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

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CROP NUTRIENT BALANCE SHIFT IN THE LAKE ERIE WATERSHED

The economics of farming are changing dramatically. The balance between the nutrients applied to and removed by crops in the region surrounding Lake Erie is shifting.

Nutrient balance is an important indicator of sustainability. It gauges whether nutrients are accumulating in the soil, or being depleted. Coupled with indicators of soil fertility status, it can show whether a production system is being managed in a way to sustain profitable crops and fertile soils while minimizing losses of nutrients that might contaminate water and air.

Several trends are changing the balance. The past 3 years have seen big swings in prices for crop commodities and fertilizers, reducing the rates of fertilizer applied, particularly for P and K. In response to competitive end-uses for feedgrains, the livestock industry has shrunk. For the livestock that remain, new livestock feeding practices and technologies are reducing the amount of N and P in manure. Thus, both the amount of manure for land application and its nutrient content have declined considerably. In the meantime, crops have continued their upward trend in yields, removing more nutrients with harvest.

The combination of all these trends has moved the nutrient balance from surplus to deficit. Over the past 10 years, the P balance in the agricultural areas of Ontario, Michigan, and Ohio shifted from a surplus of 4% over crop removal to a deficit of 12% below the amount removed by crops.

Is this cause for alarm? We need to consider a few other facts. First, the history of the agricultural nutrient balance. If we go back a few decades, prior to 1990, we find P was being applied in surplus. Where there was surplus nutrient application, soil P levels were building up. In soils that were deficient, it was a good thing. Increasing the fertility of nutrient-poor soils is a fundamental first step for increasing their productivity and supporting high crop yields. But other soils were built up to levels beyond the needs of the crops. On those soils, the transition to a deficit balance may not be a problem for a number of years. The large shift in the regional nutrient balance, however, underscores how important it is that producers pay attention to the nutrient balances and soil fertility status at the level of their individual fields and farms.

A declining surplus doesn't mean all the environmental problems have disappeared. Water quality issues arising from P losses remain. Reducing nutrient losses from crop production requires attention to more than just the amounts applied. The P applied in the past remains in the soil, a benefit to the nutrition of crops, but a risk factor for areas from which water runs off or leaches. Managing the risk of water contamination involves careful attention to site-specific nutrient balances, placement and timing of nutrient applications, and appropriate management of crop residues and buffer areas next to watercourses.

A commitment to 4R Nutrient Stewardship brings people together for sustainable solutions. At a Great Lakes Phosphorus Forum held recently in Windsor, Ontario, people involved in various sectors of agri-business and environmental protection visited farms and fertilizer dealers—discovering the site-specific reasons for their choices of sources, rates, timing and placement practices—while discussing trends in P loading into Lake Erie and its water quality. Collaborative efforts that build mutual understanding are essential for progress toward more sustainable production.

—TWB—

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium.

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COOLER THAN NORMAL SPRING SOIL TEMPERATURES ALONG WITH DRY SOILS MAY RESULT IN SHORT-TERM NUTRIENT DEFICIENCIES

Weather conditions, especially temperature and moisture, greatly affect nutrient availability and movement in a soil. This is especially true for nutrients such as P and K that move relatively slowly in the soil by chemical diffusion. Plant available P exists in soils primarily as low solubility compounds, such as calcium phosphate under neutral to alkaline pH conditions and iron and aluminum phosphates under acidic pH conditions. Only a small amount of dissolved P is ever present in a soil as the $H_2PO_4^-$ (acidic soil pH) and HPO_4^{-2} (neutral to alkaline soil pH) ions. Plant-available K is present in soils primarily as the K^+ ion that is strongly attracted to the negatively-charged clay particles in the soil. Thus, for both P and K, the soil solution concentrations are low and as plant roots take up these plant nutrients, there is slow dissolution or dissolving of the low solubility P-compounds, or slow movement of the K^+ ions off clay particles into soil solution.

Soils that have normally adequate P and K availability may show P and K deficiencies in a cooler and drier than normal spring. This was common in much of the area of the Northern Great Plains region early in the growing season of 2009. Below normal temperatures and low soil moisture combined to have numerous reports of slowly emerging and stunted crops. If it was P deficiency, the plants were usually just stunted and slow growing with some purpling of older leaves for small grain cereal crops, while with K deficiency there may have been a yellow discoloration along the edges and tips of lower leaves.

