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

From Scientific Staff of the
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Summer 2011, No. 1

THE RIGHT PLACE TO PUT PHOSPHORUS

Phosphorus is an essential nutrient for growing crops. But in the wrong place – in excess concentration in streams, rivers, and lakes – it can lead to algal blooms. To grow crops without harming water, fertilizer P must be put in the right place.

Unexpectedly, losses in some regions seem to be increasing. In the Lake Erie watershed, Heidelberg University reports that soluble P levels in rivers and algal blooms in lakes are trending upward over the past 15 years, in contrast to the downward trends from 1975 to 1995. Fertilizers applied to cropland are not the only cause, but are one possibility among many. The approach of choice for managing losses from fertilizer is 4R Nutrient Stewardship, ensuring the right source of P is applied at the right rate, right time, and right place. The "right place" likely holds the greatest opportunity for improvement, but the other three need to be in tune as well.

Source. Plants need P dissolved in water. If we had a source that would dissolve only in the water taken up by the plant, but not in the water leaving the field, it would be the solution. But we don't. We do need sources that can be conveniently placed in the soil.

Rate. Fertilizing to recommendations based on soil and plant analysis is important. Crop nutrient balances show that current typical rates applied don't exceed removals, and reduction opportunity is small.

Time. It's important to apply when the risk of runoff is low. Research shows that when P fertilizer is left on the soil surface, any rainfall-induced runoff within the next several weeks will contain much-elevated levels of soluble P. While such runoff wouldn't carry away more than a small percentage of the P applied, it doesn't take much P loss to start an algal bloom.

Place. The right place to put P is…

1. **…where the soil doesn't have enough.** Soil testing identifies where crops need it most. In the Lake Erie drainage basin, the proportion of cropland on which some level of P application would be recommended has increased from 50% to 60% over the past 5 years.

2. **…in zones of need within fields.** This calls for mapping and managing spatial variability in soil properties and soil test levels.

3. **…close to the roots of the plants that need it.** Phosphorus isn't very mobile in the soil. Many crops, especially corn, have a special need for P early in the growing season. With or near the seed is a good place for P. Applying it in bands below the soil surface reduces the risk of it moving to water by surface runoff.

4. **…in a cropping system geared to higher yields.** Phosphorus enrichment gives a seedling greater potential, which can only be attained when everything else is managed to avoid limitations. High yields remove more P from the soil, and the removal must be replaced to maintain soil fertility.

5. **…into a soil that can take in and hold as much water as possible.** Tillage and crop residue management, over the long term, influence soil structure in a site-specific manner. No single tillage system fits all situations, but the soil conservation strategy needs to aim for high water infiltration, high water storage, and minimal stratification of soil P levels.

There are wrong places to put P, too. To minimize impacts on water quality, growers need to avoid putting soluble forms of P on the surface of runoff-susceptible soils, especially during the critical periods – late fall and early spring in most areas.

What's the right place for P? In the soil—not on the soil. Facilitating the availability of the sources and equipment to get P fertilizer into the right place is an important contribution toward better crops… and better water.

—TWB—

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Abbreviations: P = phosphorus

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Summer 2011, No. 2

VARIABLE RATE FERTILIZING—SOME NEW DEVELOPMENTS

Recent developments in precision agriculture technologies are exciting. As refinements are being developed, more and more practical and beneficial tools are becoming available for on-farm use. One area that greatly affects plant nutrient management is variable rate technology (VRT). The capability to change the rate of fertilizer being applied has been available for a couple of decades, but there are some recent products or techniques that make better use of VRT.

One is the capability to have "sectional control" on an air-drill planter or a fertilizer applicator. For example it divides a formerly 48 ft. wide machine into six sections, each 8 ft. wide, that can be turned on or off to prevent overlap. This technology was initially used in sprayers applying pesticides, but is now available for fertilizer applications. This is beneficial because not all fields are easily accessible and depending on the natural obstructions in a field — for example creeks, sloughs, bush areas, rock piles, or exposed bedrock — it is not possible to drive in straight lines from one end of the field to the other. Field operations usually involve turning around the obstructions. Earlier, this meant either leaving areas untreated or unplanted, or overlapping to ensure no gaps of application. I have seen presentations that show reductions of fertilizer product applied of up to 10% by eliminating the previous overlapping.

