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

From Scientific Staff of the
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NOTICE OF CHANGE TO ALL PRINT SUBSCRIBERS OF PLANT NUTRITION TODAY

The International Plant Nutrition Institute (IPNI) is discontinuing its distribution of the printed version of the *Plant Nutrition Today* quarterly series and will be relying solely on our electronic (pdf) version moving forward.

New and archived issues of *Plant Nutrition Today* are available for download from our website at http://www.ipni.net/pnt.

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On behalf of IPNI's North American Directors, I thank you for your continued interest in *Plant Nutrition Today.*

Sincerely,

Gavin Sulewski

Gavin Sulewski, IPNI Editor

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Summer 2016, No. 1

PHOSPHORUS LEGACY AND 4R NUTRIENT STEWARDSHIP

Phosphorus feeds the world. Take away the nutrient phosphorus from agricultural crop production, and how much of world food production would be lost? The answer depends on the length of time considered, and we have data from only a few long-term research trials. A 40-year study in Kansas found that without phosphorus inputs, yields were lower by 27% for corn and by 10% for grain sorghum. At Rothamsted in England, wheat without phosphorus for 25 years yielded 44% less. In many tropical soils, crop yields are even more strongly dependent on it. Phosphorus contributes a lot to global food security. 4R Nutrient Stewardship manages its legacy to reduce harm from the little that's lost.

Definitions of phosphorus legacy vary. But they usually include any human influence on phosphorus stored or its pathways of transfer. The practice of agriculture typically builds up a store of phosphorus in soil through application of fertilizers and manures. But it can also deplete those stores when crop removal is not replenished. Legacy can include accumulations in stream banks and sediments, built up from human-induced soil erosion. Some authors include the modification of stream flows and installation of tile drains that expedite the transfer of phosphorus from field to stream.

Phosphorus legacy in cropland is reflected in the soil test. Soil test summaries have been conducted over time by the International Plant Nutrition Institute and its predecessors. They reveal that across North America, the fraction of soils testing below critical for phosphorus decreased from about 60% in the 1960s to a low of 40% in 2005, but has increased to 44% over the past ten years. In key states of the Corn Belt, the depletion trend continues from the mid-1980s.

The 56% of soils currently above critical represent two levels of legacy. Many of these soils are at optimum levels, levels at which losses to the environment do not much exceed those coming from lower P soils. But a considerable proportion is also built up well beyond the range of crop need. The legacy in the latter is a chronic risk to water quality, and sustainable nutrient stewardship calls for drawing it down. While it is difficult to define the precise soil test level that separates “too much” from “optimum” legacy, the tools of precision agriculture should equip growers to maintain soil test levels just a little above critical. Variable rate technology—applying the “right rate” of phosphorus in the “right place” to match soil and crop need—enables the management of legacy to desirable levels.

Most soils retain most of any phosphorus applied. The little that leaks, however, can harm the environment. Acute risks of losses accompanying application of fertilizers or manures can be controlled through “right time” and “right place.” Timing applications to avoid periods when risks of runoff are high, and placing them into instead of on top of the soil can make large differences on the amount of phosphorus delivered to the edge of the field. Conservation practices that control soil erosion are also important in controlling losses of particulate forms of the legacy.

Phosphorus use efficiency is important, but requires careful interpretation. Many organizations promoting conservation and ecological integrity focus on efficiency, for good reasons. Excess nutrients harm the environment and waste resources, so efficient use is desirable. But it’s important to focus on the right kind of efficiency. At optimum soil test levels, short term recovery of phosphorus is low, but its ratio of output to input can often be close to 1, with replenishment equaling removal. At lower soil test levels, optimum yields depend on adding more than crops remove. And at higher soil test levels, the output-input ratio can and should be greater than 1. The interpretation of use efficiency of phosphorus, therefore, depends on its soil test.

The phosphorus legacy reflected in an optimum soil test is beneficial. A soil test in the optimum range indicates ability to deliver an optimum concentration of soluble phosphorus to crop roots. Managing phosphorus using 4R Nutrient Stewardship conserves resources, limits losses, and optimizes crop yields.

– TWB –

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HOW MOBILE ARE PLANT NUTRIENTS?

