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

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Winter 2011, No. 1

ADAPTIVE MANAGEMENT FOR CORN NITROGEN

Agronomists have long sought to improve N recommendations for corn. While it is well known that yields depend strongly on N input, the precision on the amount recommended is often less than desired. The optimum rate for a given field can vary year-to-year by 60 lb/A or more, owing to weather. A wide variety of decision support systems are available for choosing the right source, rate, timing, and placement of N. To make the most progress in improving N use efficiency, these support systems need to be tested on-farm through adaptive management.

Applied N can go in many possible directions. The intent is to feed the crop. But there are many paths leading it astray. Some gets held up by microbes as they decompose crop residues. Some of it is lost to the air as one of several gases. Some leaches away in water as nitrate. Getting a bigger proportion to the crop reduces the amount potentially harming the environment.

Decision support systems range widely in complexity. They are designed to help you choose the source, rate, timing, and placement that will get the most N to the crop and the least to the other paths. The simplest are guidelines based on previous crop, expected yield, and expected prices, or on a single indicator like a soil test. More sophisticated systems may address spatial variability using real-time or remote sensing and may address weather variability through the use of computer models predicting crop growth and soil processes. A decision support system that integrates information on crop demand, soil supply, and loss processes is a powerful tool essential to improved N management.

Adaptive management is an on-going process. No matter how sophisticated, a decision support system needs to be evaluated and adapted to meet the needs of your specific operation—your soils, microclimate, business environment, and enterprise goals. Adaptive management aims to develop improved practices for efficient production and resource conservation by use of participatory learning through continuous systematic assessment. Adaptive management of N involves a continuous cycle of planning, evaluating, learning, and making adjustments to choices of source, rate, timing, and placement.

Nutrient balance serves as an important measure to evaluate in adaptive management. Achieving high yields with a minimal surplus of N input over crop removal is a particularly difficult challenge, because N is easily lost. Response trials often show that the economically optimum rate for yield exceeds nutrient removal by a considerable amount. The optimum rate is often close to a pound of N for each bushel of yield, but a typical bushel contains only about two-thirds of a pound of N. The goal is not just a more precise decision for rate on a fixed response curve; it is to alter the response curve through better choices for source, time, and place for nutrients applied, and better choices for soil and crop management.

Tools for on-farm evaluation abound. Soil nitrate tests, tissue tests, visual observations, sensors, aerial photos, satellite photos, and stalk nitrate tests can all provide useful input to the decision support system. But the requirements for evaluating nutrient balance and progress toward potential yields, while simple, involve diligence and hard work. Yield measurement, weigh wagons, some means of measuring N contents, and good records are essential. And it is hard to avoid replicated test strips for making comparisons. In addition, an adaptive approach needs to consider the logistics of operations on the farm and how choices fit into the farm's crop and soil management.

Adaptive management involves collaboration. Involve experts. By giving crop advisers, extension agents, and research scientists opportunity to provide suggestions, and by engaging the most powerful decision support tools, you will find ways to manage N with enhanced efficiency.

–TWB–

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Abbreviation: N = nitrogen.

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Winter 2011, No. 2

CROPPING PRINCIPLES THAT APPLY TO ALL CROPS?

I wouldn't consider myself an extensive world traveler, but I have been able to travel some in different parts of the world. When in new areas I like to take the opportunity to observe the local farming practices and especially what and how crops are grown… and what nutrient management practices are used. There are differences among areas such as: climate (i.e. temperatures, growing season, precipitation amounts and timing), use of irrigation, crops grown, tillage methods, and types of nutrient sources used. However, even though there are differences I am amazed at the similarities when you compare areas. When considering primarily field crops the following cropping principles are important all over the world.

First is the tillage and seedbed preparation system. In order to grow an annual crop, or establish a perennial crop, either seeds or plant propagation parts are placed in soil. This usually involves a primary intense tillage operation (e.g. plowing, disking, or even hand hoeing), followed by a secondary tillage operation or two (e.g. cultivating, harrowing, or even raking) to smooth the soil surface and establish a suitable seedbed. In the case of no-till or conservation tillage systems some or all of the tillage operations are replaced by the use of pre-plant, non-selective herbicide applications for weed control, followed by planting using specialized residue clearing equipment.

