IPNI
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 30092-2806 USA
Phone: 770-447-0335 Fax: 770-448-0439
E-mail: info@ipni.net Website: www.ipni.net

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CONNECTING FERTILIZER MANAGEMENT TO SCIENCE

Crop advisers promote best management practices for fertilizer use. Everyone supports the concept of applying the right source at the right rate, time and place, but determining what is "right" is not a simple matter. Society has high expectations for progress on environmental sustainability issues associated with producing sufficient safe nutritious food. A framework to connect fertilizer management to science is essential to such progress.

Best management practices contribute to four objectives. To evaluate what is "best" or "right," each practice's influence on productivity, profitability, sustainability, and environmental health needs science-based assessment. Progress toward these four interconnected objectives benefits both producers and the public. Let's look at what each entails.

1. **Productivity.** It means more than crop yield per acre. Total factor productivity includes yield per unit of labor, water, nutrient, energy, and machinery inputs as well. The level of each input influences the productivity or efficiency of the others.
2. **Profitability.** No cropping system can keep going without it. Profitability is one measure of the value of a system's output to society. Both producers and their local economy depend on crops producing profits.
3. **Sustainability.** Essentially, productivity in the long-term. It's been defined as a cropping system in which output does not decrease when inputs are not increased. Today's real-world situation demands continuously increasing outputs—and inputs. Soil quality, in terms of both fertility and physical structure, is key to sustainability.
4. **Environmental health.** It's the total impact of the cropping system on the surrounding ecosystem. Both producers and the public value ecosystem services such as clean water, clean air, and natural biodiversity.

How do we ensure that fertilizer management contributes to all four objectives? We need multiple indicators of performance. For example, recent research in Ontario, Canada showed that tomatoes grown with fertigation management had higher optimum N rates. This finding was counter to expectations, since the higher N use efficiency (a single indicator) associated with fertigation was assumed to justify lower rates. The assessment of a higher optimum being "right" depended on a more complete set of measured indicators including higher yields and quality, and acceptable values for crop N recovery and residual soil nitrate.

So what's the role of science? When best management practices are evaluated, good science relates their impact to all four objectives. Such science includes general principles relating to the comprehensive measurement of system output changes, and specific principles relating to the disciplines of crop and soil sciences. These principles determine a balanced set of indicators reflecting progress toward the four objectives.

The science is not complete. The evaluation of some practices has gone no further than yield and profit. Others have been assessed for only a single specific impact on the environment. Continuing research—on-farm, at the experiment station, and in the laboratory—needs to define and document the right source, rate, timing and placement for fertilizer use in each cropping system. Increased public and private investment into such research is key to meeting society's high expectations.

Further information on a global framework connecting fertilizer management to science is available at the IPNI website: >**www.ipni.net/conceptpapers**<.

—TWB—

For more information, contact Dr. Tom Bruulsema, Northeast Director, IPNI, 18 Maplewood Drive, Guelph, Ontario N1G 1L8, Canada. Phone: (519) 821-5519. E-mail: Tom.Bruulsema@ipni.net.

Abbreviations in this article: N = nitrogen.

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THIRD-PARTY SOIL SAMPLING: IS THIS THE WAY OF THE FUTURE?

Soil sampling and testing is one of the best tools we have to assess field nutrient availability. In the small grains growing area of the Northern Great Plains, only 10 to 15% of fields are soil tested annually, and only 25% are soil tested every few years. The exceptions are areas of specialized crop production, like sugar beet or potato fields where soil testing is a mandated part of the grower contract with the processing company. Because of increasing grain and fertilizer prices, there is a growing demand for more soil samples to be taken in order to fine tune fertilizer recommendations and assist in maximizing net returns.

Why are more fields not soil tested? Farmers usually don't have time to do their own soil sampling, especially as the size of farms continues to increase. Also fertilizer retail locations have reduced their services because of insufficient staff. In some cases, soil samples are taken by consulting agronomists who have them analyzed by a soil test laboratory, and provide the fertilizer recommendation. The challenge for these agronomists is that soil sampling is time consuming and there is a limitation on how many fields they can realistically sample during the fall and spring seasons.

