending on soil texture); consider using nitrification inhibitors or slow- or controlled-release N sources which help time N availability with crop demand.

Consult your fertilizer dealer, crop adviser, agricultural consultant, or Extension agent to learn more about ways to enhance your crop's N use efficiency this year. You may need to adjust your plans from past management practices. Use the tips mentioned above to return better profits and to minimize environmental losses. Good fertilizer N decisions include the fundamental principle of selecting the appropriate N source, applying the right N rate, choosing the right time of application, and placing the N source properly in the soil.

—CSS—

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Abbreviations: N = nitrogen;

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PLACING FERTILIZER IN-FURROW WITH THE SEED

Placing fertilizer in the seed furrow during the planting operation is a common practice in small grain production, and to a lesser extent in row crop production. In-furrow fertilization is an effective crop production management practice, but some caution should be used since over-application and mismanagement can result in seedling damage, and ultimate stand and yield loss. Following are some of the factors affecting how much fertilizer can be safely applied with the seed.

- **Type of crop:** Some crops are more susceptible to injury from in-furrow fertilization than others. Oil seed crops are particularly sensitive, therefore most guidelines allow no fertilizer placed with the seed of these crops. The general order of sensitively (most to least) among major Great Plains crops is soybeans> sorghum> corn> small grains.
- **Type of fertilizer:** Fertilizers are salts, and these salts can affect the ability of the seedling to absorb water… too much fertilizer (salt) and desiccation or "burn" can occur. Some fertilizer materials have higher salt index or burn potential than others. Salt index values are usually included in basic agronomic texts or are available from fertilizer dealers or extension resources. As a general rule, most common N and K fertilizers have higher salt index than P fertilizers; therefore, a common predictor for the potential for salt damage is the sum of $N+K_2O$ per acre applied with the seed. For example, most guidelines for corn in 30 in. rows will allow for no more than 10 lb/A $N+K_2O$ in medium to fine textured soils (no urea containing products).
- **Ammonia formation potential of fertilizer:** Fertilizers that have the potential to release free ammonia can cause ammonia toxicity to seed. Thus, in-furrow placement of urea-containing fertilizers is usually not advisable. In some cases UAN is applied successfully in-furrow in small grain production, but there is a notable risk in this practice because of the potential for ammonia damage. The use of urea or UAN in-furrow in row crop production is even more risky and should be avoided.
- **Row spacing:** For a specific set of circumstances (crop, soil conditions, etc.) safe rate of in-furrow fertilizer increases as row space narrows or decreases. This is because narrowing row space has the effect of diluting fertilizer over more linear feet of row.
- **Soil type and environment**: Soil conditions that tend to concentrate salts or stress the germinating seed increase the potential for damage. So, the safe limit for in-furrow fertilization is reduced with sandier soil texture and in drier soil conditions. Also, environmental conditions that induce stress and/or slow germination (e.g., cold temperature) can prolong fertilizer-seed contact and thus increase the likelihood of damage.
- **Seed bed utilization:** The more scatter there is between seed and fertilizer in the seed band or row the more fertilizer can be safely applied. The type of planting equipment and seed opener influences the intimacy of seed-fertilizer contact. The concept of "seed bed utilization" has been used to address this factor. SBU is simply the seed row width divided by the row width, i.e., proportion of row width occupied by seed row. The wider the seed row for a specific row width the greater the SBU. As SBU increases so does the safe rate of in-furrow fertilization.

The information presented here is rather conceptual and general in nature. A detailed listing of recommendations and guidelines is beyond the scope of this brief publication. For more specific information regarding safe rates of in-furrow fertilization for specific crops and conditions one should refer to university extension resources, and/or consult a knowledgeable crop adviser or industry professional.

—WMS—

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium; SBU = seed bed utilization; UAN = urea ammonium nitrate.

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