If a grower notices slower than normal growth and stunting early in the growing season, they can become quite alarmed. It is common for a retail agronomist, or crop consultant to be called out to look at affected fields displaying P or K deficiencies. This can happen on both fields that have been managed quite well for P and K nutrition, as well as fields that have not received much attention to P or K availability.

The important question is whether the crop will come out of the deficiency, or should some remedial nutrient applications be tried to prevent a potential crop failure. The challenge is that P and K deficiencies are not easily corrected in-season like N or S deficiencies. Deficiencies of N or S can be corrected through top-dressed N or S fertilizers early in the growing season. For example, before stem elongation in cereal crops or before bolting in an oilseed crop like canola. For P and K, there is not much that can be done after planting and it is usually most effective to put plans in place to correct deficiencies for subsequent crops. Some of the most effective ways to apply P and K fertilizers for field crops are to place the P and K fertilizers in seed-row blends, or precision placed bands near the seed-row, or broadcast and incorporate P or K fertilizers if inversion tillage is used.

Fortunately, on most fields where P and K have been managed well, these cool-dry spring P and K deficiencies are short-term. As the later spring temperatures increase and moisture is received, the crops will usually improve in appearance and growth. It is a test in patience for a grower-customer to be content that there is no real problem and that their crop will be fine. This is a situation where the best way to proceed is to do nothing and rely on the normally adequate P and K availability to improve.

The most effective way to determine whether or not a true P or K deficiency exists is to take soil samples and have the soils analyzed for P and K availability. If soil-test levels are lower than optimum, P and K fertilizer applications can be beneficial for subsequent crops. Growers should contact their local crop adviser or agronomist to review the P and K soil test levels on recent soil samples (e.g. sampling done within the last couple of years). Arrange for soil samples to be taken and analyzed if no samples have been previously done, or it is newly acquired or rented land where the history of soil-test results are not known.

—TLJ—

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium.

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THE ROOTS OF NUTRIENT UPTAKE

We clearly see that plant growth suffers when there are low concentrations of nutrients in the soil, when the nutrients are not sufficiently soluble, or if nutrients do not move to the roots. But in our quest to grow abundant and healthy crops, it is easy to overlook all of the complex chemical and biological activity occurring around the plant roots that make nutrients available for uptake.

The availability of plant nutrients for roots is controlled by factors such as soil properties, root characteristics, and interactions with surrounding microorganisms. Traditional soil testing techniques measure the availability of nutrients in the general soil, but this may differ from the nutrient concentration in the immediate vicinity of the root (the rhizosphere). Nutrients with restricted mobility in the soil (such as P, K, zinc, iron, manganese, and copper), may be in adequate supply in the bulk soil, but their concentration may be low near the root if the movement in the soil is too slow to replenish the nutrients entering the root.

Focusing on P as an example, supplying this nutrient to the root includes several complicated mechanisms. This involves excretion of organic acids, increased root hair formation, and enzyme release.

- <u>Release of Organic Acids:</u> When soil P supplies are low, many plants excrete a wide range of organic compounds to increase the availability of relatively insoluble compounds, such as some calcium phosphate minerals. The organic acids have a role in dissolving nutrients (due to pH), complexing soil cations, and providing an excellent growth substrate for soil microorganisms. Common organic exudates include substances such as malate, citrate, acetate, and oxalate which can lead to root-zone modification.

  Most soils have populations of microorganisms that are capable of dissolving P-containing minerals, so addition of an organic substrate may encourage their growth in low-P conditions. Mycorrhizal fungi also form complex relationships with most plant species, where the fungi provide various benefits for the plant, including improved nutrition, in exchange for carbohydrate for fungal maintenance and growth.

- <u>Changes in Root Structure:</u> Plants growing in a low-P soil tend to direct more of their photosynthate energy to root development and often have more fine roots with a small diameter, resulting in a larger surface area. A large root surface area allows plants to access more of the soil and scavenge any soluble phosphate that may be present.