Who has the capability to do more soil testing? A growing trend is to have the sampling done by independent "third-party" soil sampling companies. These businesses specialize in soil sampling and are separate from the fertilizer retailer and the consulting agronomist. Their clients consist of a mix of direct farm customers, retail fertilizer companies, and even consulting agronomists. They are usually a one-person business operating within a limited geographic area such as a few adjacent counties or rural municipalities.

What is the advantage of using a third-party soil sampler? They are specialized and know how to efficiently sample fields and they invest in good soil sampling equipment and associated location fixing global positioning systems (GPS) and they take the required number of soil cores (i.e. 15 to 20 cores per composite sample) to achieve a statistically representative sample, because soil sample quality or accuracy is important in order to maintain client trust and continued business.

How expensive is it to have soil sampling done? Fertilizer retailers used to offer soil sampling as a "free service" as long as the customer purchased the fertilizer from that specific retailer. In reality, the service was never free, but was paid through an increased margin between wholesale and retail prices. Today, most retailers charge for soil sampling and testing as separate services. The exact price varies from one area to another and depends on sampling methods. With rising fuel costs the cost of having soil sampling done by a third-party soil sampler is expected to increase. The prices charged are usually quite reasonable when you consider the time it takes, the cost of equipment and travel distances…a good investment.

How many fields can a one-person soil sampling business sample in a year? Field time is the main limitation for soil sampling in the Northern Great Plains, with about two-thirds of the sampling being done in the fall after harvest and before freeze-up and one-third in the spring before planting. In an average fall and spring period there are about 40 suitable field days to take soil samples. In a 10 to 12-hour day about 20 fields can be sampled, consisting of 15 cores per field for a total of 300 soil cores. This is if the fields are within a relatively close proximity, e.g. 20 miles (30 km).

Consider hiring the services of a third-party soil sampling business. Having accurate soil test results can help formulate adequate while not excessive rates of fertilizer to be applied to individual fields. This allows growers to maximize their net income and minimize addition of excess nutrients.

—TLJ—

For more information, contact Dr. Thomas L. Jensen, Northern Great Plains Director, IPNI, 102-411 Downey Road, Saskatoon, SK S7N 4L8. Phone: (306) 652-3535. E-mail: tjensen@ipni.net.

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CATCH THE DRIFT OF AMMONIA

With the renewed emphasis on getting the most benefit out of fertilizers, no one wants to lose ammonia from applied N fertilizer. Research has given us excellent management tools for keeping ammonia where it belongs…in the soil. This includes using the right form of N fertilizer, placing it in the proper place, avoid leaving urea-based fertilizers on the soil surface, and even using additives when appropriate. Farmers are very concerned with avoiding the loss of a valuable crop input.

Ammonia is also a concern for air quality in many locations. When emitted to the air, ammonia reacts with oxides of nitrate and sulfate in the atmosphere to form very fine particles…called particulate matter (PM) of 2.5 microns or smaller---PM 2.5. Fine airborne particles can come from a variety of sources, but they can pose a respiratory problem for some individuals. These small particles travel deep into the lungs and can irritate people with asthma or respiratory problems.

Depending on the location, there can be multiple sources of ammonia volatilizing into the atmosphere. Common sources of ammonia include livestock, fertilizer, soils, forest fires, industry, vehicles, oceans, humans, pets, wild animals, and waste disposal activities. Of these sources, livestock is by far the single largest source of atmospheric ammonia in the United States. There is still uncertainty about the absolute amount of ammonia released from these various sources, but new measurement techniques and assessment are improving these estimates.

Emission of ammonia from agriculture is a growing area of concern to regulators. There are many management practices that can be used to reduce volatile losses from fertilizer. When fertilizer is properly managed, ammonia losses from susceptible fertilizers are very small. However, to reduce ammonia emissions from animals, the solutions to reducing ammonia loss are more complex. For example, animal ammonia emissions can arise from barns, pastures, waste storage facilities, or from manure spread on crop land, each requiring different management practices.

There are currently no regulations governing the release of ammonia from fertilizers or manures, but future policies and control measures appear likely as public awareness of this issue grows. Use every opportunity to keep ammonia on-farm and in the soil where it can help nourish crops.