Another is improved ways to decide what rate of fertilizer to apply on different parts of a field, called "management zones". When VRT became available, it lacked the ability to assess different areas separately and then decide and justify what different nutrient rates to apply. It is not uncommon for equipment engineering developments to exist before the agronomic justification and decision making capability is refined. Initially, different management zones were delineated based on one or a few sources of information. For example, topographic position (e.g. upper slope, mid-slope, lower slope, and depression), or soil color (e.g. different shades of dark or light as affected by organic matter content of the topsoil), or previous yield maps breaking a field into categories a number (e.g. 5) of low to moderate and to high yielding areas. Each source of information was called a layer of information. Now there are sophisticated systems that combine remotely sensed satellite technology images measuring crop growth over multiple years (e.g. up to 25 years), along with topographic position, soil color, and yield map layers of information, in order to break a field into a series of unique and repeating management units.

Separate soil sampling by management zones is now possible. This is a way to access soil testing result information separately for specific management zones, as described above, to come up with unique and improved recommendations for each zone. This can reduce the number of soil samples gathered, and reduce the time and cost of taking and analyzing samples. Previously, fields were grid-sampled where soil sample locations were set based on an actual physical grid, e.g. one sample in the center of a set area (1 to 5 acres), and maps showing areas of different nutrient availability levels were developed. Instead, now a series of random soil samples, usually 15 to 20, are taken within the same delineated management zone types and bulked together. Then, a sub-sample is analyzed separately for each different management zone.

These are just three examples of recent developments of precision agriculture products that are now available to improve the way VRT is used on farms. The benefits of using VRT continues to improve with time and is being used by an increasing number of farmers.

—TLJ—

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WHERE DOES PHOSPHATE COME FROM?

Maintenance of an adequate phosphate supply in the soil is essential for sustaining global food supplies. Many soils need an additional source of phosphate to supplement the native supply in order to meet this minimum requirement. Crops remove relatively large amounts of phosphate from the soil in the harvested portion. At some point, it is necessary to replenish the supply of this nutrient.

Early sources of P were limited to animal manure, which did not supply any new nutrients, but merely allowed them to be transported from one area to another. The first commercial fertilizer became available when it was discovered that adding acid to animal bones would chemically unlock the phosphate and make it available for plant uptake.

Phosphate rock is the raw material now used in commercial fertilizer production. Phosphate rock is extracted from the earth in many countries. Most of the phosphate rock is used for fertilizer production, with smaller amounts going to various industrial uses. Although phosphate rock is a limited natural resource, at current rates of use the world phosphate rock reserves and resources should be adequate for the foreseeable future.

Phosphate rock is generally extracted with surface mining techniques and then the pit is later filled, revegetated, and reclaimed. The quality of the rock will vary depending in the level of naturally occurring impurities. The rock is screened and crushed to prepare it for processing with a source of acid. After the phosphate rock has reacted with acid, the soluble phosphate is transformed into many common fertilizers and transported across the world. The largest users of phosphate fertilizers are China and India.

Phosphate has many important functions in plants. Perhaps the most noted roles are in photosynthesis, respiration, energy storage and transfer, cell division, and cell enlargement. Adequate phosphate also promotes early root formation and growth.

Plants absorb most of their P as the primary orthophosphate ion ($H_2PO_4^-$). Smaller amounts of secondary orthophosphate ion (HPO_4^{2-}) are taken up. Other forms of P can be utilized, but in much smaller quantities than orthophosphate.

