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

From Scientific Staff of the
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MANAGING PLANT NUTRITION FOR MULTIPLE GOALS

Managing plant nutrition sustainably requires that multiple goals be addressed at the same time. Plant nutrition research focuses on many diverse goals. They include maximum crop yields, maximum economic yields, lower emissions of ammonia and nitrous oxide to the air, and smaller losses of nitrate and phosphate to water. Scientists also seek to manage plant nutrition for the quality and healthfulness of the foods harvested.

In some cases, there are trade-offs. Practices that maximize yields don't always minimize nutrient losses. Nutrient sources that minimize ammonia loss may not minimize nitrate loss. Rates of N that maximize corn yields don't always minimize nitrate losses. Application timing for P in the fall may maximize economic yield but may not minimize risk of phosphate loss. Placement of phosphate in the soil may decrease loss of dissolved phosphate in runoff, but the soil disturbance may increase total phosphate loss through erosion. **So how do we reach all these goals at once?**

The first step is to look for what these goals have in common. They are all related to, and impacted by, choices for source, rate, time and place of nutrient applications. These choices are all site-specific; they change with soil properties like texture and drainage, and with changes in weather and climate. And there's a tendency that whenever nutrient use efficiency is improved, opportunity for nutrient losses goes down. This tendency is most obvious for the larger potential losses, like ammonia volatilization and nitrate leaching, but it holds true even for the small losses that cause big impacts such as nitrous oxide emissions warming the atmosphere.

The second step is to embrace the 4Rs. It means choosing the right source, right rate, right time and right place for each nutrient application. That means looking for things the key nutrients have in common, with respect to how they behave in site-specific interactions of the weather with the soil. Nitrogen and P are the two nutrients that have the most significant impacts on air and water. The similarities in the way they respond to the 4Rs are numerous.

Source. The most economic sources of P—manure, commercial ammoniated phosphate fertilizers—contain N. Right time and place minimizes losses of both nutrients.

Rate. Since N is mobile in soils in more humid climates, its optimum rate depends mostly on weather and crop yield potential. The optimum rate of P depends more directly on soil test level, but the rate to maintain that soil test level is proportional to yield too. Right rate considers crop demand.

Time. In climates with excess rainfall, the optimum time to apply N is as close before crop uptake begins as is practical, since excess rain can cause either nitrate leaching or denitrification losses. While the optimum time to apply P is more flexible, P losses, too, are driven by rain. It's important to minimize the risk of water running off the field after any source of P has been broadcast on the soil surface. An eye on the weather forecast is important for both nutrients. Applying before a gentle rain that can move the nutrients into the soil yields much different results than before a hard rain that drives losses through runoff, leaching and denitrification.

Place. Loss risks of both N and P are minimized by placement in the soil. Ammonia escapes to the air much less when fertilizers containing urea or ammonium are mixed into the soil. Risk of phosphate loss in runoff is reduced when fresh fertilizer applications aren't lying on the soil surface when runoff events occur.

The weather is not a controllable factor. So you need to tailor the 4Rs to the weather. To manage for multiple goals, focus on the similarities of how your key nutrients respond to the weather.

– TWB –

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Abbreviations: N = nitrogen; P = phosphorus.

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IS IT WORTH COMPROMISING NUTRIENT USE EFFICIENCY TO IMPROVE FIELD OPERATION LOGISTICS?

Planting season in the Northern Great Plains (NGP) is always a bit of a race against time. It is amazing how well crops grow in the short growing season characteristic of the high latitudes of North America. The ideal time to plant crops in central Saskatchewan for example is the first two weeks of May. In some springs, planting may begin as early as the last week of April and if there is a late spring, or excessive rainfall in the first half of May, planting may need to continue into the first week of June. However, for most crops there is a point where it is too late to plant so that the crop has time to grow, set seed and mature before killing frosts in the fall. As a result, the month of May is a very busy time for farmers.

When fertilizers were first used in the NGP the only method of application was broadcasting fertilizer using pre-plant or post-planting applications. It was soon discovered that seed-row applying low to moderate rates of P-based fertilizers helped crops emerge and establish well under cool seedbed conditions. As a result most planters were soon manufactured with separate fertilizer boxes, to hold and meter out P-based starter fertilizers, along with seed in the seed furrow. The majority of N fertilizers were pre-plant broadcast applied and incorporated using tillage before planting. However, research in the late 1970s and early 1980s indicated that there could be improved N fertilizer use if the N fertilizer was also banded in the soil. This banding of N fertilizer was done as either a pre-plant operation in the late fall or in the spring just prior to planting.