Application of supplemental plant nutrients is usually practiced. Most often this is in the form of fertilizer or recycled biosolids (e.g. animal manures, crop residues, sewage sludge, and or green manure crops), or a combination of fertilizers and biosolids. The aim is to effectively apply the nutrients using the 4R Nutrient Stewardship Principles of applying the right source of nutrient at the right rate, right time, and right place, so that adequate nutrients are available to the crop to optimize crop yields, net returns for the farm, and minimize any unwanted nutrient movement away from the field in surface run-off, leaching into groundwater, or gaseous emissions and losses of N (e.g. N_2O and N_2). Depending on the nutrient, its application can be done as a pre-plant operation, at planting, or an in-season top-dressing. Often non soil-mobile nutrients such as P, K, and most micronutrients are applied and incorporated before planting using pre-plant tillage operations, placed in the seed-row furrow with the seed, or a precision side-band as part of the planting operation. The two soil-mobile macronutrients (i.e. N and S) can be successfully applied as an in-season top-dressing, usually within a couple of weeks to one month after planting, but in low-to-moderate rainfall regions they can be applied as pre-plant or at planting operations as noted above. High rates of N need to be placed away from the seed furrow to avoid excess NH_3 toxicity, or an adverse osmotic salt effect.

The planting operation is critical for crop establishment so that crop seeds or plant propagation parts (e.g. potato tuber pieces), are placed into the seedbed with adequate soil contact at the appropriate depth to access soil moisture and germinate well. This usually is done using a planter that has a soil engaging disk or hoe-type soil opener that makes a small furrow into the soil, the seed is placed in the bottom of the furrow, and soil is placed over the seed followed by moderately packing so that the seeds will absorb (imbibe) soil moisture and germinate well. Many planters are equipped with fertilizer tanks and distribution systems so that fertilizer can be seed-row applied or side-banded as discussed above. It is most interesting to me how these same correct planting methods are used whether the farm is highly mechanized or is done using animal or human power.

There needs to be in-crop weed control and pest control done. This is often done using herbicides, insecticides, and fungicides as spray applications. However, weed control in some areas and crops is done effectively using between crop row tillage, or even hand weeding.

The harvesting of crops needs to happen in a timely manner so the crop is ripe enough for storage and transportation, while avoiding excess exposure to weather, and damage by rodents or birds. Adequate storage is critical for preserving the quality of the harvested crop parts (e.g. grain or forage) until the farm products are used on-farm or sold off-farm for needed cash income.

The last stage of cropping done is crop residue management by evenly spreading, or in some cases removing non-harvested crop residues to facilitate tillage and planting operations the next growing season or period.

If any of these principles is done poorly or neglected anywhere in the world, the growing of a successful crop and adequate returns to the farmer are compromised. Fortunately, in my observation farming practices in most areas are well done and grow adequate crops for feeding the human family. I encourage you to make your own observations of cropping practices when you travel outside your local region.

–TLJ–

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Abbreviations: N = nitrogen, N_2O = nitrous oxide, N_2 = dinitrogen , NH_3 = ammonia, P = phosphorus, K = potassium, S = sulfur.

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Winter 2011, No. 3

IS THERE A NEED FOR MORE CALCIUM?

Humans and animals need Ca to build strong bones. Plants also require plenty of Ca to develop strong cell walls and membranes. Animals fed a diet with low Ca develop weak bones and osteoporosis. Similarly, insufficient Ca in plants leads to a breakdown of cell walls and membranes, and to a variety of disease and post-harvest problems. In addition to plant nutrition benefits, sufficient Ca has a role in maintaining soil physical properties, alleviating subsoil acidity, and the reclamation of sodic soils.

There are soil conditions where Ca applications are very helpful. Sandy soils and crops irrigated with low Ca water may be particularly vulnerable to low Ca availability. Soils with low pH generally have low Ca availability. Unusually high exchangeable Mg may pose a problem for Ca uptake by roots.

Most agricultural soils contain considerable amounts of Ca. A good estimate is that each cmol of exchangeable Ca is equivalent to 400 lbs/A (in a depth of 6 2/3 in.). Many soils contain several tons of exchangeable Ca on cation exchange sites. Therefore, it may take large applications of Ca to make significant changes in soil chemistry.

Probably the best known symptom of Ca deficiency is blossom-end rot of tomato fruit, but this problem is closely related to plant water stress and the difficulty in delivering Ca to the fruit. This illustrates one of the problems with Ca deficiencies—is it a lack of Ca that is the problem or is it a problem with delivery of Ca within the plant?