There are many excellent sources of phosphate fertilizer. The selection of a particular product depends on price, physical characteristics, and nutrients accompanying the phosphate. Agronomic studies have shown that there is no significant difference in plant response to common phosphate fertilizers if they are used properly. The most common fertilizers include:

- **Diammonium phosphate (DAP)** – *DAP is the world's most widely used P fertilizer. It is made from two common constituents in the fertilizer industry and it is popular because of its relatively high nutrient content and its excellent physical properties.*
- **Monoammonium phosphate (MAP)** – *A widely used source of P and N, it is made of two constituents common in the fertilizer industry. MAP has the highest P content of any common solid fertilizer.*
- **Ammonium polyphosphate (APP)** – *When phosphoric acid and ammonia are reacted, water is driven off and individual phosphate molecules begin to link together to form a polyphosphate fluid fertilizer.*
- **Triple superphosphate (TSP)** – *TSP was one of the first high analysis P fertilizers that became widely used in the 20th century. It is an excellent P source, but its use has declined as other P fertilizers have become more popular.*

The use of regular soil testing and consultation with a local certified crop adviser will provide guidance on how to best manage the phosphate supply for your crops. The next time you apply phosphate fertilizer, consider the complex journey that it took to get those nutrients to your plants.

A visual tour of the phosphate production process can be seen at this URL: **http://info.ipni.net/phosphatetech**

—RLM—

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Abbreviations: P = phosphorus

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FLOODS AND FUNGI AND PHOSPHORUS—OH MY!

Standing water in fields. It comes from those Wizard-of-Oz-like storms that inundate the soil. The longer the water sits, the more processes get set into motion – all of which can create P deficiencies in crops.

The cause? Soil fungi called mycorrhizae, and no, it's not because these fungi appear after flooding and cause problems. In fact, it's the lack of these fungi that cause the problems.

Most field crops form symbiotic relationships with mycorrhizae. These fungi explore the soil and take up nutrients, similar to plant roots. However, for fungi to grow, they need a host that provides a source of carbon, which they can't get on their own. Enter the crop and its carbon-rich sugars – the perfect sweet treat for the fungi.

Once fungi colonize the roots of the crop, the nutrient trading starts. Fungi get the sweet stuff and the plants get some of the nutrients the fungi took up from the soil. This relationship is so important that plants regularly depend on mycorrhizae for part of their P supply each season – except for the mustard family. They always were a little different.

Mycorrhizal fungi do two things that really help the plant. First, they explore areas of the soil that plant roots don't always reach, especially those "hard to get to" places like small soil pores. Second, they can take up P from compounds in the soil that aren't as easy for plants to tap.

Recommended rates of P depend on crops playing well with these fungi, except of course for that odd mustard family down the block. But when soils remain flooded for days or weeks, the beneficial relationship gets hit hard. It turns out these fungi like oxygen, just like we do, and being under water for a long time really sets them back.

It takes about one cropping season to get things back on track. So if water stands in a part of a field this year and reduces crop growth, P nutrition can be affected next season too.

A couple of options can be tried. A cover crop can be planted in those previously flooded areas before next season's crop, in an attempt to provide a late-season host for the fungi to help them get reestablished. Second, banding P near the seed when planting the next year can provide an additional, well-positioned P supply to help make up, at least partially, for a reduced supply of P from the struggling fungi.

So the next time you see water standing in a field for days to weeks, just remember that your good fungi may not be in Kansas anymore.

—TSM—

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Summer 2011, No. 5

A PETIOLE TESTING PROGRAM FOR SOUTHERN COTTON

The use of petiole testing to determine foliar feeding requirements for southern cotton has declined considerably over the past few years. In 1996, the University of Georgia (UGA) soil testing laboratory sold 800 petiole sampling kits; in 2010, eight kits were sold. Part of the decline in use may be inconsistency in foliar feeding results, the complexity of the program, or the cost (US$50/kit, which will provide one analysis per week for 10 weeks). However, the current high cotton prices may encourage growers to consider revisiting this site-specific nutrient management strategy.

Petiole testing is used to monitor plant nutrient status during the growing season. Most petiole testing programs are composed of weekly monitoring throughout the bloom period. The UGA program begins at first bloom and continues for 10 weeks. The sampling strategy involves collecting 30 petioles (the small stem connecting the leaf blade to the main branch) from random locations throughout the field. The petioles are placed in a provided envelope and submitted to the lab along with a card containing information such as sampling date, plant size, and fruiting positions. Accuracy of the results depends on a good quality sample being collected, so be sure to contact a local extension agent or crop consultant with questions.

Upon receiving the sample, the UGA lab will analyze the nutrient content in the petioles and return a chart indicating whether the levels of nitrogen and potassium are adequate. Since samples are being collected weekly, growers can track the nutrient status of the plant throughout the critical bloom period and identify deficiencies before they appear as symptoms on the leaf. When problems are detected, recommendations are made for foliar nutrient applications.