Application of supplemental plant nutrients is a common practice in most agricultural fields around the world. Most often this is done by using fertilizers or animal manures, or some combination of both. The aim is to apply nutrients using the principles of **4R Nutrient Stewardship**. That is, applying the **Right Source** of nutrient at the **Right Rate**, **Time**, and **Place** so that adequate nutrients are available to the crop to maximize crop yields and net returns for the farm, but minimize any unwanted nutrient movement away from the field in surface run-off, leaching into groundwater, or gaseous emissions to the air [e.g., nitrogen lost as di-nitrogen (N_2) or nitrous oxide (N_2O)]. Depending on the nutrient, its application can be done pre-planting, at planting, or as a top-dressing during the growing season.

It is important to know the mobility of the nutrients in the soil to decide how best to apply them. Often slowly soil-mobile macronutrients such as phosphorus and potassium, and most micronutrients are applied and incorporated before planting using pre-plant tillage operations, placed in the seed furrow with the seed, or precision side-banded close to the seed furrow as part of the planting operation. This allows the crop roots good access to the low mobility nutrients early enough during the life cycle of the crop to gain the benefits of increased yields and often improve crop quality. The two soil-mobile macronutrients, nitrogen and sulfur, can be successfully top-dressed within a month after planting, but in low to moderate rainfall regions they can be applied as pre-plant or at planting operations, and even sometimes in the fall preceding spring planting.

The effect of the applied rate of nutrient needs to be considered. Too high a rate of any fertilizer in the seed furrow, or very close to the seed furrow, can result in an adverse osmotic salt effect that can reduce or stop seed germination and emergence. Many nutrients can be seed furrow applied at a low rate to enhance early crop uptake and overall crop yields, especially if the nutrient is slowly mobile in the soil, but the rate applied is critical. For example, copper (Cu) is a nutrient that is slowly mobile in soil and a low rate (1 lb Cu/A) applied in the seed furrow of a small grain cereal grown on a Cu-deficient soil can be beneficial, but a high rate (10 lb Cu/A) can be toxic to seedlings.

You need to know both the rate of nutrient needed and the nutrient soil mobility, in order to consider how best to apply a nutrient. Consider the very mobile nutrient nitrogen. Concern over seed safety usually prevents the full nitrogen need of the crop to be placed in the seed furrow. However, applying a low rate (5 to 10 lb N/A) in the seed furrow can be beneficial for early seedling establishment and growth, while the remainder is placed away from the seed furrow to avoid adverse effects. A compound fertilizer that is a homogenous combination of other non-mobile soil nutrients such as P, S and zinc (Zn) is commonly an effective source.

Seek the advice of an experienced consulting agronomist, or crop adviser in your local area to design an effective nutrient program for each of the crops you grow.

– TLJ –

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A CHECK-UP USING NUTRIENT DEFICIENCY SYMPTOMS

When the uptake of any of the essential nutrients is inadequate, the plant metabolism becomes disrupted and distinctive symptoms often begin to appear. Since nutrients are involved in specific growth processes, deficiency symptoms provide clues to what nutrient might be lacking. However, most nutrient deficiencies begin to interfere with plant productivity long before the symptoms become visible.

Plant tissue testing is needed to verify that a visual symptom is caused by a specific nutrient deficiency. This differs from soil analysis, which verifies a sufficient reserve of nutrients in the soil, but does not account for conditions that may be interfering with nutrient uptake by roots (such as cold, dry, or compacted soils).

When the cause of deficiency symptoms is known, it still must be determined if a prompt nutrient application will correct the problem. There may be economic constraints or difficulties getting equipment into the field to alleviate the deficiency. Foliar sprays of soluble nutrients are often useful to treat deficiencies as they appear during the growing season. Some nutrients may be added to irrigation water and applied via fertigation to correct plant shortages. However, nutrient deficiencies result in permanent loss of growth and plants may fail to recover from severe deficiencies even after corrective measures.

