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

From Scientific Staff of the
International Plant Nutrition Institute (IPNI)
3500 Parkway Lane, Suite 550
Norcross, Georgia 30092-2844 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

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THE RIGHT TIME TO TEST

The right time to take soil samples is in rhythm with the crop rotation. Normally it's best to sample following the same crop, giving a consistent basis for comparing fields and picking out trends over time. Most samples are taken in late summer and fall, to allow ample time for planning a crop nutrition program based on the 4Rs—right source, rate, time, and place. But, with this year's drought, is fall sampling still a good idea? There are several reasons why it is.

Severe drought reduces the crop's uptake and removal of nutrients. The effect on the soil test is not likely to be large. Leftover nutrients from a typical corn crop might increase soil test levels by 3 to 5 parts per million for P and K, assuming the worst-case scenario with nothing harvested from the field. If the drought cuts yield in half, the increase is likely to be smaller. And leftover nutrients that show up in the soil test are likely to be available to the next year's crops.

Of course, nutrients can also change chemical forms when the soil dries out. But it can be hard to predict whether their availability will increase or decrease. Generally, soil test K increases as a soil dries, so we expect to see higher levels in samples taken during a drought. Most laboratories dry all their samples before testing, but some use a field-moist sample for K analysis. The drought difference is likely to be larger for the latter. In general, however, a recent sample affected by drought is a better basis for next year's crop nutrition program than a sample that is older than the typically recommended sampling interval of 3 or 4 years.

Are soils being sampled often enough? It seems—on average—that most cropland is sampled about as often as is recommended. In the Northeast USA, including states from the watersheds of the Chesapeake Bay and the Great Lakes, the number of samples represented in the 2010 IPNI Soil Test Summary (http://info.ipni.net/IPNI-3186) amounted to one for every 45 acres of census cropland. That's more intensive than what is generally recommended—one sample from every 25 acres every three years translates into one sample from every 75 acres each year. But included in this average are the more intensive sampling schemes of many practitioners of precision agriculture (with each sample representing as little as an acre). So while most of the cropland gets sampled often enough, there still may be a portion that could be sampled more often.

What's more important is what the soil test shows. While the distribution of soils testing below, in, and above the optimum range varies by region, most states in the Northeast and most provinces in Eastern Canada still show a substantial portion of soils testing below and above the optimum range, for both P and K. Obviously, this is not because the soils aren't being sampled. Non-optimal soil test levels persist partly because recommendations are not being followed. Sampling more frequently than once every three years will not change these soil test levels. Following the soil test-based recommendation moves most soils into the optimum ranges for both P and K, and keeps them there.

Sampling soils more often than once every three years won't reduce losses of P in runoff either. Soils testing above the optimum range may increase risk of P loss to some degree. Fertilized at rates below crop removal, such soils will decline in soil test P. Sampling once every three years will suffice to track and prevent a decline below the optimum range.

4R Nutrient Stewardship also encourages the tracking of crop nutrient balances. Recommendations from a soil test often relate to crop removal: the basic recommendation is to apply more or less than crop removal for soils testing below or above, respectively, the optimum or maintenance range. Also, there is always some uncertainty with both soil testing and with nutrient removal information. Doing both increases confidence because the uncertainties in each tend to cancel each other out.

Soil testing should proceed as usual this fall. The opportunities in a dry year will probably be better than in a wet year. Considering current prices for fertilizers and crops, you can't afford to miss this one!

– TWB –

For more information, contact Dr. Tom Bruulsema, IPNI Northeast Director, Phone: (519) 835-2498. E-mail: Tom.Bruulsema@ipni.net.

Abbreviations: P = phosphorus; K = potassium.

Note: ***Plant Nutrition TODAY*** articles are available online at the IPNI website: www.ipni.net/pnt

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POTASSIUM IN NORTHERN GREAT PLAINS SOILS

The soils of the Northern Great Plains tend to be geologically young soils because soil development has only occurred over the past 10,000 years or less since the last glaciation. This is in contrast to many soils in other regions of the world that can be hundreds of thousands, to millions of years old. One plant nutrient that tends to occur in relative abundance in the Northern Great Plains is K. This is because soil minerals have developed from rock containing naturally high levels of K. Northern Great Plains soils tend to be only slightly weathered due to the short time of soil development, the cooler climate, and only moderate amounts of precipitation. This can be in contrast to highly weathered tropical soils. Time, moisture, and warm temperatures cause weathering of tropical soils and release K from the soil minerals that leach out of the soil. Many of these weathered soils require large K fertilizer additions (e.g. at least 100 lb K_2O/A) to achieve high-yielding crops.