Foliar application of plant nutrients in cotton is often a controversial subject. Part of the controversy is likely due to inconsistent results. There are several solution, plant, and environmental factors that can affect the efficacy of a foliar nutrient application. One of the keys to a successful foliar application is the spray volume. Typically, only 10 to 15 gal/A of a low-concentration nutrient solution is applied. Dr. Glen Harris, an Extension Soil Fertility Specialist at UGA, indicates that many growers choose to use pivots or planes to make recommended foliar applications. They have little to no success due to spray volumes being too high and most of the nutrients running off to the ground or being too low (in the case of an aerial application) to achieve good coverage without burning the leaves. Recommendations through the UGA program are made for N and K. However, several micronutrients such as Mn, B, and Zn can be applied effectively through foliar feeding.

Petiole testing can be especially useful when enhanced efficiency fertilizers have been soil-applied. The growing use of urease and nitrification inhibitors along with controlled-release N sources in cotton production increase the value of petiole N monitoring. Petiole testing is also an effective tool when using organic nutrient sources like poultry litter. The mineralization of plant available N from organic sources can be tracked and supplemented through foliar feeding if necessary.

Foliar feeding is best used as a supplement to a good soil test-based fertility program. Following a sound soil testing program remains the first choice for establishing and maintaining optimum soil fertility. In-season monitoring of plant nutrient status using petiole testing is a great way to enhance and fine-tune a nutrient management program. Several universities, fertilizer dealers, and consulting services offer petiole testing programs. With cotton prices higher than they have been in decades, growers can't afford to risk losing yield due to inadequate plant nutrition.

–SBP–

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Abbreviations: N = nitrogen; K = potassium; Mn = manganese; B = boron; Zn = zinc

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Summer 2011, No. 6

NUMERIC NUTRIENT CRITERIA IN YOUR WATERSHED – HOW WILL YOU COPE?

The U.S. Environmental Protection Agency (EPA), which is responsible for protecting the designated uses of water resources and enforcing the Clean Water Act in the U.S., has stated that N and P pollution is a "widespread, significant, and growing problem". The U.S. EPA expected states and tribes to adopt or revise ecoregional nutrient criteria for lakes and reservoirs, rivers and streams, and wetlands – that were published in 2000 and 2001 – into water quality standards by 2004. As of December 2008 (the latest public EPA posting: **http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/status.cfm**), half of the 50 states had not adopted numeric nutrient criteria into standards. In August 2009, a call to action was issued to EPA Administrator Lisa Jackson by the State-EPA Nutrient Innovations Task Group, stating the urgent need for a "common framework of responsibility and accountability for all point and nonpoint sources." This urgent call added to the burdens of the states because they are ultimately responsible for completing and implementing N and P loss reduction plans to protect water resources. Some states have made good headway in defining and implementing nutrient criteria for their own water resource priorities and needs. However, in Florida, which was considered to be among one of the most proactive states in developing nutrient criteria, a consent decree to settle a 2008 lawsuit forced the U.S. EPA to step in and federally establish water quality standards for lakes and flowing waters, using causal (total N and total P) or response variables (chlorophyll *a* and clarity).

On top of federal and state budget deficit challenges, financial and professional resources are being strained as public servants and private contractors strive to scientifically develop numeric nutrient criteria and standards. Financial and professional resources are expected to be stressed even more as standards are enforced; especially for nonpoint source or diffuse nutrient pollution, which includes agriculture. The total annual regulatory compliance costs of such numeric nutrient criteria and standards regulation have been estimated to range from hundreds of millions of dollars to multi-billions per state, based on the current case in Florida. Unsurprisingly, some state and local water quality authorities and many agricultural stakeholders question the practicality and economic feasibility of trying to regulate nonpoint source (diffuse) N and P pollution. It has been commonly argued that it would be virtually impossible to monitor individual farm and field nutrient management and application activities, while others contend that random audits could be effective enforcement "sticks".

