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

From Scientific Staff of the
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EFFICIENCY AS A METRIC OF SUSTAINABLE CROP NUTRITION

Nutrient use efficiency attracts increasing attention in today's sustainability dialogue. Serving as one of the key metrics of crop nutrition, it reflects responsible management and relates to risks of nutrient loss. However, it hardly connects to the productivity of cropping systems or the fertility of soils, nor does it tell us where the losses are going. It is as complex as the cropping systems to which it applies, and yet it reflects only partially the outcomes we expect from applying nutrients.

It would seem to be so simple. An efficiency in most uses is the ratio of output to input. Divide nutrients out by nutrients in, and you have your answer. But, there are three complications.

First, approaches differ in defining the system out of which and into which the nutrients are flowing. Is it a field, a farm, a country, or the world? Soil surface, or farm gate? A single cropping season, a whole year, or a whole crop rotation?

Second, which of the following do you consider as outputs: the harvested crop, the whole crop, the nutrients in either, the nutrients over and above the uptake that would have occurred without the input in question, the nutrients retained in the soil, those returned to the air, and those leaving the field with the drainage water?

Third, which of the following inputs do you include or ignore: fertilizer, manure, deposition from the air, biological nitrogen fixation, and mineralization from the soil? Putting all these options together, hundreds of possible combinations could provide a ratio of outputs to inputs. Not only that, many of the outputs and inputs aren't measured and reported and can only be estimated.

So let's look at some of the simplest estimates of nutrient use efficiency. Partial nutrient balance is defined as the nutrient in the harvested crop divided by the nutrient in the fertilizer applied. For nitrogen in cereal crops in Canada, the United States, and the world, we've estimated it at 71, 74 and 67 percent, respectively, for the years 2006 to 2010. Extended to a wider range of crops, including fruits, vegetables, pulses and oilseeds, but not forages, the estimate for the world declines to just over 50 percent.

What happens to the rest of the nutrient applied, if less is harvested than applied? "Lost to the environment" is one answer commonly given. But, it doesn't tell you where in the environment. Some nutrient fates can cause harm: nitrate loss to groundwater, nitrous oxide and ammonia loss to the air, and nitrogen and phosphorus in drainage water. Some are benign, such as dinitrogen going back to the air. Some can even be beneficial. Surplus nitrogen, when combined with high inputs of crop residues, can help increase soil organic matter. Surplus phosphorus can move soil test levels from low to optimum.

And what if more is harvested than applied? In most cases, mining from soil reserves is indicated, meaning depletion of soil fertility. What this means is that nutrient use efficiency doesn't always need to increase. It has an optimum level, and that level depends on the current level of the soil's fertility.

Does higher nutrient use efficiency mean higher yield? Not always. Recent yield increases have raised nutrient use efficiencies. A singular focus on nutrient use efficiency, however, can lead to yield-reducing rate reductions. That's why the right source, rate, time and place of nutrient application optimizes nutrient use efficiency, yield, and soil fertility. Sound nutrient stewardship tracks all three.

– TWB –

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COMPARING FOLIAR AND IN-SOIL METHODS OF APPLYING PLANT NUTRIENTS

Field crops normally absorb the majority of nutrients from the soil through root absorption, but above ground plant structures, especially leaves, are capable of absorbing limited amounts of some nutrients. Because of this, most supplemental nutrients supplied to crops as fertilizer are applied to the soil, and soluble nutrients in the soil contact root hair surfaces, where they are absorbed into the roots and transferred to other parts of the growing plant for metabolic use. However as noted, leaves and also to a lesser degree stems, and flowering plant tissues, can absorb limited amounts of nutrients. It is important to understand which nutrients can practically be supplied by foliar applications, if the soil supply is inadequate for optimum crop growth.

There are a couple of situations where nutrient supplementation using a foliar application may be considered more effective than an in-crop topdressing application:

Situation one. Only a small amount of a specific nutrient is required, and due to low soil mobility of the nutrient it is actually more efficient to supply the small amount of needed nutrient as a foliar application. This can be the case for both macronutrients and micronutrients. There can also be soil conditions that cause a nutrient to be less available to crop roots. One example is cool excessively wet conditions on an alkaline soil (e.g., pH >8.0) where iron is less available to certain crops (e.g., iron chlorosis of soybean), even if supplemental iron fertilizer has been applied to the soil before or at planting.

