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

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PLANT NUTRITION, FOOD QUALITY, AND HUMAN HEALTH

Management of plant nutrition can influence the quality of foods in many ways that affect human health. There are numerous aspects of quality that could be considered, but let's look at the major categories of proteins, minerals and vitamins.

Since N is a major part of protein, applying N to cereals adds to the protein they produce. In corn and wheat, rates of N for optimum protein levels are higher than those for optimum yield, but the nutritional value of such protein increases is limited owing to lower concentrations of lysine, an essential and often limiting amino acid. An exception is the Quality Protein Maize developed by plant breeding: its lysine concentration remains high, so when more N is applied, the protein has high quality. On the other hand, genetic improvements to N use efficiency in cereals may require careful attention to the impact on protein quantity and quality.

Fertilizing rice with N boosts both yield and quality of protein. While the yield effect is bigger, a small increase in protein quality arises, since the glutelin it promotes has higher concentrations of lysine. In potatoes, N increases starch and protein concentration while P, K, and S enhance protein biological value. Management tools that more precisely identify optimum source, rate, timing, and placement of N fertilizer can help attain these quality increases without undue impact on the environment. These tools may include controlled-release technologies or late foliar applications to boost N availability for protein production while keeping losses of surplus N to a minimum.

Many of the mineral nutrients used in plant nutrition are also important minerals in the human diet. The levels of Ca, Mg, K, Zn, and other minerals in foods are influenced by application of these nutrients to crops. In countries like Bangladesh and Nigeria, inadequate dietary intake of Ca is common. Around the world, 1.5 billion people suffer from inadequate intake of the micronutrient Zn. Supplementing crops with these nutrients can improve human health by boosting levels in crop products, and thereby dietary intake.

Fruits and vegetables are important components of a healthy diet. Scientific evidence from numerous sources has demonstrated that judicious fertilizer management can increase productivity and market value as well as the health-promoting properties of fruits and vegetables. Concentrations of carotenoids (Vitamin A precursors) tend to increase with N fertilization, whereas the concentration of vitamin C decreases. Foliar K with S can enhance sweetness, texture, color, vitamin C, beta-carotene, and folic acid contents of muskmelons. In pink grapefruit, supplemental foliar K can boost beta-carotene and vitamin C concentrations. Several studies on bananas have reported positive correlations between K nutrition and fruit quality parameters such as sugars and ascorbic acid, and negative correlations with fruit acidity.

Fertilizers can also influence levels of health-promoting nutraceutical compounds in crops. Soybeans growing on K-deficient soils in Ontario, Canada had isoflavone concentrations about 13% higher when fertilized with K. Potassium has also been reported to promote concentrations of lycopene in grapefruit and in tomatoes. The potent antioxidant pigments lutein and beta-carotene generally increase in concentration in response to N fertilization. Together with vitamins A, C, and E, they can help lower the risk of developing age-related macular degeneration, which is one of the leading causes of blindness.

The mission of agriculture is to sustain human health. There are many components of the world's agricultural systems that could change to accomplish this mission more effectively. Plant nutrition is one of them. Paying more attention to the impacts of plant nutrition on the quality of food is an area of great opportunity for improving the health of the human family.

—TWB—

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Abbreviations: N = nitrogen, P = phosphorus, K = potassium, S = sulfur, Ca = calcium, Mg = magnesium, Zn = zinc.

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HOW DO LOWER-RATE LIQUID STARTER FERTILIZERS COMPARE TO TRADITIONAL SEED-ROW FERTILIZER BLENDS IN THE NORTHERN GREAT PLAINS?

Starter Fertilizer is usually applied close to the seed, so that after germination and during early growth the seedling will have access to a source of fertilizer nutrient that will encourage improved growth. Starter fertilizers are usually composed of a low rate of N and a moderate rate of P. They may be formulated to include K, S, and some micronutrients depending on soil supply and crop need. Phosphorus is the main component of starter fertilizers because it is important to root development, and improved root growth helps the crop get off to a good start.