- <u>Enzyme Release:</u> In low-P conditions, plants generally increase the production of enzymes that enhance the rate of P release from soil organic matter. The phosphatase enzymes are not effective in mineralizing phytate, the dominant form of organic P in many soils. Phytase, the enzyme responsible for phytate hydrolysis, is primarily released by microorganisms, which indirectly improves the P availability for nearby roots.

These root modifications occur as a result of low soil P availability, requiring plants to devote additional energy to the roots and away from above-ground growth. The excretion of organic compounds from roots can consume as much as half of all the carbon allocated to the root system, although this number is highly variable. The energy costs of mycorrhizal associations with various plant species ranges from 4 to 20% of the daily net photosynthesis. Plant geneticists are looking for ways to make plant roots more efficient at recovering nutrients from the soil. While we wait for improved plant genetics, there are many practical things that can be done to get the maximum benefit from added nutrients. Begin by placing nutrients in the soil in the proper form and in the correct place so plant roots can support abundant yields of high-quality products.

—RLM—

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Abbreviations: P = phosphorus; K = potassium.

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A DISTANT EARLY WARNING LINE FOR POTASSIUM

Those familiar with history may remember the importance of the Distant Early Warning (DEW) Line. This line is an array of radar stations that detect incoming enemy aircraft before they reach the mainland. The purpose of this system is to provide advanced warning, creating a window of opportunity to plan an appropriate response before things get out of hand. It is a concept that applies to more than a nation's defense system. It applies to K management too. How, you may ask? Read on.

Potassium soil tests have a nagging propensity to be variable. Unlike P and pH, K soil tests are highly influenced by moisture conditions during sampling in the field as well as sample preparation in the lab. There are many known causes for this variability, such as soil mineralogy, wetting and drying cycles, and timing of K release from crop residues. The upshot of this variability is that changes in K fertility over time can be hard to discern from the background noise of the test itself. Potassium soil tests are still a good diagnostic tool, but they often require some additional information to be interpreted properly.

So what can be done to augment soil tests? The answer: applying a field-length strip, or "line" of K at a rate that is adequate for crop growth. Not sure what this rate should be? If you don't have a soil test to guide your application rate, consider applying at least 50 to 75 lb K_2O/A, depending on local experience. Make this application before each crop and apply K in the same strip each time. This will create a reference area where K fertility is likely adequate. If you do have a soil test from the strip, follow the recommended guidelines for application rates based on that test. The objective is to create a strip where you are fairly confident that the soil supply of K is adequate for crop growth and development. If you can't put your fingers on K crop removal rates, visit >**http://nanc.ipni.net/articles/NANC0005-EN**<.

You now have a DEW Line for K. Comparing crop growth and development in this strip to adjacent areas of the field will give you early indications of K malnutrition. If you notice that the crop in the DEW Line develops more rapidly, matures earlier, or has lower disease pressure or just looks healthier, consider such observations to be early warning signals on the radar and begin strategizing. Soil tests, tissue tests, and yields in the strip compared to those outside the strip will help assess the situation. University Extension recommendations provide scientifically founded approaches for rectifying K nutritional problems and getting crop production and health back on track. Use them as initial guidance, making any needed changes with knowledge of local conditions.

The K soil test isn't perfect, but it's still a good diagnostic tool. Adding a DEW Line for K will provide additional information that will help interpret soil test information. It serves as an early warning of K malnutrition, allowing you to plan a solid fertilization strategy before things get out of hand.

—TSM—

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Abbreviations: K = potassium.

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IMPROVING PRODUCTIVITY AND PROFITABILITY OF SOUTHERN COTTON

The recent Beltwide Cotton Conference was host to several presentations from the Southeast and South Central Great Plains regions. A variety of topics were covered, but the underlying theme was that cotton remains a viable crop in the South and with good management can be profitable for growers. The opening presentation in the soil management and plant nutrition technical conference focused on fertilizer BMPs and how growers can apply 4R nutrient stewardship (applying the “right” fertilizer source at the “right rate”, “right time”, and “right place”) to cotton production for more efficient and effective fertilizer use. The presentation and an accompanying publication titled *Apply the Four Rights for Cotton Production in the Midsouth and Southeast* are available at **>www.ipni.net<**.