Situation two. The crop is late in its life cycle and there may not be sufficient time or rainfall to move a soil mobile nutrient into the soil to be absorbed by the roots, and transferred from the roots to the growing points where it is needed. Again, this can be the case for both macronutrients and micronutrients. An example of this can be foliar nitrogen (N) applied as a liquid urea solution to high protein bread wheat in the early heading growth stage. The added N as urea solution at a lower rate, e.g., 10 lb N/A, is sufficient to moderately increase grain protein, e.g. up to 1 percent. A broadcast granular urea application even at three times the rate (i.e., 30 lb N/A) may not be available to the crop in time to have the desired grain protein enhancement, especially if little or no rainfall is received after broadcasting the urea as a late in-crop application.

There are other situations where foliar applications are less efficient or not practical logistically or economically compared to a pre-plant, or in-crop side-dressing, or broadcast application to the soil for root uptake.

One situation is when large amounts of a nutrient are needed and the amount that can be effectively applied and utilized by the crop as a foliar application is inadequate. An example of this is side-dressing of half the N requirement for a corn crop as the in-crop split application that was preceded by half of required N applied as a pre-plant application.

Another situation is when a foliar application is relatively effective, but not enough of the needed nutrient can be supplied in one application, so multiple applications would be needed, spaced out sufficiently in time (e.g., once a week). Multiple applications in field crops can be expensive due to fuel, equipment, and labor costs, and there may not be sufficient time to apply sufficient amount of the needed nutrient. An example of this could be a severe phosphorus (P) deficiency where there is not time to apply sufficient applications of low rates of foliar P and the application costs to do this are excessive. In this situation it may be better to realize there is not much that can be done for this seasons P deficient crop. The preferred course of action is to apply sufficient P fertilizer to the soil prior to the planting of subsequent crops to correct the P deficiency.

Foliar applications of nutrients can be effective, but there are many factors to consider before making a decision including both mobility of the nutrient in the crop foliage and mobility in the soil, the amount of required nutrient to improve crop growth, and the economic cost of both the form of fertilizer and its application.

– TLJ –

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INTERNATIONAL YEAR OF SOILS: NUTRIENTS AND SOIL BIOLOGY

It is a tendency of some people to only think of plant nutrition in terms of how much fertilizer to add. This simplification may be understandable since a healthy crop reveals only the above ground plant; the roots that support the visible plant are seldom seen without further exploration.

Plant roots grow in an incredibly complex soil environment, teeming with billions of organisms, particularly bacteria and fungi, which play a crucial role maintaining an adequate supply of plant nutrients for crop growth.

There is still much to learn about the complex interaction between microorganisms and plant nutrition, but the importance of these relationships is clearly recognized. Living organisms have a crucial role in controlling the transformations of plant nutrients. In most soils, nitrogen (N), phosphorus (P) and sulfur (S) are mainly present in various organic compounds that are unavailable for plant uptake. Understanding the role of microorganisms in regulating the conversion of these organic pools into plant-available forms has received considerable attention from soil scientists and agronomists.

The microbial conversions of nutrients into soluble forms take place through numerous mechanisms. Extracellular enzymes and organic compounds are excreted to solubilize nutrients from soil organic matter, crop residues, or manures. Organic acids released by microbes can dissolve precipitated nutrients on soil minerals and speed mineral weathering. Some nutrients become more soluble as microbes derive energy from oxidation and reduction reactions.

Mycorrhizal fungi are found in symbiotic association with the roots of most plants. These soil fungi can increase the supply of various nutrients to plants in exchange for plant carbon. The boost in P uptake provided by mycorrhizal fungi is especially important for crops with high P requirements or growing in soil with low concentrations of soluble P. Mycorrhizal fungi release various enzymes to solubilize organic P and they can extract soluble P from the soil at lower concentrations than plant roots are able to do alone.