In soil that seems to have adequate Ca, why do deficiency symptoms sometime occur? The problems often appear when Ca does not adequately move to the plant organs where it is needed. Calcium moves primarily with the transpirational water moving up from the roots. Once in the plant, Ca is not readily mobile from one plant part to another. Plant organs that have low transpiration (e.g fruits such as melons, apples, and tomatoes with a waxy skin, or the inner/sheltered parts of leafy plants such as lettuce) can develop low-Ca disorders. When these disorders develop, sometimes it is related to the soil Ca supply, but it is frequently related to water stress, cool temperature, and limited transpiration.

When low Ca is causing plant problems, start with getting the soil tested. Make sure there is adequate Ca present and low pH is not a problem. Large amendments with Ca inputs such as lime or gypsum may be recommended to address these conditions. When targeted inputs are needed during the growing season, several highly soluble Ca sources are available. They may be best applied to the active root zone to promote rapid uptake. Foliar sprays containing Ca can also be beneficial to address potential deficiencies, but only a limited amount of Ca can be assimilated this way.

Calcium is required by plants in relatively large amounts. Many forage crops, such as alfalfa, remove over 100 lbs Ca/A/yr in harvested hay. When plant deficiencies occur, it is necessary to examine the cause of the problem in order to know the best response. There are many excellent sources of Ca available, but their appropriate use depends on your individual situation.

–RLM–

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Abbreviations: Ca = calcium, Mg = magnesium.

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Winter 2011, No. 4

THE SCIENCE BEHIND THE NITROGEN CREDIT FOR SOYBEANS

"Take a N credit for corn following soybean." This statement, or something like it, is common to most N recommendations for corn. The idea is that after a soybean crop, corn doesn't need as much fertilizer N. The common perception is that because soybean is a legume, it adds to the overall N supply in the soil. Let's take a closer look at what is going on with this credit.

The credit itself amounts to a reduction in fertilizer N ranging somewhere between 20 and 60 lb N/A, depending on the recommendation system. It can even be more in some cases. Some universities recommend a flat rate reduction, while others vary the credit based on soybean yield. Still others use a combination of the two. Common to all of them is that the credit is based on a comparison to a continuous corn system, which typically takes more N to grow a corn crop to the same yield level.

S**o does corn following soybean use less N or should we really think of it as the continuous corn crop needing more N?** It all depends on which one is used as the basis of comparison. A continuous corn crop has more residue that is higher in C. Soil N can be immobilized for a time by soil microorganisms as they utilize the C in this residue, reducing the N available in the soil. Adding the additional 20 to 60 lb N/A makes up for the immobilized N and may also speed the organic matter mineralization process.

Contrary to common perception, levels of nitrate in the soil are often lower after a soybean crop than they are after a corn crop. Soybeans get their N either from the nitrate already present in the soil or from the N fixed by the bacteria present in the nodules. The more nitrate present in the soil, the less comes from the nodules. Consequently, soybeans actually deplete, rather than increase, soil nitrate levels.

So where does the "extra" N come from following a soybean crop? It is currently thought that exudates from soybean roots, as well as the roots themselves, increase a pool of organic N that is easily mineralizable. In the Midwest and Northern Corn Belt, this N becomes available early enough in the season that it reduces the fertilizer N needed, leading to the credit. However, in the warmer, more humid southeast U.S., this N can be mineralized too early in the season, resulting in no credit. In fact, many states in the southeast U.S. do not have a soybean credit.

The soybean credit therefore appears to have more to do with the soybean root system than with the above-ground stem, leaf, and pod residue left after harvest. Consequently, a late season disaster like hail damage wouldn't be expected to reduce the N credit much if the crop was near maturity when it happened. In fact, it likely increases the credit since the high N soybean seed is left in the field and will quickly mineralize once contact with the soil occurs. The magnitude of this credit will be influenced by the duration of warm soil temperatures and the amount of precipitation received afterward in the fall and subsequently in the spring.

The N credit is more than a number. Although it is a simple part of recommendations, it actually reflects a complex set of reactions in soils. Having a better understanding of the science behind the credit can help advisers make adjustments under changing conditions.

–TSM–

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Abbreviations: N = nitrogen, C= carbon.

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Winter 2011, No. 5

NITROGEN MANAGEMENT FOR SOUTHEAST POTATO PRODUCTION

Potato is an important, high-value crop in the Southeastern vegetable industry. With approximately 25,000 acres, Florida produces one-third of the nation's winter/spring crop with an annual value of over $160 million. When producing such a high-value crop, the tendency of some growers is to over-apply certain inputs like N fertilizer and water to provide "insurance" against yield loss. However, over-application of N to a potato crop is just as likely to result in production problems as under-fertilization.