In general, leaf nutrient deficiency symptoms fall into general categories:

- Chlorosis (yellowing) may appear between the leaf veins or impact the entire leaf
- Necrosis (leaf death) usually begins at the leaf tip or edges, or appears between the leaf veins
- Lack of new plant growth as a result of the growing points dying and failure of new leaves to develop
- Accumulation of plant pigments (especially purple-colored anthocyanin)
- Overall plant stunting with normal or abnormal coloring

A shortage of a nutrient does not immediately result in visible deficiency symptoms. Overall plant growth and metabolism is usually hindered for some time before visual symptoms are present. This so-called "hidden hunger" occurs with low levels of chronic nutrient deficiency, and is far more common than visible deficiency symptoms. By the time obvious visual symptoms first appear, the plant can no longer function properly.

Nutrient deficiency symptoms are most useful for diagnostic purposes (and correction) when they are identified as early as possible. Even when supplemental nutrients are applied to correct deficiencies, irreversible damage to yield or crop quality has likely already occurred.

Environmental stresses also cause abnormal symptoms to appear on plant leaves that may not be directly related to nutrient deficiency. Additionally plant disease, insect damage, herbicide impacts, or excessive salinity are examples of non-nutrient factors that cause leaf disorders and stunting.

Nutrient deficiency can cause secondary plant damage that is not readily visible. For example, potassium shortages have been shown to reduce plant resistance to various diseases and insects. Many turfgrass diseases are more common under nitrogen-deficient conditions. Maintaining an adequate supply of phosphorus reduces the severity of diseases such as root rot in wheat and barley, and minimizes various infections of corn and soybean.

IPNI is developing guides to help growers identify nutrient deficiencies symptoms of important horticultural and agronomic crops. The first e-book was written by Drs. Pitchay and Mikkelsen (on broccoli) and is available for free for download from iTunes® or for small fee from Amazon®. A collection of outstanding images of deficiency symptoms of important world crops is available for purchase at the IPNI store.

– RLM –

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IPNI RELEASES NEW SUMMARY OF SOIL TEST LEVELS IN NORTH AMERICA

The International Plant Nutrition Institute (IPNI) recently released its fourth in a series of summaries dating back to 2001. This 2015 summary has captured information on 7.5 million soil samples. The summary is made possible through the generous, voluntary participation of 61 private and public soil testing laboratories. For a complete list of participating labs, see soiltest.ipni.net/about/Labs.

The recently released bulletin, available at http://ipni.info/NAP-3018, provides summary information at the North American scale for phosphorus (P), potassium (K), soil acidity (pH), magnesium (Mg), sulfur (S), zinc (Zn), and chloride (Cl^-). For the first time, IPNI has now statistically analyzed trends for 2001 to 2015.

Over the period 2001 to 2015, fewer samples now test higher in P and K and more samples test lower. Many states in the eastern Corn Belt showed increased needs for P. Increasing needs for both P and K were demonstrated for the Cotton Belt in 2015. Across the 15-year period, more samples across North America now test in the range of soil acidity where crop growth and nutrient availability are greatest: pH 6.1 to 7.5.

Fewer years of data are available for the other nutrients. Data from 2005 to 2015 indicate an increase in soil test Mg levels for North America. During the same period, the percent of samples testing low in S has been growing—a trend consistent with lower S deposition from the atmosphere during the same time period. Data from only 2010 and 2015 are available for Zn and Cl^-. No trends can yet be determined for those nutrients.

A free, interactive website (soiltest.ipni.net) has been developed to access data on any combination of states and provinces. Data are available from 2001 to 2015 and include percentages of samples in various soil test categories and changes in those percentages over time. Data from state to state and province to province are often quite variable.

North American agriculture relies heavily on soil testing to assess soil fertility and guide future nutrient management decisions. This summary demonstrates that soil tests do indeed change over time in response to management. Producers who have soils that have not been sampled recently have much to gain by getting into the regular practice of soil sampling.

–TSM –

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WHAT CAN VARIABLE RATE PHOSPHORUS APPLICATIONS DO FOR YOU?

Many agricultural fields possess a high degree of spatial variability in soil test phosphorus (STP) that can affect crop yield. Spatial variability of nutrients in the field results from changes in soil type, topography, previous cropping history, and many other factors. Common practices like composite soil sampling and uniform fertilizer application rates ignore spatial variability and can result in inefficient fertilizer use by under- and over-applying nutrients in some areas of the field. Variable rate (VR) P fertilizer applications can provide several benefits compared with uniform applications.