Knowledge of two soil analysis measurements, cation exchange capacity (CEC), and base saturation (BSat), can be used together to give an indication as to how much K may be available in a soil. CEC is a measure of how much positively charged ion (cations) a soil holds primarily on its clay-sized particles. A very low CEC is in single digits (e.g. 1 to 5 cmol/kg) compared to a high CEC soil with a CEC from 20 to 30 cmol/kg. BSat is a measure of what portion of CEC is occupied by the base cations Ca^{+2}, Mg^{+2}, K^+, and Na^+, expressed as a percentage. Other cations that can be a portion of the CEC that are not base cations are Al^{+3}, Fe^{+3}, and H^+. Generally, a soil with a greater CEC and high BSat, with ample K present, will have a neutral-to-alkaline soil pH and higher amounts of plant available cations.

The most common soil texture and parent material in the Northern Great Plains is a clay loam, formed from glacial till. Glacial till tends to have a homogeneous mixture of clay, silt, and sand-sized particles due to the grinding and mixing action of glacier ice. On this type of soil, K fertilization rates tend to be only 5 to 15 lb K_2O/A applied in the seed-row for a small grain crop. However, not all soils are clay loams. After glaciation a portion of the landscape was modified by flowing water and by wind movement of soil particles. These forces sorted the glacial deposits into different soil textures, some with greater proportions of sand (coarse-textured), some with greater proportions of silt (medium-textured), and some with greater proportions of clay (fine-textured). The proportions of sand, silt, and clay-sized particles greatly affect the CEC and available base cations of a soil. It is important to know what dominant texture a farmer has in a field and how this may affect the rate of K fertilization.

The Table below compares two Northern Great Plains soils located only 20 miles (32 km) apart in south central Alberta. The coarse-textured sandy loam soil has a CEC of 4, and available K of 66 lb K/A, compared to the clay loam soil that has a CEC of 21 and available K of 1,090 lb K/A. An average fertilizer K rate for the sandy loam soil is about ten times greater compared to the K rate for the clay loam soil. It is recommended that a more accurate fertilizer K rate be developed for a specific soil and field by using soil testing and analysis, along with a recommendation developed by a qualified crop adviser.

Table 1. Location of soil, soil texture, parent geologic material, percentages sand, silt and clay, CEC and plant available Ca, Mg and K, and common K fertilizer rate, on two nearby soils.

Nearest town	SoilTexture	Parent material	Sand, %	Silt, %	Clay, %	CEC, cmol/kg	Plant available cations, lb nutrient/A (24 in or 60 cm)			Fertilizer K rate, lb K_2O/A (50 bu/A wheat)
							Ca	Mg	K	
Strathmore, AB	Sandy loam	Sorted sands	75	5	20	4	2,620	780	66	50
Rosebud, AB	Clay loam	Glacial till	45	22	33	21	13,300	1,620	1,090	5

– TLJ –

For more information, contact Dr. Thomas L. Jensen, Northern Great Plains Director, IPNI, Phone: (306) 652-3535. E-mail: tjensen@ipni.net.

Abbreviations: Ca = calcium; Mg = magnesium; K = potassium; Na = sodium; Al = aluminum; Fe = iron; H = hydrogen.

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WHERE DOES NITROGEN FERTILIZER COME FROM?

Nitrogen is one of the most widely distributed elements in nature since it is the most abundant gas in the atmosphere. But N is not found in mineral forms like P or K, but is largely present in organic compounds. When it is present in the soil, it is subject to many complex biological transformations that make it challenging to manage.

Nitrogen is essential for many metabolic processes in plants and animals. Perhaps the best-known role of N is in forming amino acids, which are the building blocks for protein. The human daily protein requirement ranges between 40 to 70 grams, depending on gender, age, and size.

Since the Haber-Bosch process for synthesizing N fertilizer was developed early in the 20th century, it's importance in maintaining the global food supply has rapidly grown. It is estimated that half of the food produced now in the world is supported by the use of N fertilizer. Another way to look at this is that inside every cell, protein, or DNA molecule in your body, on average half of the N is a product of the Haber-Bosch process from a N fertilizer factory.