Over the past few decades as no-till or direct seeding became common, there was development of planting equipment capable of planting and fertilizing in one operation. Side-banding fertilizer to the side and below the seed furrow usually accomplishes this. For example when planting spring wheat it is advised to have at least a 1.5 to 2 inch separation of the N fertilizer band away from the seed. There are many different configurations of planting equipment, with some units placing most of the P, K and S fertilizer in the seed-row and the majority of the N in the side-band or mid-row bands, while other units may side-band all the fertilizer in one common band. For the units applying seed-row fertilizer, the amount of fertilizer in the seed-row can't be excessive or it causes poor germination.

As average farm size increases there is a growing need to be more efficient, as far as time, in order to plant all fields within the limited planting window. In the 1970s average farm size in much of the NGP was 640 to 1,280 acres. Now average farm size is 3,000 to 4,000 acres and there are many farms in the 15,000 acre size or even larger. More acres planted per day can be accomplished in a few different ways. One is to have larger and specifically wider planting equipment, and this has been a solution on many farms. Another is to spread out the field operations, and return to the practice of pre-plant fertilizer applications. By handling less fertilizer while planting, equipment can be filled with more seed, covering more acres between stops. Also, there is less need of a separate truck and truck driver, to haul fertilizer to the field to fill up fertilizer tanks. There is a trend back to pre-plant broadcast applications of fertilizer as a way to reduce steps and time. Broadcasting N in the form of urea does this, but surface banding liquid urea ammonium nitrate solutions is also used. In some areas broadcast fertilizer equipment had almost become non-existent, as the majority of farmers are one-pass seeding and side-banding all fertilizer at planting. However, there is a growing demand for retail fertilizer dealers to offer broadcast fertilizer services.

The important question is whether or not the time saved in order to plant more acres during the ideal planting window is of greater benefit than the decreased efficiency of broadcast applied N fertilizer compared to side-banding N fertilizer. There is on-going research to answer this question. It initially appears that in the semi-arid regions of the NGP, pre-plant broadcast applications compare reasonably well to side-banding at planting under no-till cropping. The farmers that are using pre-plant broadcast applications feel that the amount of fertilizer incorporation as a result of the no-till planting operation is helping to reduce potential losses of surface N applications compared to subsurface band placement. They stress the importance of planting within a few days of broadcast applying the N fertilizer. Hopefully on-going research will confirm if this is correct or not. It is clear that the improved logistics of quickly applying N fertilizer using broadcast applicators and freeing up time for earlier planting is appealing to more and more farmers.

– TLJ –

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BOOSTING HUMAN NUTRITION WITH FERTILIZER

In discussions about using fertilizers and various plant nutrients, the entire purpose of using these materials is too frequently overlooked. All of the effort that goes into acquiring, transporting, applying, and managing these valuable resources is for the primary goal of growing healthy and abundant crops for humans and animals.

Removing crop products from the field extracts nutrients from the field. The harvested products may be used for things such as blue jeans, biodiesel, animal feed, or eaten directly by people. It becomes necessary to replenish the soil as the nutrient reservoir becomes gradually depleted. Some of the goals of productive agriculture include:

Food security—refers to having access to adequate food, without fear of hunger or starvation. Commercial fertilizers are estimated to support over half of the current global food production and clearly have a vital role in meeting the goal of food security for everyone.

Nutrition security—means having access to adequate food components for human nutritional needs. Many of the healthful components of food are boosted by the application of fertilizer (such as protein, carbohydrates, oil, vitamins, and minerals). This security involves access to nutritional food and making wise dietary choices.

Micronutrient nutrition—is increasingly important in many parts of the world as human diets in many less-developed countries have shifted towards greater consumption of “staple” cereal crops (such as corn, wheat and rice). The yield of many micronutrient-rich crops (such as various beans, fruits and vegetables) has not benefited as much from the Green Revolution, and these foods now comprise a smaller proportion of the diet of the world’s poorest people.

A variety of practices are being used to boost the nutritional value of crop plants. This includes improved agronomic practices to achieve “biofortification” with minerals such as zinc (Zn), selenium (Se), and iodine (I). Genetic approaches are effective in boosting the concentration of iron (Fe) and vitamins in plants.

Some recent scientific papers indicate that there may have been a decline in the nutrient concentration of some vegetables during the last 50 to 100 years. This is likely due to the well known “dilution effect”, where higher-yielding and larger plants may take up the same quantity of nutrients from the soil. This results in an apparent dilution of the mineral concentration in the harvested crop.

To a large extent, the supply of soluble plant nutrients in the soil determines the composition of the plant. Crops grown in nutrient-deficient soils will likely have low yield and may have poor nutritional qualities for humans and animals. Adding the appropriate plant nutrients to soil supports high yields, and also sustains the essential nutritional food properties. Without the proper nutrients, plants cannot possibly provide an adequate and nutritional food source for people.