Most experienced agronomists, conservationists, ecologists, and land managers recognize that it takes time to accomplish significant cropping system management and conservation changes in the landscape or watershed … and it may take even longer for those changes to impact the quality of adjacent and downstream water resources. Because the large majority … if not all … of us in agriculture want to protect and preserve the integrity of our water resources, there have been increased discussions and proposals for the adoption of practice-based standards, as opposed to strict water quality or *performance standards*. These discussions are raising thoughtful questions, such as:

- Could increased agricultural stakeholder involvement in open discussions with state water quality authorities, and other interested parties, foster opportunities to address state-level policies that would intensify nutrient management and water quality education?
- Could state-level strategies and public policies endorse and expand implementation of science-based nutrient best management practices (BMPs), which adhere to the principles and objectives of **4R Nutrient Stewardship**? (Visit **http://www.ipni.net/4r** and **www.nutrientstewardship.com**)
- Could pilot efforts be undertaken in selected watersheds, to evaluate the impacts of intensified '4R' BMP implementation, using rigorous water quality monitoring, to evaluate achievement of scientifically-defensible, realistically-attainable, designated use goals?

If (or when) strict water quality numeric nutrient criteria and standards are required within your state, or within your watershed, how would you cope? Could you continue to farm and economically prosper with potentially mandated reductions in nutrient use? Is it time to get more involved in supporting and implementing **4R Nutrient Stewardship**?

–CSS–

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Abbreviations: N = nitrogen; P = phosphorus

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Summer 2011, No. 7

QUALITY ALFALFA REQUIRES GOOD FERTILITY

Alfalfa is an important component of agricultural production in many areas of North America. It can be harvested as hay or silage, and in some cases may be used for pasture and grazing. It is often preferred over other forage legumes due to its high yield potential, protein content, and palatability. Good quality hay has excellent nutritive value and may be in high demand, especially for horses and dairy cattle.

There are many factors involved in producing a high quality alfalfa crop. Some of these factors, like rainfall and temperature, are uncontrollable; however, many other critical factors are controllable and can be carefully managed. Alfalfa is relatively sensitive to soil acidity, and does best in soil pH range of 6.5 to 7.5. The bacteria that fix atmospheric N for alfalfa also do best in this soil pH range. Thus, soil acidity issues and liming needs should be addressed before planting.

Among the other controllable factors important in the production of quality alfalfa is an adequate supply of nutrients. A few of the general benefits of a complete and balanced fertility program include:

- Increased yield
- Improved quality
- Higher profit potential
- Greater water use efficiency
- More resistance to pests
- Improved winterhardiness
- Enhanced drought tolerance
- Improved nodulation and N fixation

In most areas, alfalfa begins growth in the early spring and continues into the late fall, therefore there is a continuous demand on the soil nutrient supply for several months. Alfalfa hay removes about 56 lb N, 15 lb phosphate (P_2O_5), 60 lb potash (K_2O), and 5 lb each of S and Mg per ton of production. Rhizobium bacteria on well nodulated alfalfa can fix enough N to meet crop needs, although a newly planted crop may require some N fertilizer (15 to 20 lb N/A) until nodulation occurs. On the other hand, P, K, and other nutrients can be rapidly depleted from alfalfa fields if not replaced by fertilization.

Phosphorus performs several vital functions in alfalfa plants. It is involved in energy storage and transfer, is a structural component of biochemicals, and is involved in maintenance and transfer of genetic code, root growth, crop establishment, hastening maturity, and accelerated recovery. Adequate P in the soil also helps 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.

Alfalfa takes up and removes large amounts of K, in fact more K is removed than any other soil nutrient (50 to 60 lb K_2O per ton). Alfalfa forage may contain 2 to 3% K. Potassium has many critical roles in plant growth and development. It has long been recognized as a factor affecting disease incidence. It is also important in stomatal regulation, photosynthate transport, and has an important role in enhancing N_2 fixation in alfalfa. Adequate K also helps to reduce grass and weed invasion and improves stand persistence and winter survival.

Alfalfa provides excellent forage. Stands can remain productive for years with proper care and nutrition. Remember that not all yield robbing deficiencies are visible to the naked eye. So, to determine best rates of fertilization of alfalfa in a specific area use tools such as soil testing, plant analyses, local information, and nutrient input and removal history.

—WMS—

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