All N fertilizer begins with a source of hydrogen gas and atmospheric N that are reacted to form ammonia. The most-used source of hydrogen is natural gas (methane). Other sources of hydrogen, such as coal, are used in some regions. After hydrogen and N are combined under conditions of high temperature and pressure to form ammonia, many other important N-containing fertilizers can then be made. Urea is the most common N fertilizer, but there are many excellent N fertilizers that can be made from ammonia. For example, some ammonia is oxidized to make nitrate fertilizer. This same conversion of ammonia to nitrate takes place in agricultural soils through the microbial process of nitrification.

Because the production of hydrogen gas required for the synthesis of ammonia largely comes from natural gas, the price of this primary feedstock is the major factor in the cost of ammonia production. Ammonia factories sometimes close or open in various parts of the world in response to fluctuating gas prices. Higher energy costs always translate into higher prices for all N fertilizers.

There are a number of organic sources of N that are commonly used to fertilize crops. But remember that much of the N in animal manure, composts, and biosolids come from crops that received applications of fertilizer N. Therefore, the N in many organic fertilizers originated as inorganic N fertilizer.

Nitrogen fertilizers clearly make an essential contribution to maintaining an adequate supply of nutritious food. However, careful management is required to keep N fertilizer in the form and in the location where it can be most useful for sustaining healthy plant growth. The tremendous benefits from N fertilizer must be balanced with the disruptive environmental impacts that may arise when N moves into areas where it is not wanted.

A visual tour of the N fertilizer production process can be seen at: http://npg.ipni.net/article/NPG-3003

– RLM –

For more information, contact Dr. Robert Mikkelsen, Western North America Director, IPNI, Phone: (209) 725-0382. E-mail: rmikkelsen@ipni.net.

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

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DROUGHT: FERTILIZING FOR THE NEXT CROP

Drought. The impact on crop production has been sobering, but more than yield has been affected. The cycle of every nutrient has also been impacted. This year, taking measurements is more important than ever in 4R Nutrient Stewardship programs.

Compared to seasons with normal rainfall, residual soil nitrate can be higher after a drought where N was applied to a cereal crop. Higher levels arise from decreased downward movement of soil water and from reduced fertilizer N uptake by the drought-stressed plant.

Whether or not residual N will be available for next season's crop depends greatly on the precipitation that occurs after harvest. In the Midwest, precipitation occurring early in the following season is associated with higher losses of nitrate in tile drainage. Soil nitrate tests are the best tool for assessing the quantity of residual soil N available to the next crop. Additionally, cover crops can be planted after harvest to take up some of the residual nitrate and protect it from environmental losses.

In many areas, crops originally intended for grain harvest were cut instead for forage. The change from harvesting grain to harvesting most of the aboveground portion of the plant changes how much of each nutrient is removed. If grain was harvested as planned, grain nutrient concentrations of drought-stressed crops may or may not differ from unstressed plants, depending on the crop as well as the timing and severity of water deficits. Tissue testing of harvested crop portions is essential this year to determine changes from planned nutrient removal. This is especially important for P and K.

Very little data exist on how N credits are affected for cereals grown after legumes under drought conditions. If drought occurred during the growth of the legumes, it is hypothesized that more residual nitrate will exist in the soil, since legumes often scavenge soil nitrate under normal growth. How drought affects the amount of readily mineralizable N from root exudates is not well quantified. However, legumes are regularly used in arid areas to provide N to cereal crops, so it seems reasonable to take some to all of the N credit used normally.

Soil tests after a drought may contain some unexpected variance when compared with tests from more normal years. The immobile nutrient most sensitive to environmental conditions during sampling is K. Lack of rainfall reduces the leaching of K from plant tissues prior to sampling, which can reduce soil test results. Additionally, soil mineralogy can either increase or decrease the amount of available K under drought conditions. Taking soil samples in a drought year and looking at the changes can provide valuable data for improved interpretation in future years when dry conditions strike again.

The impacts of drought on crop nutrition are profound. Soil testing and plant analysis remain our best tools to quantify these impacts to adjust nutrient management for the next crop. Discussing analytical results with a trusted and knowledgeable agronomist ensures informed strategies can be created to meet local conditions.

For more information from IPNI on nutrient management following a drought, visit http://www.ipni.net.

–TSM –

For more information, contact Dr. T. Scott Murrell, Northcentral Director, IPNI, Phone: (765) 413-3343. E-mail: smurrell@ipni.net.