Biological N fixation is another essential contribution of microbes to plant nutrition. Specialized symbiotic bacteria living in root nodules can fix atmospheric N into ammonium-based compounds for plant nutrition. The most important of these organisms for agricultural plants are from the species Rhizobium and Bradyrhizobium. There are symbiotic N_2-fixing bacteria that infect woody shrubs, and asymbiotic bacteria, such as Azospirillum, that provide N to the roots of grasses such as sugarcane.

An often-overlooked contribution of soil microorganisms to plant nutrition is their benefit to improving soil physical properties. Good soil structure enhances plant root growth, resulting in greater water and nutrient extraction. Individual soil particles are bound into aggregates by various organic compounds such as polysaccharides and glomalin. The small hyphal strands of mycorrhizal fungi also contribute to improved soil aggregation by binding small particles together.

A better understanding of the essential link between soil microbes and plant nutrition allows more informed management decisions to be made for proper stewardship of soil resources and for sustaining crop productivity

– RLM –

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SCIENTISTS MEET TO CHART FUTURE COURSE FOR IMPROVING POTASSIUM NUTRITION OF CROPS

A small group of internationally recognized scientists met recently in Kona Beach, Hawaii to brainstorm the future of potassium (K) nutrition of crops. The Frontiers in Potassium Science Workshop focused on creating a list of strategies for explaining and managing significant spatial and temporal variability in the contributions of fertilizer K and soil K to plant nutrition. The group was asked to identify critical concepts that were missing or were inadequately characterized in existing soil K assessments or K recommendations.

"One of the key findings of the group was the need to focus on research and education that deals with how quickly the soil can supply potassium to the growing plant," says Dr. Scott Murrell, a Director in the North American Program of the International Plant Nutrition Institute (IPNI) who led the organizing committee for the workshop. "Improving potassium management ultimately relies on improving our understanding of how to manage the myriad of factors that affect a soil's ability to supply adequate amounts of K in a timely manner. This group is proposing that certain scientific measurements and concepts become a priority in our research and education efforts. That kind of focus is a first in this area and is critical to working collaboratively to make advancements as quickly and efficiently as possible."

"Potassium management is growing in importance in cropping systems around the world as genetic yield potential climbs, new regions of K deficiency appear, and the need for more efficient use of all system inputs increases," comments Dr. Paul Fixen, Director of Research for IPNI. "This group clearly demonstrated that science has more to offer the world of K management and that there are highly knowledgeable and passionate scientists that can contribute to that effort."

The workshop was held in conjunction with the International Symposium for Soil and Plant Analysis. Many of the attendees represented commercial and private soil testing and plant analysis laboratories or scientific disciplines impacting soil testing and plant analysis methodology.

Before the workshop, symposium attendees were given the opportunity to discuss ideas with the invited scientists. After the workshop, recommended priorities were presented to symposium attendees. "The attendees were impressed with how much this small group of scientists had accomplished in the short time they met," says Murrell, "and they provided very valuable feedback that will be used as we move this effort forward."

Twelve scientists from ten different institutions participated in the workshop and represented plant and soil science programs in Australia, Brazil, China, France, the United Kingdom, and the United States. A report of the workshop, complete with a list of attendees, objectives, outcomes, and short background papers and abstracts can be downloaded at http://www.ipni.net/article/IPNI-3396.

–TSM –

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UNMANNED AERIAL SYSTEMS FOR AGRICULTURE

Interest and excitement continues to grow around the potential uses for unmanned aerial systems (UAS) in agriculture. This interest is reflected in the increasing number of UAS-related exhibitors, sponsors, and speakers at the annual InfoAg Conference. The 2015 conference will be held in St. Louis, MO, July 28-30 (www.infoag.org) and will feature several companies, flight demonstrations during the pre-conference tour, and speaker sessions on equipment, data management, and regulations.

Not only will UAS's offer growers an opportunity to rapidly collect large amounts of data, but the potential economic impact of the technology is also noteworthy. In her 2014 presentation at InfoAg, Gretchen West, VP of Business Development and Regulatory Affairs for DroneDeploy, reported that the global UAS market was $11.3B and was expected to grow to $140B over the next 10 years. She also noted that the economic impact of US airspace integration had the potential to grow to more than $82B between 2015 and 2025, with precision agriculture uses expected to total approximately 80% of the commercial market.