—RLM—

For more information, contact Dr. Robert Mikkelsen, Western North America Director, IPNI, 4125 Sattui Court, Merced, CA 95348. Phone: (209) 725-0382. E-mail: rmikkelsen@ipni.net.

Abbreviations: N = nitrogen.

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KEEP A LOG OF SOIL ACIDITY

Applying N again this year? Chances are you applied N on the same field last year – that is, if you're one of the many farmers planting more corn after corn. In the Midwest, much of the additional corn acres are coming from ground that used to be rotated to soybean production every other year. So now, instead of applying N once every 2 years, many are applying N every year.

Nitrogen acidifies the soil. Whether the source is urea or anhydrous ammonia, the acidifying effect is the same. A rule of thumb is that for every 100 lb of N applied, enough soil acidity is produced to require 225 lb of agricultural limestone. Does that mean you need to apply 225 lb? Probably not. But applying N more frequently increases the chances that soils will become more acid more quickly.

Soils differ in how they respond to the acidifying effects of N fertilizers. Some soils will be very sensitive, such as sands, and others, like silt loams, will not change as much. If you want to find out just how much agricultural limestone is needed, take a soil sample and send it to a reputable laboratory. They will run a test that determines how well the soil is able to buffer changes. This test is often reported as "buffer pH" on the soil test report. The laboratory compares this test result with calibration data to determine how much agricultural lime should be applied.

A ton is not a ton. Often, when people see that a ton of agricultural lime is recommended, they apply a ton of limestone. If only it were that easy. Here's the twist. Not all limestone has the same chemical makeup. Some limestone sources contain more impurities or are not as finely ground as others. Both the purity and the fineness of a particular source are used to adjust the rate from the one recommended to the one that actually gets applied. Soil test reports usually contain guidance on how to calculate this adjustment and university Extension publications do, too. The bottom line – if a source has more impurities and is more coarsely ground, that one ton of lime recommended on the soil test report will need to be more than one ton of agricultural limestone that actually gets applied.

Soil acidity affects how plants respond to nutrient applications. Generally, when soils are too acid, crops grown on them make poorer use of the nutrients applied. So keeping soil acidity in check can improve the economic returns to other applied nutrients.

Monitor changes in soil acidity over time. If you soil test only occasionally, consider picking out a couple of areas to sample every year. Look at how the soil pH and the recommended lime rates change with time. Consider doing this on fields that have just been limed as well as those that haven't. Keeping a log of soil acidity will help you gain insight into how quickly your soils become more basic after a lime application as well as how quickly they become more acid when N is applied more frequently.

—TSM—

For more information, contact Dr. T. Scott Murrell, Northcentral Director, IPNI, 2422 Edison Dr., West Lafayette, IN 47906. Phone: 765-463-1012. E-mail: smurrell@ipni.net.

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Summer 2008, No. 5

THE TIME IS RIGHT FOR PRECISION AGRICULTURE TECHNOLOGIES

Precision agriculture technologies have not always been economical for small to medium-sized farming operations. However, with precision agriculture equipment becoming less expensive, tools such as guidance systems, yield monitors, and variable-rate fertilizer applicators may now be profitable for nearly all growers. The rising costs of inputs and higher commodity prices considerably increase the risk of making the wrong management decision. Thus, even small farms can profit from using technologies that improve production efficiency.

Some technologies, like RTK auto-steering, can improve efficiency without changing management practices. Using a GPS-guided steering system can eliminate sprayer overlaps and planter skips that can result in lower profits. The magnitude of savings depends on how well the grower was doing without the guidance system. Considering an example from an Ohio State University extension article, a grower using row or foam markers on the planter and sprayer, conservatively speaking, might be farming 102 acres in a 100-acre field. This extra area might not seem significant, but when one considers that this translates into spending 2% more on all associated inputs such as seed, fertilizer, pesticides, fuel, and labor, even small application errors can become quite costly. An RTK guidance system with 1-in. driving accuracy can eliminate this risk.