Variable rate P can increase crop yield in areas of the field that are low in STP. Yield maps combined with fertilizer application maps can show where efficiency gains may have occurred, but yield benefits following VR applications are often difficult to observe in practice because rate comparisons are not included in the field. Test strips in the field also won't always show the benefits of VR if they transect different zones across the field. A study conducted in Iowa reported that although yields from transects across areas of a field receiving uniform or VR P applications were not different, yield comparisons within soil test classification zones showed that VR increased yield over the uniform rate when soil test levels were very low. Some service providers are beginning to include high and low fertilizer rate check plots within management zones to allow growers to more easily evaluate yield response to VR applications.

Variable rate P can reduce the total P applied to the field—but not always. The average amount of P applied using VR methods depends on the scale of variability and distribution of STP values. In the six fields included in the Iowa study, four received lower average P rates using VR compared with a uniform rate; one received the same rate; and one received more fertilizer using VR. Averaged across the six fields, VR methods resulted in 12% less P being applied compared with the uniform rate method. Factors that can affect the average P rate applied using VR methods include: 1) adequacy of assessing STP variability (grid size selection); 2) whether P is applied for one or multiple crops; and 3) whether P rates beyond crop requirement are recommended to build up STP in soils testing below optimum.

Variable rate P can reduce spatial variability in crop yield. Less yield variability usually occurs in fertilized areas compared with unfertilized areas and in the Iowa study, 33% of the sites showed further reduction in corn yield variability following VR P applications compared with the uniform rate. Half of the study sites showed no difference, while 16% had increased variability in yield using VR. What is interesting about these results is that the reduction in variability often occurred in fields where no difference in grain yield between methods was observed. This reduction was considered to be due to increased P rates resulting in nominal (statistically non-significant) yield increases in areas of the field that test low or very low in STP and no P being applied to high-testing areas.

Variable rate P has the potential to reduce P loss from fields. Following three years of P applications, the Iowa study showed smaller increases in STP using VR in five of the six fields used in the study and no difference in the sixth compared with the uniform P rate. The VR applications also reduced within-field STP by eliminating P applications to high testing areas. The potential for VR P applications to increase yield in low STP areas, eliminate unneeded P applications in high STP areas, and reduce spatial variability in yield and STP make it a valuable management choice for reducing P loss from fields to water resources.

– SBP –

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SILAGE PRODUCTION AND FERTILIZATION

Silage can be defined as any plant material that has undergone fermentation or "pickling" in a silo. A silo is a storage structure (bunker, trench, bag, etc.) in which green, moist forage is preserved. The purpose of ensilage is to preserve forage for later use as animal feed. Silage production is important in parts of the Great Plains, especially where there are significant numbers of animals in feeding operations such as dairies and feedlots.

There are several advantages of silage compared to hay and other forage conservation systems. These advantages include less field and harvest losses, many crop options, mechanization of harvesting, storage and feeding, less likelihood of weather damage during harvesting, relatively low loss of nutrients with proper ensilage, and silage can be used in many livestock feeding programs. The disadvantages of silage include its bulkiness in handling and storage, it requires additional equipment and structures for harvesting, storing, and feeding, high potential for loss if not stored properly, not readily marketable off-farm, and silage must be fed soon after removal from the silo to minimize spoilage.

The major factors affecting silage quality are the type of crop, stage of maturity, moisture content, and length of chop. Within forage species the stage of maturity has the greatest effect on quality. The optimal moisture content depends on the crop and type of silo used, but is generally around 65 to 70%. Material ensiled below 50% moisture is usually called haylage. Length of chop is factor since it affects air exclusion in the silo, where fine chopping and packing help ensure proper fermentation.

Many crops, including grasses and legumes, can be preserved through ensilage. The most common and perhaps the best adapted is corn. It is a high energy crop that results in good animal performance. Sorghum (grain and forage) is a popular silage crop in some areas. Alfalfa is also used for silage, but the process of ensilage is somewhat more difficult than with other common crops.