Specialized formulations of liquid starter fertilizer became popular in corn production because, under high yield corn production, the higher relative per acre rates of fertilizer (e.g. 200 lb N; 100 lb P_2O_5; 70 lb K_2O; and possibly 40 lb S) have traditionally been broadcast and incorporated prior to planting. Placement of all the pre-plant fertilizer close to the corn seed-row adversely affected germination, due to ammonia toxicity or fertilizer salt damage. However, placing a liquid starter fertilizer (e.g. a 6-22-4 N-P_2O_5-K_2O formulation) applied at 3 US gal/A, using a retrofit liquid fertilizer kit on existing corn planters, supplied lower rates (i.e. 2 lb N, 7.3 lb P_2O_5, and 1.3 lb K_2O/A) and was found to be beneficial to early seedling growth.

Because of the success of liquid starter fertilizers in corn production it is often thought that they will be of benefit in small grain cereals and broadleaf crops planted in narrower rows. It has been suggested that use of a liquid starter fertilizer could replace traditional applications of seed-row applied granular fertilizer or liquid fertilizer blends. In much of the Northern Great Plains of North America the majority of P fertilizer has already, for decades, been applied as a seed-row application primarily in the form of mono-ammonium phosphate (11-52-0) but liquid ammonium poly-phosphate (10-34-0) is also used in some areas. This application method functions both as a starter and season-long P source. For example, for a target yield of 40 bu/A of spring wheat, traditionally a 65 lb/A blend of 11-52-0 (50 lb product) and potash (0-0-60 at 15 lb product) has been used. This practice supplies rates of N, P, and K that are safe to germinating seeds. Additional N fertilizer is usually applied as a pre-plant band, or a side-band at planting, using urea (46-0-0) or anhydrous ammonia (82-0-0), at a rate of about 70 lb N/A.

The question is whether or not a liquid starter formulation such as 6-22-4, applied in the seed-row at a rate of 3 US gal/A, is as effective as the traditional seed-row blend described above. It is important to compare the rates of N, P, and K applied relative to the harvested grain nutrient removal. The Table below compares nutrient removal in a 40 bu/A wheat crop, as well as the nutrient additions for the dry granular blend and starter liquid fertilizer described above.

Nutrient removal or addition	N	P_2O_5	K_2O
	lb/A		
Removal in harvested grain	60	24	16
Addition in 3 US gal, Liquid 6-22-4 Starter	2 *	7.3	1.3
Addition in Dry Granular Seed-Row Blend of 50 lb 11-52-0 and 15 lb of 0-0-60	5.5 *	26	9

*70 lb N/A is supplied as pre-plant band using urea or anhydrous ammonia

The nutrients supplied in the traditional dry granular blend plus the separately banded N are similar to the wheat crop nutrient removals, except for the K, but much of the dominate loam to clay-loam soils of the Northern Great Plains tend to be high in plant available K. The liquid starter practice along with the separately banded N only supplies roughly one-third as much P. This practice is probably adequate for early seedling needs. However, in order to better match crop P removals for the whole season, either the liquid starter fertilizer needs to be applied at a three-fold increased rate, or additional P needs to be applied using a different source.

If a grower who has been using the traditional seed-row fertilizer blends decides to switch over to using the lower P rate liquid fertilizer starter system, there is a possibility that plant available P levels in soils will decline. This will not happen in one growing season, but most likely will be observed over 3 to 5 years. The best way to monitor this is to have soil samples taken and analyzed regularly (e.g. annually or biennially) and if soil test P levels begin to decline, applications of P fertilizer should be increased to better match crop removals.

—TLJ—

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Abbreviations: N = nitrogen, P = phosphorus, K = potassium, S = sulfur.

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Fall 2011, No. 3

WHAT IS IN A NITROGEN BUDGET?

Getting a return on an investment is a concept familiar to all of us. Decisions regarding equipment, field practices, and labor are all governed by getting a benefit from the action. However measuring the benefit from the action is sometimes hard to do.

Farmers and government regulators are increasingly asking how to document the benefit from applied fertilizer. One way to do this is to make a balance of nutrients entering and leaving a field. There are several ways to do this, but the simplest way is to make a checkbook-type budget to compare inputs (purchased fertilizer and feed) with outputs (crop or animals sold).

A more detailed approach to an N budget considers more of the sources and losses. This closer look is very useful for identifying areas for improvement. This budget includes:

Sources of N:

N fertilizer – This is perhaps the easiest to measure, but efficiency also depends on having the applicator properly calibrated for supplying an accurate rate and for uniform distribution.