IPNI has recently published a comprehensive scientific review of this topic, which can be downloaded for free at: http://info.ipni.net/FCIHH.

– RLM –

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THE FUTURE OF 4R NUTRIENT STEWARDSHIP

The 4Rs of nutrient stewardship – right source, right rate, right time, and right place – are factors that have been investigated by crop and soil scientists for decades. With such a rich history, does agriculture really have anything new to bring to these management practices?

Right source. Rather than producing only bulk commodities like MAP, DAP, urea, and anhydrous ammonia, fertilizer manufacturers are investing more and more resources into developing new technologies that improve the synchrony between nutrient release and crop uptake. Such advances may significantly increase future nutrient use efficiencies, reducing the risk of nutrient movement to unwanted places in the environment.

Right rate. The standard for past rate recommendations has been static look-up tables. The future is looking very different. Crop growth models are being integrated into nutrient rate algorithms, making it possible to estimate crop nutrient needs during the season as weather changes. Crop sensors also provide valuable in-season assessments of nutritional status, making it possible to alter rates within the season. Ongoing advances in GPS and GIS are making it easier and simpler to design and deploy on-farm nutrient rate experiments. Additionally, freely-available software tools can get rid of "bad" yield monitor data and statistically analyze studies to identify optimum rates. Models that estimate nutrient losses through a variety of pathways continue to develop and some of those algorithms are already finding their way into nutrient rate recommendation tools. All of these advances continue to make scientific methods and knowledge more accessible to farmers and advisers, allowing them to determine what rates work best under local conditions, not only to increase production but also to meet an ever expanding set of ecosystem services.

Right time. Changing weather patterns are making it difficult to rely on some past application timings to achieve the same results. The suite of tools available for on-farm research allows farmers and advisers to test different application timings to determine which ones produce the highest yields as well as have the best logistics. Equipment is constantly changing as well, increasing the time window in which applications can be made. Improved fertilizer technologies may also provide more options in the future.

Right place. Real-time kinematic (RTK) guidance systems have created unprecedented records of where bands are placed in the field, making it possible to create, over time, customized networks and configurations of subsurface bands. In the future, these bands could be arranged to be in the best position for each crop in the rotation. Research continues as well into where to place nutrients in the landscape and how to combine that placement with other management practices, such as buffer strips, tillage, and cover crops, to reduce nutrient losses.

While the 4Rs have a rich history, they also have a promising and bright future. Improvements in nutrient management have always been a process rather than an end point. The journey ahead will bring many innovations that can improve our ability to achieve not only production and economic goals, but social and environmental targets as well.

–TSM –

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Abbreviations: MAP = monoammonium phosphate; DAP = diammonium phosphate; GPS = global positioning system; GIS = geographic information system.

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IMPROVING COTTON SUSTAINABILITY WITH PRECISION AGRICULTURE

Sustainability of an agricultural system can be simply defined as "meeting the needs of the present while maintaining the ability for future generations to meet their own needs." What sustainability is not, is a sole focus on the environmental impacts of an agricultural operation. There are three pillars of sustainability: economic, environmental, and social, with each one being equally as important as another when developing nutrient management plans. To meet the food, fiber, fuel, and feed needs of the growing population, defining sustainability goals must be a priority for all agricultural systems.

4R Nutrient Stewardship begins with the process of setting sustainability goals. Once the goals for the operation are established, nutrient management practices best suited to achieve the goals are selected. These practices will be a combination of the 4Rs, applying the right nutrient source, at the right rate, at the right time, and in the right place. Incorporating precision agriculture technologies such as grid or zone soil sampling, variable-rate fertilizer application, and automatic section control can enhance the effectiveness of the 4Rs.

Field to Market: The Keystone Alliance for Sustainable Agriculture has an online tool available called the Fieldprint calculator that allows users to compare the sustainability of their particular operation with county, state, and national averages. The Fieldprint calculator also allows growers to evaluate the effect of a change in management practices on various sustainability metrics, such as energy use and greenhouse gas (GHG) emissions.

Switching from single to variable application rates of P and K, reduced energy consumption and GHG emissions 15% and 10%, respectively, for a 72-acre cotton field in Tennessee. Annual application rates for the farm in this example were 30 lb P_2O_5 and 90 lb K_2O/A. Adopting a variable-rate application strategy based on 2.5-acre grid soil sampling dropped the average P_2O_5 rate to 25 lb/A and the average K_2O rate to 51 lb/A (ranging from 0 to 85 lb/A), without reducing lint yield. According to the Fieldprint calculator, these nutrient reductions resulted in energy use dropping from 7,373 to 6,273 BTU/lb and GHG emissions went from 1.849 to 1.655 lb CO_2e/lb. The management change also saved the grower US$24.57/A in input costs and reduced nutrient use by 360 lb of P_2O_5 and 2,808 lb of K_2O.