Despite the fact that yield monitors have been around over a decade, many growers still don't fully understand how to use them to improve farming efficiency. This lack of knowledge is being actively addressed in a series of extension programs and classroom courses developed at North Carolina State University. This training involves on-farm demonstrations, hands-on classroom training using "Virtual Yield Monitor" custom software, and introduction to spreadsheet-based analysis of yield monitor data, yield-limiting factors, and potential changes in management that could increase yield. Efforts like this provide growers the knowledge needed to fully utilize yield monitor technologies to better manage on-farm spatial variability.

Variable-rate fertilizer applications have been shown to improve efficiency and increase profits in many grower fields. Several universities and USDA-ARS research units have developed strategies for using on-the-go, sensor-based applicators to improve fertilizer use efficiency. Profits have come in the form of increased grain yields without increasing total nutrient inputs or as sustained production at lower input levels. Most of these systems consider both spatial and temporal variability, which can affect production. Current work is focused on incorporating additional layers of data such as real-time weather, soil EC, and other spatial information into the processes used to determine fertilizer application rates.

Precision management pays more now than ever. Current grain and fertilizer prices greatly increase the value of precision agriculture technologies. The information generated using precision agriculture equipment and the decisions based upon it can help mitigate the growing risk of yield loss. To learn more about precision agriculture technologies, consider attending the 9th International Conference on Precision Agriculture (ICPA) in Denver, Colorado, July 20-23, 2008. The ICPA will provide a forum for presentations on the current state of precision agriculture research and applications. Also, dedicated sessions for practitioners entitled "Precision A to Z Tracks" will offer practical advice from international authorities on key topics of precision agriculture for producers and professionals. Visit the website: **www.icpaonline.org**.

—SBP—

For more information, contact Dr. Steve Phillips, Southeast Director, IPNI, 3118 Rocky Meadows Road, Hampton Cove, AL 35763. Phone (757) 787-4045. E-mail: sphillips@ipni.net.

Abbreviations: RTK = real time kinematic; GPS = global positioning system; EC = electrical conductivity.

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BUILDING YIELD POTENTIAL IN A FLAT WORLD

When Thomas Friedman wrote his best-selling book, *The World is Flat*[1], it is unlikely that crop production was the center of his thinking. Yet the 10 "flatteners" that have leveled the global playing field, as presented in this "brief history of the 21st century", apply very well to improving yields for today's global agriculture industry. They are listed below.

1) **Collapse of the Berlin wall**. As the symbolic end of the Cold War, this event opened a whole new section of the world as a new market for international trade…including agriculture.
2) **Netscape**. This software package unlocked the power of the Internet to literally the whole world. The explosion of communication potential that resulted suddenly broke down barriers to knowledge exchange, facilitating unprecedented sharing of information about crop conditions, production practices, technology, weather, yields, etc., with neighbors across the section or around the globe.
3) **Workflow software**. Machine to machine communication has been more subtle in agriculture, but is having an impact. From on-board networks built into tractors and harvesters to international networks for grain trading, farmers are impacted by this technology that Friedman called the "crude foundation of a whole new global platform for collaboration". We are just beginning to see its potential.
4) **Uploading**. Consultation and support are no longer limited to the local Extension office or local dealers. Farmers today regularly get help from "communities" of specialists half a world away…and may not even know it. Technology providers have to maintain 24/7/365 support for a global customer base.
5) **Outsourcing**. Farmers, traditionally proud of being self-sufficient, are moving toward doing what they do best, and outsourcing the rest, and gaining efficiency and profit in the process.
6) **Offshoring**. This one may seem like a stretch, but a growing number of U.S. growers are investing in…and even operating…farms in other countries. And the reverse is happening as well.
7) **Supply chaining**. Technology is changing the picture of where our grain is sold, how it gets there, and the infrastructure of getting inputs to the farm. Gains in efficiency and globalization go directly to the bottom line of the balance sheet.
8) **Insourcing**. Efficiencies are also gained by combining services, or having service performed by non-traditional agents. Quicker response time, more efficient use of labor, and other benefits accrue to the farmer.
9) **In-forming**. Information is power, even in crop production. The Internet and the information services it brings to the farm office---or tractor cab---are unlimited. Information comes not just from the local sources, but literally anywhere in the world. Results from research, or new product specifications, can literally be in the farmer's hands the moment they are released. Global access to science and experience.
10) **"The Steroids"**. Who is better positioned than a farmer to take advantage of the digital technologies like cell phones, smart phones,iPAQs, iPods, and other personal digital assistant technologies. They can learn on-the-go, buy inputs, sell grain, and communicate with others from the cab of the tractor—which is probably guiding itself with auto-guidance technology. Global learning, communication, collaboration.