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INTEGRATING 4R NUTRIENT STEWARDSHIP AND PRECISION AGRICULTURE

In his keynote address at the 11th International Conference on Precision Agriculture, Dr. Newell Kitchen, USDA-ARS, highlighted the significant role that nutrient management plays in the industry. "Nutrient management has been a starting point, the seedbed of a lot of the concepts where we got going [in precision agriculture]." He noted that in the early years of the conference, as many as 70% of the papers presented dealt with nutrient management. That number continues to be around 50% and may increase in coming years as options for precision nutrient management continue to grow.

The history of precision nutrient management can be thought of as having occurred in three phases: adaption, integration, and accountability. Dr. Kitchen pointed out that early on, we basically took what we knew about nutrient management and applied a spatial component to it. The precision agriculture movement really started to expand and overcome many of the short-comings of the adaption approaches when existing knowledge began to be integrated with new technologies. He cited the use of crop canopy sensors as an example of the growing options for precision nutrient management created by integrating real-time spatial and temporal information into the decision-making process.

4R Nutrient Stewardship is another example of integration in nutrient management. Dr. Kitchen acknowledged that the ideas of applying the right source at the right rate, at the right time, and in the right place have always been fundamental in our understanding and application of soil fertility and plant nutrition. However, the language, descriptiveness, and holistic emphasis put forth in the 4R's is unique and fresh and that "precision agriculture is woven into many of the concepts of 4R stewardship". He also said, "Precision science and technologies allow us to emphasize [the 4Rs] all at the same time; to wrap our arms around the concepts in a way that we can move forward in a meaningful way."

Precision agriculture tools can provide the feedback and recordkeeping necessary for the accountability that is needed in nutrient management. The inclusion of accountability is another way 4R stewardship moves beyond traditional nutrient management. One of the main ways this is accomplished is through the inclusion of a dynamic feedback mechanism. In the past, nutrient management has been linear, mostly from the top down, with no feedback nor any assessment of changes in practice. 4R Nutrient Stewardship provides the framework for stakeholder involvement at the farm, regional, and policy-making levels and precision agriculture tools can provide feedback to all of these positions. The use of performance indicators as an objective evaluation of management practices, which can increase the level of accountability that is important to most all stakeholders, can also be done more accurately and effectively using precision agriculture technologies. Dr. John Fulton, Auburn University, echoed Dr. Kitchen's feelings on accountability in nutrient management in his presentation by stating, "I really think there should be a 5th 'R', right recordkeeping."

Integrating precision agriculture and 4R Nutrient Stewardship enhances our ability to meet the sustainability goals of crop production systems. As more growers adopt precision technologies for guidance, variable-rate control, data collection, and information management, their ability to apply the right nutrient source, at the right rate, at the right time, and in the right place increases considerably. This integration also enhances feedback among stakeholders and increases the confidence that the economic, environmental, and social challenges that face agricultural production can be viewed as opportunities to further advance nutrient management. When we, as an agricultural community commit to this approach, we will begin to change people's attitudes about nutrient management and find, as Dr. Kitchen stated in his closing remarks, "a great frontier ahead of us."

– SBP –

For more information, contact Dr. Steve Phillips, Southeast Director, Phone (256) 529-9932. E-mail: sphillips@ipni.net.

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DROUGHT, NITROGEN AND WATER QUALITY?

Mother Nature pummeled farmers across the U.S. this summer; crops wilted and collapsed, soils parched, and some streams faded to trickles. Important N management questions faced by farmers suffering through this drought are:

- How much of my applied N is left in the soil profile this fall?
- How much of that N will remain in the soil until next spring?
- What can I do to prevent loss of the residual N from the field?
- How do I adjust my fertilizer N rates for the next crop?

Plan now to collect samples to at least 2 to 3 feet deep in most soils, and analyze the samples for nitrate-N. Since it is difficult to manually insert and extract a soil probe to this depth, consider collecting samples with the aid of a hydraulic or powered sampler. If samples are collected in a nominal depth increment (e.g. 6 inches), one can identify where the concentration of nitrate is in the soil profile, and use that information to determine both risks and magnitudes of loss from the root zone.