Variable-rate N application can also have a significant effect on the sustainability of Mid-South cotton production. In another example from Tennessee, a grower had been applying 120 lb N/A to the entire field and began using a variable-rate N application strategy based on soil electrical conductivity-based zone management. The average N rate dropped to 104 lb N/A, ranging from 70 to 123 lb N/A, with no effect on lint yield. This change resulted in a decrease in energy use from 12,966 to 8,875 BTU/lb. Greenhouse gas emissions went from 1.55 to 1.11 lb CO_2e/lb.

Incorporating precision agriculture technologies into 4R Nutrient Stewardship plans can improve the sustainability of cotton production in the Mid-South. Lori Gibson, Row Crop Sustainability Specialist at the University of Tennessee says, "Utilizing precision ag technologies can reduce our impacts on the environment, make you money, and most importantly, keep you farming." For more information on 4R Nutrient Stewardship, visit www.ipni.net/4R and also check out www.fieldtomarket.org to learn more about the Fieldprint calculator.

– SBP –

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Abbreviations: P = phosphorus; K = potassium; CO_2e = carbon dioxide equivalents; BTU = British thermal units.

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FERTILITY CONSIDERATIONS FOR FORAGE BERMUDAGRASS

Bermudagrass is an important hay and pasture crop in many states. In some southern states it is considered the most important of all warm season forages. The prevalence of bermudagrass is attributable to its high yield potential, drought resistance, and tolerance of somewhat acidic soil conditions. Bermudagrass yield potential, like any other crop, is subject to water availability—amount and distribution of rainfall, and soil depth as it relates to water storage—but another important and all too common limiting factor is nutrition and fertilizer input.

Bermudagrass can be produced for grazing, hay, or a combination of the two. Hay is generally cut at about 30-day intervals with from two to as many as six cutting per season, depending on climate and moisture. In hay production, nutrient uptake is essentially the same as removal, so whatever the crop takes up is exported from the field in harvest. Thus there is potential for rapid depletion of soil nutrient (P and K) reserves in hay production. In grazing systems some nutrients are recycled via animal urine and feces. How much to credit to this recycling depends on distribution of animal waste, which is a function of several factors such as grazing intensity and water and shade distribution.

Nutrient management practices can impact bermudagrass yield and forage quality, as well as stand density and longevity. Following are a few basic facts to keep in mind when fertilizing bermudagrass this season.

Adequate N nutrition is associated with improved shoot and root growth, stress tolerance, resiliency, and higher protein content. Bermudagrass will take-up about 50 lb of N per ton of biomass. Tissue levels of N should be maintained at about 2.2% of dry matter. Basic N fertilizer recommendations for hay production may call for the application of N at 100 lb/A in the spring, with the remainder applied in split applications just after, or between harvests. As with any general recommendation this should be adjusted to specific conditions.

Phosphorus fertility is commonly associated with increased root growth and branching, increased N use efficiency, and improved drought tolerance and recovery. Bermudagrass will take-up about 12 lb P_2O_5 per ton, thus a top yielding hay crop can remove as much as 100 lb P_2O_5 per acre. Fertilizer P applications should be based on soil test results, but crop removal can also be useful in developing strategies.

Adequate K fertility is associated with increased disease resistance, improved winterhardiness, maintenance of good stand density, and better N use efficiency. Additionally, maintaining adequate K levels through the summer months to the onset of dormancy is important in the manufacture of carbohydrates for root growth and carbohydrate storage. Bermudagrass will take-up about 50 lb of K_2O per ton with uptake reaching as much as 4 lb K_2O per acre per day in a rapidly growing crop. Consequently, reserves of soil K may be reduced rather rapidly under intensive bermudagrass production, resulting in stand density and yield reductions. Soil testing is useful in developing K recommendation for bermudagrass; however, removal should be considered as well, especially in sandy soils with limited cation exchange capacity (CEC).

Secondary elements and micronutrients can also be important in achieving optimal bermudagrass production. This was shown in an east Texas study (Better Crops with Plant Food, No. 2, 2007) where in the fourth year of production Tifton 85 bermudagrass yield was increased 1 ton, or 17% with the application of S fertilizer.

Optimal fertility management practices for bermudagrass can vary considerably with production goals and climatic and soil environments; however, application of the 4Rs of nutrient management (right fertilizer rate, source, time, and place) helps ensure optimum yield and forage quality, improved stand longevity, and profitability regardless of the environment or system.

– WMS –

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

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