All of these "flat world" changes affect crop production, sometimes in unseen ways, but they are changing the way we do business, the way we incorporate information technology into the production system, and the opportunities for interaction with crop producers and markets around the world for mutual benefits. As Friedman notes, when these 10 independent flatteners converged around the year 2000, the global playing field got much more level, and those who learned to collaborate horizontally across old boundaries gained from innovation and sharing of information, and created a new business model for success. We are in a global production and market system. We need to embrace it and move forward if we want to be a participant. Adapting to the "Flat World" is agriculture's best hope for meeting the global demand for food, feed, fiber, and fuel, with a minimum environmental footprint, and with a sustainable economic benefit to producers.

—HFR—

For more information, contact Dr. Harold F. Reetz, Jr., Director of External Support and FAR, 107 S. State Street, Suite 300, Monticello, IL 61856-1968. Phone 217-762-2074. Fax: 217-762-8655. E-mail: hreetz@ipni.net .

[1]Friedman, Thomas L. 2007. ***The World is Flat***. Release 3.0. Picador. New York, NY.

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SOIL COMPACTION—AGRONOMIC AND ENVIRONMENTAL FOE

After all the wet weather in much of the central U.S.A. this spring, when soils began to dry there was an urgency to get in the field as quickly as possible to prepare soils and to plant, as the optimum planting window narrowed. As a result, some soils may have been tilled at moisture levels that were prime for increased compaction at the bottom of the implement's depth of travel. Soil compaction may have also increased more than normal beneath the traffic tracks of tractors, and the tracks of heavy fertilizer, herbicide, and seed tender units.

Soil compaction is like a silent thief whose robbery is not discovered until the symptoms of damage are severe. It increases soil bulk density, decreases soil porosity (especially the large or macropores), lowers the total water holding capacity, lowers the plant-available water capacity, and causes significant resistance to root penetration and root elongation. It can severely limit soil infiltration of rainfall and irrigation water and contribute to increased runoff loses. A close examination of the root system early this summer may expose yield-robbing soil compaction problems. Look for "flat-bottomed" root patterns in monocots like corn and sorghum, or "J" or "L" shaped taproots in dicots like soybean and cotton. As summer heat becomes more intense, certain areas in fields may be seen where plants begin to wilt more quickly between rain showers than in other areas in fields. Crops like corn and sorghum may roll their leaves in response to drought stress and in crops like soybean and cotton - flowers, pods, and young bolls may abort excessively.

While it is too late to take any special action this summer, by knowing what to look for, a strategy can be developed to disrupt the soil compaction with deep chiseling or shallow subsoiling in portions of fields where it has been identified as a yield limiter. University and USDA research has shown that there is usually no benefit to tilling any deeper than an inch or two beneath the depth of the surface soil compaction. Those depths can vary, but often are no deeper than 6 to 9 in., depending on the specific tillage implement or equipment traffic pattern.

Besides limiting yields, soil compaction has also been identified as a key factor that aggravates or increases the soil emission of nitrous oxide (N_2O), a potent greenhouse gas. Because soil compaction results in a lower soil oxygen status, reduced root growth rates, and reduced nutrient absorption rates…any nitrate present in the surface soil under warm, wet to near-saturated conditions--which is not rapidly absorbed by roots–can be quickly converted by certain soil microorganisms to N_2O. Even mild compaction can increase N_2O emissions by more than 20%.