Several presentations discussed the potential for using optical sensors to improve N management in cotton. Researchers from Louisiana, Mississippi, Missouri, Oklahoma, Tennessee, and Texas reported on useful relationships among sensor measurements, leaf N content, crop yield potential, and plant height that could be used to more accurately identify optimum N rates. The studies from Missouri and Texas, in particular, showed significant increases in profitability using sensor-based N fertilization strategies compared with standard practices.

Researchers at Texas A&M took a unique look at site-specific nutrient management (SSNM) in terms of energy returns. Using cottonseed feed value as the output in a center pivot irrigation system, SSNM and blanket N fertilization resulted in negative energy returns to N fertilizer application. However, in a second case study, a subsurface drip irrigation system was tested and positive energy returns to N fertilizer were observed, with optical sensor-based SSNM yielding more energy than soil test-based N management.

Potassium fertilization of cotton has received much attention at the conference through the years and continued to be a topic of interest in 2010. Research conducted at Mississippi State University (MSU) showed that soil K depletion directly influenced yield, regardless of cultivar maturity. Thus, producers who choose to mine K run the risk of a dramatic decline in yield. The results from MSU also suggested that K uptake dynamics may differ for late maturing varieties versus early maturing varieties. However, more research is needed regarding variety cotton response to soil test K levels throughout the growing season.

The 2010 Beltwide Cotton Conference also included the inaugural graduate student poster contest for soil management and plant nutrition. The first, second, and third place winners were: Tyson Raper, Mississippi State University; Josh Lofton, Louisiana State University; and Andrea Jones, University of Missouri, respectively.

–SBP–

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COULD INADEQUATE P AND K CAUSE POOR CROP N USE?

Economic pressures and elevated input costs the last 2 years have resulted in some reductions in fertilizer applications in many parts of the country. While many of the reduced fertilizer input decisions have been viewed as temporarily necessary, to stay within operating budgets and borrowed capital limits, it would be wise for farmers and their crop advisers to consider the impacts of such reduced fertilizer inputs for the 2010 crop year.

Wise use of fertilizers in prior years (i.e. before 2008-2009) may have allowed some farmers to "coast" a year or so and rely on built-up soil P and K fertility. Developing and maintaining high soil test P and K levels enabled some farmers with greater flexibility in nutrient management during tough economic times. How have fertilizer use reduction decisions affected soil fertility levels? Many folks do not understand that even yearly soil sampling and testing…because of the wide annual and seasonal variations in moisture and temperature… may fail to detect significant changes in soil P and K levels from year to year.

Last year proved to be a very wet one for much of the U.S., especially in the Corn Belt where weather conditions were favorable for good yields and resulted in higher crop harvest nutrient removal than in previous years. To assess crop nutrition needs for 2010, farmers should consider their individual fields, long-term soil test P and K fertility trends, current soil sample results, and the budget estimation of P and K inputs vs. crop harvest removal. The International Plant Nutrition Institute (IPNI) has posted crop harvest nutrient removal values on-line at: **>www.ipni.net/nutrientremoval<**. These values can be used to help inform nutrient budget estimations, in the absence of on-farm, specific crop nutrient removal values based on grain and harvested crop nutrient analyses.

Inadequate or below-recommended applications of P and K can lower yield potential and impair the efficiency of use of all crop inputs—including N. For example, long-term corn nutrition research by agronomic scientists at Kansas State University showed that neglect of adequate P nutrition can lower yields more than 30%, and result in a 66% build-up in soil profile nitrate-N. Such soil nitrate-N residual may pose serious threats to groundwater and to surface water resources through drainage interception by tile lines or via lateral flow to streams and rivers. The inefficient crop use of N, induced by inadequate P nutrition, also represents significant lost revenue.

Research with corn by Ohio State University agronomists several years ago showed that inadequate or below-recommended K nutrition can also impair crop N use and lead to less crop N uptake and recovery in plants and the soil. In the Ohio research, adequate soil K nutrition (soil test K above 135 ppm or above about 270 lb/A) resulted in an optimum corn yield of more than 208 bu/A with roughly 190 lb of N/A. At low soil test K levels (below 100 ppm), about 275 lb N/A were required to achieve peak corn yields of about 167 bu/A, which was about a 20% reduction in yield. The better soil K nutrition approach resulted in more than a doubling of N recovery in the plant biomass, which translates to potentially less residual nitrate-N left in the soil and a lowered risk for loss to the environment.