Excessive N fertilizer applied at or before tuberization can extend the vegetative growth period and delay tuber development, resulting in a lower yield. Too much N applied later in the season can delay maturity of the tubers, reducing yield and adversely affecting tuber quality and skin set. Over-irrigation can result in poor soil aeration, which can also result in lower yield and market grade, increased disease problems, and leaching of mobile nutrients like N. Leaching of N can be a particularly high risk on the coarse-textured, low-organic matter soils common to the Southeast.

One of the ways that potato producers can meet the environmental, economic, and social goals of a sustainable agricultural system is to practice 4R Nutrient Stewardship. This involves applying the right fertilizer source at the right rate, at the right time, and in the right place. Considering all four "rights" when determining a fertilizer recommendation will result in a nutrient management strategy that efficiently and effectively meets the grower's objectives. In the case of N recommendations for potato, what's "right" will vary among locations and cropping systems, but the scientific principles behind specific recommendations are the same.

University of Florida researchers are currently evaluating N management strategies to optimize potato production. Started in 2010, this three-year study is investigating the effect on yield and tuber quality of various combinations of N rate and timing, the interactive effects of environmental conditions such as rainfall and air and soil temperature on N requirements, and N uptake and accumulation by potato during the growing season in northeast Florida.

The key to optimizing fertilizer rate in potato is to match nutrient supply with crop requirement. Current N guidelines in florida provide a recommendation of 200 lb N/A; however, they do not address how environmental conditions or varieties affect specific crop requirements. Other research has shown that as yield potential increases, so does the N requirement, with between 40 and 75 lb N being required for every 100 cwt of tuber yield. The current study is being conducted using various chipping varieties grown under seep irrigation with yield potentials exceeding 400 cwt/A.

Results from 2010 indicate that a difference in N uptake and N fertilizer requirements may exist among varieties. The N uptake for cultivar FL1867 ranged from 130 to 190 lb N/A, while 'Atlantic' potato only accumulated 90 to 140 lb N/A during the growing season. Highest tuber yields for the two cultivars were 290 and 395 cwt/A for 'Atlantic' and FL1867', respectively. No yield responses to rates above 230 lb N/A were observed for any cultivar in 2010; however, no definite conclusions regarding optimum N rate can be drawn following only one year of data (2011 yields have not been analyzed). It was also noted in 2010 that N fertilizer rates exceeding 200 lb N/A resulted in residual soil N (after harvest) between 60 to 120 lb N/A.

This research is scheduled to be continued through the 2012 cropping season. Following the 2012 harvest, a comprehensive analysis of all the data should provide growers with the information necessary to select the right N rate, the right application timing, and the right placement strategy required to optimize yield and profitability within the context of their cropping system.

–SBP–

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Abbreviation: N = nitrogen.

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Winter 2011, No. 6

NITROGEN IN SOIL ORGANIC MATTER – HOW MUCH IS RELEASED IN YOUR FIELD?

The most difficult task for any farmer and crop adviser who is developing a N management plan is estimating the fertilizer and/or manure N rate for the expected crop uptake demand. While crop N uptake demand can be estimated based on a three to five-year yield history, knowledge of expected uptake (and removal) at the targeted crop yield, new crop genetic yield potential, and the provision of other essential nutrients and adequate plant protection… the most unpredictable factor that complicates such estimation is the weather.

In sandy mineral soils of the southern U.S., the soil organic matter content of the surface soil is often below 1%, while in the Midwest and Great Plains it can range above 4% because those areas natively supported productive grasslands. Humus is considered the more stable fraction and makes up roughly two-thirds to more than three-quarters of soil organic matter. The N content of organic matter is approximately 5%. The rate of release of the N from soil organic matter depends to a great extent on the C to N ratio of the organic matter acted upon by soil microorganisms. On average, soil organic matter has a C to N ratio of 10:1. If we assume that an acre of soil roughly 6 2/3 in. deep weighs about 2,000,000 lb, then that surface soil depth may contain between 20,000 and 80,000 lb of organic matter; or between 1,000 and 4,000 lb of total N/A.

It is not uncommon for some to use a general rule of thumb of about 1 to 2% release of N in soil organic matter, during the spring through summer growing season each year. The release rate varies with soil texture or CEC, soil pH, soil microbial population, the prevailing temperature and moisture, as well as with any soil disturbance by tillage. The range of N released (mineralized) by soil microbes may be approximately 10 to 80 lb/A each growing season, or more. Obviously, more N is released during warm, moist conditions as opposed to those that are cool and dry. With such a broad range, it is no surprise that there have been many attempts to develop more reliable measures of "potentially available soil N", and in some regions, soil N tests have met with some calibration and field validation success. Often, these "potentially available soil N" tests require sampling beyond the typical 0 to 6 in. depth, and may require sampling to 2 or 3 ft. deep.