Keep a watchful eye on your crops this summer, both above-ground and below-ground. You may recognize soil compaction problems that: 1) limit crop yields, 2) decrease N and other nutrient use efficiency, and 3) which increase the risk of N_2O emissions. Once identified, a deep chisel tillage or shallow subsoiling strategy can be developed to disrupt the compaction in the fall, when soils are dry and most responsive to this tillage practice. Zone tillage or strip-tillage strategies may be developed, which may in the long term help prevent large areas of your fields from being damaged by soil compaction.

Consult your Extension agent, Certified Crop Adviser, or other agronomic professionals about ways to remedy and to limit soil compaction. Be ready this fall to eliminate this factor from the list of things that could hurt crop production, your profits, and the environment next season. Good soil management provides both agronomic and environmental benefits.

—CSS—

For more information, contact Dr. Clifford S. Snyder, Nitrogen Program Director, P.O. Drawer 2440, Conway, AR 72033-2440. Phone 501-336-8110. Fax 501-329-2318. E-mail: csnyder@ipni.net.

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PLAN WINTER WHEAT FERTILITY PROGRAMS NOW

The cornerstone of profitable crop production is a sound soil fertility program. Such programs require forethought and planning. One of the most useful tools in soil fertility planning is soil testing. Planning a fertility program without soil test data is largely guesswork. Other factors to consider in planning an efficient fertility program are fertilizer rates of application, placement, and timing.

Nitrogen performs many vital functions in the wheat plant. Wheat requires 2 to 2.5 lb N/bu of grain, or, if grazed 1lb/A for each 3 lb/A animal gain. Shortages of N may cause reduced tillering, reduction in head size, poor grain fill, and low protein content. Adequate N must be available to the wheat plant at all phases of development. Splitting N applications generally improves use efficiency, minimizes risk to investment, and safeguards the environment. Topdress applications should be made early, prior to jointing, to maximize production efficiency. Timing, placement, and N source should be managed to fit climatic conditions, soil type, and tillage system.

Fertilizer and crop prices are at much higher levels than in recent years. What does this do to the optimum rate of N fertilization? Kansas State University economists have published a tool, available at this website: **>http://www.agmanager.info/crops/budgets/proj%5Fbudget/decisions/<**

The calculator enables the user to evaluate the impact of different factors on the optimum rate of N fertilization. A simple evaluation of past versus current conditions shows that the optimum rate of N fertilization for dryland wheat (60 bu/A yield goal) hasn't really changed. Under both past conditions (i.e., $3.50 wheat and $0.20/lb N) and more current conditions (i.e., $9.00/bu wheat and $0.50/lb N) the estimated optimal rate of N is the same…106 lb N/A. So, one should be careful about overreaction to prices.

Adequate P fertility is associated with increased tillering and grain head numbers, reduced winter kill, maximum water use efficiency, hastened maturity, and lower grain moisture at harvest. Winter wheat requires about 0.6 to 0.7 lb P_2O_5/bu grain. Because P is relatively immobile in soils, banded or starter applications are often most effective in soils testing low to medium. Even in high testing soils starter applications help plants get established more quickly. Banded P also helps young plants overcome the adverse effects of soil acidity. Broadcast P should be incorporated to improve positional availability. Finally, remember that adequate P increases N recovery and use efficiency. The effect of balanced fertility and its impact on nutrient use efficiency is especially important in today's environment.

Potassium in wheat production is associated with increased moisture and N use efficiency, and decreased incidence of disease and lodging. The requirement for K is approximately equal to that of N. Placement of K is not as critical as P since it is more mobile in soils. Split applications should be made on deep sandy soils in high rainfall areas to increase use efficiency.

Don't overlook the importance of secondary and micronutrients on wheat. For example, sulfur deficiency can be a problem in some areas. Applications of these nutrients should be based on field history, soil tests, and plant analysis.

Profitable and efficient wheat production involves supplying adequate amounts of plant nutrients when and where the crop needs them. Fertilizer application rates are of little value if nutrients are not in the proper place at the proper time. Effective fertility management strategies vary from region to region, but a characteristic of all good soil fertility management programs is early planning.

—WMS—

Dr. W.M. (Mike) Stewart, Southern and Central Great Plains Director, IPNI, 2423 Rogers Key, San Antonio, TX 78258. Phone: (210) 764-1588. E-mail: mstewart@ipni.net.

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

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