While FAA regulations have slowed the development of a commercial UAS industry in the USA, there has been some recent progress. Earlier this year, the FAA released a Notice of Proposed Rulemaking (NPRM) detailing what commercial UAS regulations might look like for agriculture. While the NPRM is a step in a positive direction, several elements including line of sight restrictions, allowable flight times, restrictions on number of people in the flight area, and the limit of one drone per operator will continue to hinder growth of the US commercial market.

Less-stringent airspace regulations in other countries have allowed more rapid commercialization of UAS's and precision ag service providers are reporting favorable results with UAS agricultural applications. At InfoAg 2014, Dale Cowan, Senior Agronomist at AGRIS Cooperative, provided a comprehensive overview of his UAS learning curve and experiences in Chatham, Ontario, Canada. For his purposes, Dale chose a senseFly fixed-wing swinglet CAM, a ready-to-deploy mini UAS. He mentioned several factors that need to go into the decision to buy a UAS such as local support (training and technical support), fixed wing vs rotary, coverage needs, and durability. Durability and easily replaceable parts are not to be overlooked. According to Dale, "It's not how many times you fly, it's how many times you land" that determines the life of a UAS. In his recent ASA webinar on UAS's, Dr. Brian Arnall, precision ag specialist at Oklahoma State University, echoed this sentiment stating "They will crash. Period."

Despite the inevitable rough landings, "flying was the easy part," according to Cowan. The real challenge of a UAS, as for any other remote sensing approach, is in using the data to make a decision that leads to better crop management. The first step in utilizing a UAS is image collection and processing. The swinglet CAM can cover a 130-acre field in 19 minutes and takes a series of large (>350 MB) overlapping images that need to be mosaicked or stitched together. Most UAS's come with image processing software, but based on his commercial experience, Dale suggested a higher-end software package for final analyses. Dale and his group are using a UAS to assess winterkill in wheat, evaluate cover crop establishment, collect NDVI measurements for N management in corn, and to establish management zones to guide soil testing, fertilizer management, seeding, scouting, and yield evaluations.

The UAS is just another tool in the precision ag toolbox. It is a remote sensing platform that helps us identify and define the need for spatial management of agronomic variability. There is no doubt that the potential benefit of UAS's is huge. The opportunities for farmers to collect their own data, on-demand, have never been greater. But, just as we've seen over the years with yield maps, aerial or satellite images, or crop sensors, remotely-sensed data – in and of themselves – are useless until they are transformed into knowledge. As exciting as UAS's are, we cannot get caught up in the hoopla and forget that a successful precision agriculture program must be built on the foundation of strong, science-based agronomy.

– SBP –

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PLANT NUTRIENT ANALYSES IDENTIFIES YIELD-ROBBING SHORTAGES

In the under-developed and developing countries, we might not be too surprised to frequently observe nutrient deficiency symptoms in major field crops. In North America, there is a perception among many urban dwellers, and even many in agricultural communities, that observance of nutrient deficiencies in leading field crops like corn, sorghum, soybean, wheat, cotton, and rice is relatively rare. Yet it is important to recognize, by the time plant nutrient deficiency symptoms are visually observed, significant crop yield has been lost and soil productivity has been compromised.

Summaries of more than 2.7 million soil samples in North America by the International Plant Nutrition Institute (IPNI) showed that soil test phosphorus (P) levels had declined an average of 6 parts per million (ppm) from 2005 to 2010; mainly in the Corn Belt and the Central Great Plains. Those declines in soil test P could largely be explained by the cumulative crop harvest P removal exceeding P inputs. Similarly, median soil test potassium (K) levels declined an average of 4 ppm between 2005 and 2010; indicating 50% or more of the sampled areas likely needed K application to avoid crop yield losses, especially east of the Mississippi River and in the provinces of eastern Canada. When P and K are below agronomic optimum levels, poor crop growth and inefficient nitrogen (N) use can result. Inadequate secondary and micronutrient nutrition can also limit crop performance and N use efficiency.