In 2007, the International Plant Nutrition Institute (IPNI) published 13 papers from the Proceedings of a 2006 Symposium on Managing Crop N for Weather at the Meetings of the Soil Science Society of America (SSSA). For more specifics and guidance on ways to better account for weather in your 2012 crop N management plan, consider visiting the IPNI webpage where the proceedings may be purchased: http://ppi-store.stores.yahoo.net/books.html. Also consider contacting your Land Grant University extension office or your crop adviser to learn more about soil N testing and how to improve your crop N management plan. By integrating weather variability into your planning, and by using in-season direct plant tissue N testing, or surrogate measures by chlorophyll meters and precision agriculture crop N sensors, you may achieve improved N use efficiency.

–CSS–

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Abbreviations: N = nitrogen, C= carbon, CEC = cation exchange capacity.

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Winter 2011, No. 7

FERTILIZATION AFTER DROUGHT

Much of the Southern and Central Great Plains Region has been severely affected by drought in 2011. In some areas crops have failed altogether, while in other areas crops will be harvested, but at yields far below average. These conditions raise questions about how to handle fertility programs going into 2012.

The majority of the fertilizer applied to failed crops in 2011 should still be there in 2012—either in the soil or in crop residue. However, growers still need to soil test to determine the nutrient status of fields where corn and other crops failed. It is also good to have some idea of the amount of nutrients present in the residue remaining, and how quickly those nutrients will become available to crops. Nutrients carried over from 2011 into 2012 may include:

- Mobile nutrients such as nitrate, sulfate, and chloride in the soil profile
- Immobile nutrients such as P, K, and Zn in the surface soil
- Nutrients in crop residues

A large portion of the mobile nutrients that were not taken up by the 2011 crop in drought affected areas are likely to remain in the top foot or two of soil. With the low rainfall in most of the Southern and Central Great Plains very little of the N will have been lost. For example, the K-State Soil Testing Lab is seeing higher-than-normal soil test levels for N, reflecting an accumulation of unused nitrate-N in soils (Mengel, 2011, K State Extension Agronomy e-update No. 315). Any unused S or Cl^- will also likely remain in the top foot or two of the soil profile. Nevertheless, among the first tools farmers should think about when planning their 2012 fertilizer program is a deep profile soil test for N, S, and Cl^-.

When immobile nutrients such as P, K, and Zn are applied to the soil, they interact with different constituents of the soil and are retained. Phosphorus reacts with the clay surfaces and the Fe and Al coatings found on soil particles and is sorbed to those surfaces. Sorption reactions occur in stages, and the initial stages are highly reversible. This is part of a buffering system which maintains a constant small quantity of P in the soil solution and supplies P needed for good crop growth. Phosphorus applied in 2011 that was not taken up was likely sorbed onto clays and other minerals creating a new equilibrium in the soil and to some extent increasing soil test values for P. The carryover and probable resulting higher soil test P values should be considered going into 2012.

Potassium is a charged cation (K^+) which is attracted to and retained on the soil's CEC. Exchangeable K maintains a constant supply of K in the soil solution to support plant growth, and like P it is a part of a highly buffered system. Potassium applied and not taken up by the 2011 crop should remain available for 2012, and should be reflected in a somewhat higher K soil test value.

With Zn, a third mechanism, chelation, occurs and retains applied Zn. Soil organic matter is a strong natural chelating agent. Zinc sulfate added to soil slowly dissolves. A portion reacts with the organic matter and is retained in soluble, natural organic matter chelates. The vast majority of the Zn that moves to plant roots for uptake is present as a natural soil organic matter chelate.

The bottom line for drought affected areas is that it is likely that there will be carryover of nutrients applied in 2011 into 2012. Soil testing is an important tool in determining the extent of carryover. The mobile nutrients (N, S and Cl^-) need to be measured using a deep profile test (at least 2 ft. depth), while the immobile nutrients (P, K, and Zn) can be measured using a surface sample (6 to 8 in. depth). For an expansion of this topic see the recent IPNI Insights newsletter for the South and Central Great Plains at: http://www.ipni.net/insights.

–WMS–

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Abbreviations: N = nitrogen, P = phosphorus, K = potassium, S = sulfur, Cl^- = chloride, Zn = zinc, CEC = cation exchange capacity, Fe = iron, Al = aluminum.

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