N in irrigation water – Periodic water analysis is useful for monitoring water quality. Nitrate present in irrigation water should be considered as a nutrient input. Multiply the parts per million of nitrate N by 2.7 to get pounds of N added per acre foot.

Residual soil N – Depending on your soil and climate, there can be considerable carryover of plant-available N in the root zone. Deep soil sampling—down to where the roots will be growing—may be required to measure this resource.

N from legumes – Legumes are capable of obtaining their N from the atmosphere through fixation in their roots. If legumes are part of the rotation, account for their N contribution as they decompose.

Decomposition of plant and animal residues – If crop residues, compost, or animal manure is present in the field, their gradual breakdown will also add to the total N supply for growing plants.

Mineralization of soil organic matter – Soil organic matter gradually releases N during the growing season. Know how much organic matter your soil contains and get an estimate of N release from reliable local experts.

Losses of N:

Crop removal – Use the average yield from each field and multiply this value by the average N concentration to estimate the N removed in the crop.

Leaching – Some water will pass beyond the root zone during the year, but the challenge is to minimize the amount of nitrate that is carried with it. This is done by precisely timing fertilizer applications and carefully managing water.

Denitrification – Some nitrate may be converted to nitrous oxide gas when wet soil conditions persist. This pathway of loss can be minimized by good management. Overly wet soils can also accelerate undesired nitrate leaching.

Volatilization – Some N sources are susceptible to loss of ammonia. If animal manures or urea-containing fertilizer are being used, appropriate management practices can greatly reduce the loss of ammonia N to the air.

Making your own N budget, whether simple or detailed, will help you identify areas where efficiency can be improved. Being more efficient with N will pay both economical and environmental benefits. Take time to consider how to do a better job with your important N fertilizer.

—RLM—

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Abbreviation: N = nitrogen.

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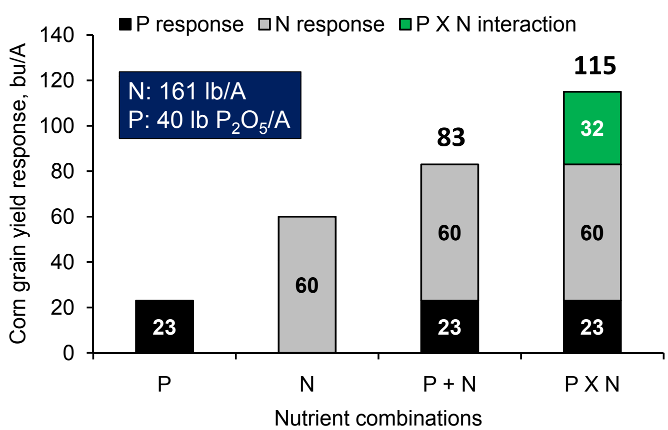
NITROGEN PLAYS WELL WITH OTHERS

"Plays well with others" is a comment every parent likes to hear about his or her child. It means that the child is interacting positively with other children and is being a good influence. Such glowing reports are often the result of good parenting. Although you may think it's a stretch, in the world of soil fertility, N has also been known to play well with other nutrients.

To quote from the widely read book Soil Fertility and Fertilizers, "An interaction takes place when the response of two or more inputs used in combination is unequal to the sum of their individual responses." To illustrate what an interaction looks like, we consider an example from a long-term Kansas study investigating crop response to both N and P. In the graph below, we see that applying P without any N increased corn grain yield by 23 bu/A (the first bar on the left). Applying N without any P increased yield by 60 bu/A (the second bar from the left).

Now according to our definition of an interaction, if N and P were both applied and no interaction took place, their combined effects would simply be additive. If this were the case, we would expect crop response to the addition of both nutrients to simply be the sum of the P effect (23 bu/A) and the N effect (60 bu/A), for a total response of 83 bu/A (second bar from the right). However, actual results from the long-term study itself indicate a yield increase of 115 bu/A, which is 32 bu/A more than the sum of the individual responses to N and P (first bar on the right). This additional 32 bu/A is the result of the positive interaction of N and P.



Note: Data are from 30th year of a long-term, irrigated study in Kansas
Source: Schlegel et al. 1996. J. Prod. Agric. 9:114-118.