Other factors like soil compaction, inadequate or excessive soil moisture, root injury by insects and pathogens and foliar diseases can also affect crop nutrition, and sometimes lead to inaccurate visual diagnoses. More farmers are using on-the-go crop greenness sensors or other aerial imagery - primarily in corn and wheat systems - to identify crop greenness as an indicator of the N nutrition status. Those greenness-sensing technologies work best when all other nutrients are at or above agronomic optimum levels. To be sure that crops have adequate nutrition in-season, and to avoid potential visual misdiagnoses, more growers and crop advisers should consider collecting representative plant tissue samples and performing plant tissue nutrient analyses. Plant tissue analysis can be used to accurately identify shortages and imbalances that short-change crop yield and quality, and which may leave plants more susceptible to attack by insects and diseases.

Make sure that crops in your fields are not experiencing "hidden hunger." Collect representative plant tissue samples, and submit them to a reliable laboratory for nutrient analyses. Be sure to sample the right plant parts; and if you are uncertain which parts to sample, consult your laboratory, crop adviser, extension agent, or a reputable plant nutrition website for guidance.

Soil testing and plant analyses are like tandem axles under vehicles and trailers. You may be able to manage getting by with one for a short time, but to avoid the risk of damage and lost performance, it is best to rely on both. Consider plant tissue sampling "healthier" versus "unhealthy," or better-performing" versus "under-performing" areas in your fields to learn if differences may be caused by inadequate plant nutrition. Don't let "hidden hunger" act like a cancer, eating away your crop productivity and economic viability until it is too late. Use both soil testing and plant tissue analyses to evaluate and fine-tune your crop nutrition management.

– CSS –

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PHOSPHORUS FERTILIZER SOURCES

Questions are sometimes asked about the effectiveness, composition, and plant availability of various phosphorus (P) fertilizer sources. Questions such as, "Is liquid more available to the crop than dry P fertilizer? Is one source better than another in alkaline soils? Can the optimum P rate be reduced with certain sources?" are not uncommon. A simple review of the fundamentals of P fertilizer sources can help address such questions.

Practically all inorganic P fertilizers come from phosphate rock (PR) which is a naturally occurring sedimentary rock composed largely of calcium phosphate minerals called apatite. Most conventional commercial P fertilizers are made by reacting PR with sulfuric acid to produce phosphoric acid (green or wet process acid). The phosphoric acid is further reacted with ammonia (ammoniation) to produce ammonium phosphate fertilizers such as diammonium and monoammonium phosphate (DAP and MAP). Production of ammonium polyphosphate fertilizer (APP) requires dehydration and polymerization of phosphoric acid prior to ammoniation.

The most common commercially available inorganic P fertilizers are DAP, MAP, and APP. These sources have the advantage of high water solubility (≥90%) and high plant food content. DAP and MAP are both ammonium orthophosphates. Orthophosphate is the form of P that is absorbed by plant roots, so after these granular materials have dissolved, their P is available for crop uptake. Although both of these sources perform similarly on a "per unit P" basis, there are differences worth noting. An important difference is in the potential for ammonia production when placing P in the seed furrow. In-furrow DAP has somewhat greater potential for seedling ammonia damage than does MAP, especially in alkaline and/or calcareous soils. Therefore, in-furrow recommendations for MAP are generally more lenient than for DAP. Another difference between the two sources is the pH of the initial soil reaction-- with DAP it is about 8.5, whereas with MAP it is 3.5. There have been some reports of improved crop response with MAP compared to DAP on calcareous and high pH soils, but most agronomists agree that there is generally little practical difference in the performance of these two sources.

The term polyphosphate refers to two or more orthophosphate ions combined together. This polymerization is accomplished by the dehydration of phosphoric acid. Liquid APP fertilizers are produced by ammoniation of polyphosphates. Before plants can utilize polyphosphate it must be converted to orthophosphate via a hydrolysis reaction. This conversion occurs rapidly enough in soils that it does not affect the value of APP as a P source. One unique and advantageous characteristic of APP is its chelating or sequestering ability. Relatively high concentrations of micronutrients can be maintained in APP solution through sequestration.

When selecting a P fertilizer source keep in mind that i) it is generally accepted that 80% water solubility is sufficient for most crops; ii) common P fertilizer sources perform similarly when equal rates are applied and method of application is comparable; iii) except where P fertilizer is to be placed with seed, the source that is the best will usually be determined by factors such as product availability, preference, dealer service, and price.

– WMS –

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