As plans are made for 2010, ensure that crop yield potential is not limited by the continued mining of soil P and K fertility. Collect and analyze representative soil samples, evaluate nutrient input and crop harvest removal budgets, and consult your crop adviser, fertilizer dealer, or Extension agent. Develop a strategy for strong crop performance, improved nutrient use efficiency and effectiveness, and better profits in 2010. Don't let P and K neglect damage the results you should be getting from your fertilizer N applications.

—CSS—

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REVISITING CONSIDERATIONS FOR CRP BREAKOUT

The Conservation Reserve Program (CRP) was initiated in 1985, and from then to 1993 over 36 million acres of U.S. cropland, mostly in the Great Plains, were removed from production under the program. The initial objectives of the CRP were to reduce soil erosion on highly erodible land, protect the capability of long-term food and fiber production, reduce production of surplus commodities, provide income support for producers, provide wildlife habitat, and improve environmental quality. Many original contracts began to expire in the mid- to late 1990s, when land was either returned to grain production, kept in forage production, or re-enrolled in CRP. Thus, considerations for returning CRP land to production was an important topic of that time. It is time to revisit this topic as many acres of land in CRP in the Great Plains are again expiring and set to expire over the next few years.

Soil moisture is likely to be low upon CRP breakout due to depletion by deep-rooted grasses. A fallow period for accumulation of soil moisture after destruction of CRP grasses and prior to planting of the first crop may be helpful in replenishing soil water. Destruction of CRP grasses is another major consideration. Crop establishment and growth is difficult without good grass control. Grasses may be difficult to control with herbicides alone, although it is possible and may take several applications. Another possibility is spraying the grasses, then planting a glyphosate-ready summer crop (soybean or corn) so additional control can be applied in-season. Tillage, or a combination of herbicides and tillage, is another option for control and destruction of CRP grasses, and is sometimes necessary due to excessive surface roughness caused by burrowing animals.

One of the benefits of long-term grass production is the effect on soil physical properties. Improvements in soil aggregation and permeability are common with time in soils under sod. These improvements can enhance water infiltration, internal drainage, aeration, and moisture holding capacity. The maintenance of these improvements after return of CRP land to production is partially dependent on tillage. One of the first changes that occur with tillage is a breaking of pore continuity that was developed under sod. No-till management can help preserve the beneficial soil characteristics developed under a sod culture.

Nutrient management is an important concern in the return of CRP land to production. Soil nutrient levels, especially N, will likely be low upon breakout. An Oklahoma study (Stiegler et al., 1996) noted that N and P fertilizer were critical for producing acceptable wheat yields in nutrient depleted CRP fields, regardless of tillage method. A Kansas study (Schlegel and Thompson, 1997) reported soil nitrate levels of 2 ppm in the surface foot following destruction of CRP grasses. Nitrogen management for the crop the first year out depends upon factors such as residue management, tillage practices, soil moisture, length of fallow, and yield goal.

Another concern for CRP land returned to production is the effect of plant residue on N management. Depending on management practices (e.g., mowing, burning, tillage), significant amounts of above-ground plant residue may be returned to the soil upon breakout. For example, an estimate for above-ground bromegrass residue in Nebraska was 4 to 5 tons/A (Shapiro et al., 1996). Additionally, grass roots represent as much as 40% of the plant biomass. The residue decomposition process will initially likely immobilize N from soil solution. This immobilization of N is temporary, and the duration of the depression in plant available N levels is variable, depending on the residue quantity, C to N (C:N) ratio, degree of incorporation, and other factors. Knifing or banding of fertilizer N can help minimize immobilization. Nitrogen immobilization and low soil nitrate levels are factors that need to be considered when planning fertilization.

Application of P, K, and the secondary and micronutrients are also important and should be based on soil tests. Banded applications of starter fertilizer containing N, P, and K will generally provide a strong early response, especially under conditions where soil levels of these nutrients are low. If tillage is planned for the first year, a large application of P and K prior to tillage may be desirable to optimize soil test levels.

—WMS—

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Abbreviations: C = carbon; N = nitrogen; P = phosphorus; K = potassium; ppm = parts per million.