Are all interactions among nutrients positive? No. Nutrients, like any other input, can be properly managed or mismanaged. Managing nutrients properly takes the fullest advantage possible of positive interactions. Because positive interactions lead to greater yield increases for the same amount of fertilizer applied, agronomic efficiency is increased. When nutrients are mismanaged, efficiency is decreased.

So is N playing well with others? The potential is there. Nutrient stewardship, like good parenting, will realize the potentially positive impacts that N can have with other nutrients.

—TSM—

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TRENDS IN PRECISION AGRICULTURE

Keeping a finger on the pulse of the precision agriculture (PA) industry is the Croplife/Purdue Precision Agriculture Survey. The PA survey is sent annually to 2,500 retail agronomy dealerships across the U.S. Dealerships are asked questions about the types of services they use and offer, the usage and adoption rates of various PA practices, as well as barriers to adoption, and about the profitability and growth potential for PA. Emerging from the 2011 survey were a few key trends that seem to exist in the PA industry.

Interest in precision agriculture practices and technologies is growing rapidly throughout the agricultural world. This fact was apparent at InfoAg 2011, a precision agriculture conference held recently in Springfield, IL, which hosted over 700 attendees. The 2-1/2 day, biennial conference featured over 50 oral presentations from university and PA industry specialists, growers, and various service providers. Attendees also had the opportunity to visit over 80 exhibition booths highlighting the newest developments in PA equipment and data collection and management. The record participation at the conference combined with the approximately 80% of dealers in the survey indicating that they plan to invest in PA technologies and services suggest that the PA industry is evolving and viable.

Agricultural practices that were once considered "precision" are now viewed as business as usual. One of the more interesting trends observed in the 2011 survey was a drop in the percentage of dealerships who said they offered PA services. This drop was interesting because it did not correspond with similar drops in specific services, suggesting that it is becoming increasingly difficult to separate out certain practices, such as georeferenced soil sampling as a stand-alone "precision" offering. Many practices previously thought of as premium PA offerings are now incorporated into standard agronomic service packages.

We are beginning to see "replacement effects" of one technology for another. One of the most rapid growing technologies in the industry has been automatic guidance (10-fold increase since 2005). However, for the first time in 2011 a virtually equal and opposite drop in manual guidance (i.e. lightbars) was observed. As prices improve and more options become available, we may see this trend begin to show up in other PA technologies and practices.

Some of the fastest growing technologies are boom section and nozzle control and variable-rate (VR) seeding. In just a few years, section control technologies have found their way onto nearly all professional grade sprayers and 39% of dealerships in the survey are using some form of GPS-enabled boom or nozzle control. Regarding section control, Purdue's Dr. Bruce Erickson and Paul Schrimpf of CropLife agree that "For stewardship, efficiency, and product saving, it's a no-brainer capability for most retailers". The explosion in GPS-enabled VR seeding (service offerings expected to increase by 50% over the next three years) is being driven by the need to precisely place high-cost seed and the emergence of highly precise clutch technology. The huge interest in seed placement technology was on display at InfoAg where NCSU's Dr. Ron Heiniger's presentation on the topic was one of the most highly attended of the conference.

Optimism reigns about the future of precision agriculture. Dating back 16 years to the beginning of the PA survey, dealers have always been optimistic about the growth of PA services in their businesses. Although the reality has never quite matched what the retailers have anticipated, the overall positive attitude about the future of PA persists. Several of the presentations at InfoAg noted obstacles to adoption such as equipment compatibility and cost, as well as political obstacles including increased regulation and lack of support. However, these challenges were offset by demonstrated benefits in crop yield increases, more efficient use of inputs, increases in overall system efficiencies, and a higher quality of life for the user. Most notable was the recognition by the industry of the key role that PA must play to address the global food security issues that currently exist and are likely to increase with the population growth expected to occur in the coming decades.

–SBP–

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PLANT NITROGEN DEFICIENCY - GOT SYMPTOMS?

Getting N management done right is always a challenge. Too much N fertilizer can lead to problems with harvesting and quality. Excessive N also can pose a challenge for the environment. Adding too much N fertilizer also wastes money.

If the N supply runs out too soon during the growing season, serious problems of decreased yield and harvest quality are common. If the N shortage is severe, deficiency symptoms are seen as:

Plant Stunting – Nitrogen is essential for cell division and enlargement. When it is lacking, plants will be shorter than usual and the leaves may be smaller. Maturity may be delayed too.