Nitrate-N is very mobile and will move readily with the wetting front through the soil. We typically think of sandy soils as being more conducive to nitrate leaching loss, but when clayey soils shrink and large cracks form upon drying, any nitrate adjacent to those voids can move downward readily with the first pulse of a good rain. One must consider the way water infiltrates the soil, the permeability of the soil, and the soil drainage characteristics to estimate potential nitrate leaching losses. If heavy rains fall between this fall and spring, and the soil is underlain by tile or a subsurface drainage system, then a large portion of that nitrate can be lost to streams and waterways. Information on water holding capacity, soil permeability, and other physical characteristics of your soil type(s) can be found at your local NRCS office, or on-line at their website (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm). If a silt loam soil contains 1 to 3 inches of available water per foot, and the soil is near wilting point, and 10 or more inches of rain occurs between fall and spring, then it is possible for the rainfall infiltration and wetting front to push any nitrate at least 36 to 48 inches downward in the soil profile.

USDA ARS research in central Iowa has shown that a winter cover crop of wheat following corn can reduce tile drain nitrate-N losses by as much as 60%. Vigorous cover crop growth can result in uptake and retention of more than 40 to 60 lbs of N/A; with N savings alone valued at more than $15 to $25/A. A good cover crop can serve as a "N bank", and release the plant N via soil decomposition of crop residues, after the cover crop is mechanically or chemically terminated. Besides conserving N, good cover crops can protect water quality.

Many will want to consider collecting profile nitrate-N samples in the spring near planting time or shortly thereafter, to verify the soil nitrate supply for appropriate adjustment of fertilizer rates. As always, seek the advice of your Certified Crop Adviser, agricultural consultant, or Extension specialist to make your cover crop and N management decisions.

– CSS –

For more information, contact Dr. Clifford S. Snyder, Nitrogen Program Director, IPNI, Phone (501) 336-8110, E-mail: csnyder@ipni.net.

Abbreviations: N = nitrogen.

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DROUGHT AND FERTILIZATION

Drought is a simple and unfortunate fact of life that agriculture must endure from time to time. Those who went before us endured these times, in fact my aged father, a retired producer, still talks about the drought of the ‘50s. A multi-year event memorialized in the novel “The time it never rained”. And just as sure as those who went before us endured and survived, so will we.

Last year the Sept. 22 US Drought Monitor Map showed severe to exceptional drought covering the entire states of Texas and Oklahoma, most of New Mexico, eastern Colorado, and southern Kansas, while Nebraska was unaffected. So far this year the conditions have shifted somewhat as a low pressure system brought needed rain in July to areas in the southern part of the Southern and Central Great Plains Region, but for the most part conditions are still tough, with the majority of the six state region still affected by some degree of drought.

Given last year’s extreme conditions, the topic of drought and fertilization was addressed in this publication series (Fertilization after drought, Winter 2011-2012 No. 7 http://www.ipni.net/pnt) and in a more in-depth Insights newsletter (Nutrient management after drought, Nov. 2011 http://www.ipni.net/insights). This current article is meant only to point out a few basics when considering drought and fertilization. For more detail on the subject refer to the publications mentioned above or see some of our other Insights newsletters planned for release in 2012.

A good starting question to ask when crops have been affected by drought is: how much nutrient export was there from crop harvest? If corn, sorghum or other crop biomass was baled, then nutrient removal will be different than if grain were harvested as normal, and stalks remained. If nothing was harvested then of course exportation is zero. Where this (zero removal) is the case the majority of the fertilizer applied should still be in the system moving forward—either in the soil or in crop residue. So some carryover or credit for the next crop will be likely.

Soil testing to determine the nutrient status of fields where crops were drought impaired is a good idea. It is also good to consider the amount of nutrients present in the residue remaining, and how quickly those nutrients will become available to crops. Nutrients carried over in drought-affected areas 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

Among the first tools farmers should think about when planning future fertility programs is a deep profile (at least 2 foot depth) soil test for the mobile nutrients, especially N. It is likely that some N will remain in the profile for use by the subsequent crop, and a soil test is the best way to tell. The immobile nutrients (e.g., P, K, and Zn) can be measured using a surface sample (6 to 8 inches depth). With P the availability and carryover is not always clear-cut, as P reacts in some soils to become less available over time; but, again soil testing is the best tool we have to make the determination. Potassium usually has a high carryover potential, since in all but a few specific cases its remains available over time.

The bottom line for drought-affected areas is that it is likely that there will be carryover of nutrients applied, and given the stressful circumstances it is advisable to make an effort to account for residual nutrition. Soil testing remains one of the best tools available for the job.

– WMS –

For more information, contact Dr. W.M. (Mike) Stewart, Southern and Central Great Plains Director, IPNI, Phone: (210) 764-1588. E-mail: mstewart@ipni.net.

Abbreviations: N = nitrogen; P = phosphorus; K = potassium; Zn = zinc.