As in hay production, the harvest of a silage crop results in the export of large quantities of nutrients from a field. For example, a 30-ton harvest of corn silage will remove about 250 lb N, 110 lb P_2O_5, and 250 lb K_2O. This is one of the most important points to keep in mind when designing fertility programs for silage crops.

Nitrogen fertilization can affect fermentation of some crops by decreasing the concentration of soluble carbohydrates required to make high quality silage. This is particularly true with cool season grasses since they tend be relatively low in available carbohydrates to begin with. On the other hand, corn is relatively high in soluble carbohydrates, so nitrogen fertilization is not a concern from this standpoint.

Phosphorus and potassium fertilization of silage crops should be based on soil test information and experience. Nutrient removal data should also be considered. Phosphorus and potassium can be rapidly mined and depleted from soils under silage production if adequate amounts of these nutrients are not applied.

There are many excellent sources of information on the topic of fertilization and ensiling of forages. Among them is a practical handbook entitled Southern Forages (available through the International Plant Nutrition Institute, https://store.ipni.net). Other good sources are available through land grant universities and local county extension offices.

– WMS –

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RAISE NITROGEN USE EFFICIENCY: REMEMBER THE BASICS

Every farmer wants to optimize crop recovery of their applied fertilizer nitrogen. The common goals are to maximize profits, while also sustaining soil organic matter and minimizing losses of nitrogen to the environment. Some relatively small nitrogen loss back to the environment is natural and not unexpected. For example, when soils become wet and stay waterlogged for days, nitrate-N (NO_3^-) is converted by soil microorganisms to di-nitrogen gas (N_2) through the denitrification process, especially under warm conditions. This soil microorganism-mediated process is part of the natural nitrogen cycle, which helps explain why our atmosphere is 78% N_2. Because it is not possible to completely control the complex microbial processes and related nitrogen losses in healthy, biologically active soils, it may always be necessary to provide just slightly more nitrogen than may be taken up and removed by the targeted crop to help sustain soil organic matter and soil organic nitrogen levels. Lesser amounts of nitrogen can lead to nutrient "mining", which jeopardizes sustainability.

The sustainability objective is NOT to "maximize" nitrogen use efficiency, since the highest recovery percentage of applied nitrogen usually occurs with the first increment, or lowest rate, of nitrogen addition.

Instead, the sustainability goal should be to "optimize" crop yields and crop nitrogen recovery, while minimizing its loss to the environment. More and more farmers are working with their crop advisers and agricultural retailers to develop and implement a robust 4R nitrogen management system to achieve such optimization.

Here are some suggested basics to improve cropping system nitrogen recovery and profitability in your fields:

- **Know** and understand the soils in each field and their physical and biological characteristics that impact crop rooting, water availability, and movement.
- **Identify** the dominant nitrogen loss pathways (i.e., leaching, runoff, volatilization, denitrification) in each field or dominant portions of each field.
- **Provide** other essential nutrients in balance with nitrogen needs; don't let other nutrient shortages limit your "bang for the buck" with each unit of nitrogen applied.
- **Work with** a knowledgeable crop adviser to develop a good 4R nitrogen management plan.
    - Implement the plan with conviction and commitment to include appropriate soil and water conservation practices (*conservation tillage, cover crops, controlled subsurface drainage, improved irrigation management, etc.*)
    - Evaluate the success of your plan by monitoring the crop's nitrogen status (*in-season plant tissue samples, chlorophyll or greenness-sensors, end-of-season corn stalk nitrate, and appropriately calibrated soil nitrogen and nitrate tests.*)
- **Track** your crop yield per unit of nitrogen applied, over a period of years (at least three) and see if the trend is up, down, or flat.
- **Estimate** the crop nitrogen harvest removal-to-use ratio, and evaluate it over time (*IPNI offers an i-OS and web-based app for estimating crop harvest nitrogen removal at* http://ipni.info/nutrientremoval).
- **Investigate** your cropping system response to nitrogen management changes (source, rate, timing, or placement) using replicated strip trials.
- **Become** part of on-farm networks in your area, and learn from other successful farmers.

Think about these nitrogen management basics to get more of your applied nitrogen in the crop.

– CSS –

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