Yellowing – The green pigment in leaves is from chlorophyll. A N shortage will cause a lack of chlorophyll and leaves become yellow.

Older tissue affected first – When there is an N shortage in the plant, the N-containing compounds in the older tissue break down and move to the younger leaves. This causes the N deficiency to become first noticeable in the tips and margins of older leaves. With a severe deficiency, the entire plant may appear chlorotic.

Protein loss – Many crops have less visible N deficiency symptoms, such as lower protein content and less plump seeds—factors that do not become obvious until after harvest.

These obvious symptoms of low N may not be noticeable until the deficiencies become severe. However hidden nutrient shortages will damage plant performance even with minor deficiencies. The loss of yield and quality begins even before the deficiencies are observed.

Take advantage of all the tools at your disposal to get N management right. This varies between regions and crops, but it always involves careful monitoring in the field. This may involve soil testing, plant tissue testing, crop monitoring, realistic yield goals, adjustment for weather conditions, and in-season fertilization.

Sometimes plants to not respond to additions of N as you might expect. Consider factors such as the cultivar, available soil N, delayed crop development from late seeding, excessive weed competition, insect and disease infestation, and low soil moisture when making fertilizer applications. Make sure that added N fertilizer will get to the plant roots.

Balancing N fertilization is like to keeping a teeter-totter level. Running out of N too early can be a disaster for crop growth. Adding too much N causes wasteful losses. Constantly adjusting nutrient inputs requires skill and experience. Using a Certified Crop Adviser to help with these decisions usually makes a lot of sense.

—CSS—

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Abbreviation: N = nitrogen.

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APPROACHES FOR RECOMMENDING P AND K FERTILIZER

After soil samples have been obtained and analyzed, the laboratory or consultant must somehow arrive at fertilizer recommendations for a crop. Part of the challenge is that there's more than one way to recommend fertilization. Most of the information below was adapted from an excellent PPI (IPNI) Better Crops article from a few years ago (Leikam et al., 2003. Better Crops vol. 87, no. 3).

Sufficiency (feed the crop) approach – The goal of this approach is to apply just enough P and/or K to maximize profitability in the year of application, but minimize fertilizer application rate and costs each year. Unless initial soil test levels are high, nutrient applications will be required every year in order to eliminate profit robbing nutrient shortages. Specific application methods, such as the use of band application, may also be needed for maximum nutrient response.

Sufficiency recommendations are typically developed to provide 90 to 95% of maximum yield. Crop response and recommended nutrient application rates are highest at very low soil test levels, and nutrient application rates decrease to zero as the soil test level increases to the 'critical' soil test value. The critical level is the soil test value at which the soil is considered capable of supplying sufficient amounts of P and/or K to achieve 90 to 95% of maximum yield. With this approach soil test values are not viewed as a managed variable and there is little to no consideration of future soil test values.

Build-maintenance (feed the soil) approach – This approach treats P and K soil test levels as controllable variables. At low soil test values, recommendations are made to apply enough P and K to meet both the needs of the immediate crop and to build soil test levels to a non-limiting value, at or above the critical level. The build-up of soil test values occurs over a planned period of time, typically 4 to 8 years. Once the soil test level exceeds the critical value, future nutrient recommendations are made to maintain it in a range at or just above the critical level (medium to high range) where the soil can provide adequate P and K to meet the needs of growing crops. Above the critical level the soil is largely capable of supplying the nutrients needed in a given year; however, below this level yearly nutrient applications are necessary to optimize production. Thus the build and maintain approach ultimately provides greater flexibility to manage both time and cash flow since farmers can choose to apply maintenance fertilizer annually, or to combine applications and only apply the fertilizer every two or three years.

Build-maintenance fertility programs are not intended to provide optimum economic returns in any given year, but to provide high levels of grower flexibility and good economic returns over the long-run by removing P and K as limiting factors. The disadvantage of this approach is the cost of the build phase when initial soil test levels are below the critical value.

Both approaches to P and K recommendations are sound, so we can't really say that one is right and the other wrong. It's really a question of which is more appropriate for a given set of circumstances. Factors such as land tenure and nutrient costs affect which approach is best for the farmer. Nutrient recommendations are not a one size fits all proposition, but should be tailored to fit the circumstances.

—WMS—

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Abbreviations: P = phosphorus, K = potassium.