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

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MORE INTENSIVE CROP NUTRITION EVADES GREENHOUSE GASES

Doesn’t fertilizer actually increase emissions of greenhouse gases? Well, yes, in its manufacture and in its use, but… when one looks at the big picture instead of the partial details, it’s surprising how much the answer to a question can change! The higher yields of better-fertilized crops have spared land from conversion to agriculture, avoiding emissions of a huge quantity of greenhouse gases.

Agricultural intensification can reduce greenhouse gas emissions. A recent study published in the Proceedings of the National Academy of Sciences estimates that the gains in crop yields since 1961 have, globally on a net basis, spared emissions of 350 to 650 million short tons of carbon dioxide equivalents. Those higher-yielding crops do emit more greenhouse gases, but not as much more as alternative scenarios in which larger areas of land would have been converted to agriculture.

Crop yields have more than doubled since 1961. The increased yields have made it possible to feed the world’s growing population with only a 27% increase in land area. Without the yield increases, 292% more land would have been required to attain the crop production levels of 2005. Even to simply maintain the per-capita production levels of 1961 would have required a 221% expansion in cropland.

Converting land to crop production entails very large emissions. The removal of trees, shrubs, and other vegetation, and breakdown of soil organic matter under cultivation releases carbon dioxide. The authors of the report—Jennifer Burney, Steven Davis, and David Lobell in Stanford, California—analyzed the literature carefully and concluded that, around the globe, the average acre available to be converted to crop production would lose the equivalent of 172 tons of CO_2 per acre. That emission is huge in comparison to the emissions increase related to higher input use.

Fertilizer use grew from 34 to 182 million tons of primary nutrients since 1961. In the alternative scenarios, fertilizer use per acre would have stayed constant, but the total use would have increased to between 74 and 97 million tons. Greenhouse gases are emitted when fertilizers are manufactured, and application of N fertilizers can increase emissions of nitrous oxide, a potent greenhouse gas. The fertilizer-associated emissions, however, were dwarfed by those associated with land use change in the comparison of these scenarios.

Increasing yields to avoid greenhouse gas emission has been cost-effective. The authors calculated that the cost of investment in crop yield improvement (including public and private research) amounted to less than four dollars per ton of emission reduction. That compares favorably with many other mitigation efforts being considered currently.

Continued improvement in crop yields is a viable strategy for a healthy planet. The study’s authors concluded, “Further yield improvements should therefore be prominent among efforts to reduce future greenhouse gas emissions.”

The carbon footprint of fertilizer needs to include its contribution to yield improvement. Higher crop yields arose not only from fertilizer, but from a combination of better genetics, better management, and better crop nutrition. Improving nutrient use efficiency can only be a viable greenhouse gas mitigation strategy in the context of continued increases in the productivity of cropping systems.

—TWB—

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Abbreviations: N = nitrogen.

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SOIL pH AND THE AVAILABILITY OF PLANT NUTRIENTS

Soil pH is a characteristic that describes the relative acidity or alkalinity of the soil. Technically, pH is defined as the negative (-) log or base 10 value of the concentration of hydrogen ions (H^+). Pure water will be close to a neutral pH, that is 10 to the minus 7 concentration of H^+ ions (10^{-7} [H^+]). This concentration is expressed as 7. Any value above 7 means the H^+ ion concentration is lower than at a neutral pH and the solution is alkaline and there are more hydroxyl (OH^-) ions present than H^+ ions. Any value below 7 means the H^+ ion concentration is greater than at neutral pH and the solution is acidic. Soils are considered acidic below a pH of 5, and very acidic below a pH of 4. Conversely, soils are considered alkaline above a pH of 7.5 and very alkaline above a pH of 8. Typically, soil pH values are measured when 10 g of air-dried soil is mixed with 20 ml of double-distilled water or 20 ml of 0.01 M $CaCl_2$ solution, and the pH is measured using an appropriate electrode connected to a pH meter. This soil analysis is a regular part of most if not all soil test protocols.

The availability of some plant nutrients is greatly affected by soil pH. The "ideal" soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range, plus this range of pH is generally very compatible to plant root growth. Nitrogen, K, and S are major plant nutrients that appear to be less affected directly by soil pH than many others, but still are to some extent. Phosphorus, however, is directly affected. At alkaline pH values, greater than pH 7.5 for example, the HPO_4^{2-} phosphate ions tend to react quickly with calcium (Ca) and magnesium (Mg) to form less soluble compounds. At acidic pH values, the $H_2PO_4^-$ phosphate ions react with aluminum (Al) and iron (Fe) to again form less soluble compounds. Most of the other nutrients (micronutrients especially) tend to be less available when soil pH is above 7.5, and in fact are optimally available at a slightly acidic pH, e.g. 6.5 to 6.8. The exception is molybdenum (Mo), which appears to be less available under acidic pH and more available at moderately alkaline pH values.

In some situations, materials are added to the soil to adjust the pH. On a field scale, this is most commonly done for acidic soils to raise the pH from an acidic level of 4.5 to 5.5 up to 6.5 or approaching neutrality. This is done by applying and incorporating a liming material, often finely ground calcitic ($CaCO_3$) limestone, or dolomitic [$CaMg(CO_3)_2$] limestone, that is spread using specialized lime spreaders, or spin-spreaders adapted with vibrating systems to prevent bridging of the material in the hoppers of the spreaders. It is possible to lower the pH of a soil using a liquid acid solution, or finely ground elemental S that oxidizes to sulfuric acid through the action of soil inhabiting S-oxidizing bacteria. However, this is rarely done on a field-scale basis because of the high cost. It is more commonly done in horticulture production applications where individual plant containers or limited areas (e.g. <10 to 20 acres) are managed to lower the pH for acidic soil adapted plants such as some flowers, trees, and/or small fruits (i.e. blueberry and cranberry). It is important to note that most on-going crop production, especially where NH_4^+ based, or NH_4^+ releasing N fertilizers (e.g. anhydrous ammonia, ammonium sulfate, and urea) are applied, will gradually lower the soil pH, as the H^+ ions are released from the NH_4^+ ions when they are converted over to nitrate (NO_3^-) by soil microbes.

Whether or not you try to adjust pH, it is important to understand other methods to increase the availability and use of added nutrients. This can be done in a number of ways for the nutrients mentioned above that are adversely affected by extremes in soil pH, acidic or alkaline. For example, P-containing fertilizer can be applied in or close to the seed-row at planting to facilitate early season uptake of phosphate ions by crop roots before allowing it to react with soil cations dominating under acidic (e.g. Al^{3+} or Fe^{3+}) or alkaline (e.g. Ca^{2+} or Mg^{2+}) soil pH conditions. Under alkaline soil pH values, the phosphate fertilizer can be applied in bands with fertilizer which generates NH_4^+ as noted above. That will allow slight acidification of the soil adjacent to the fertilizer band. Another method is to manufacture compound nutrient fertilizer granules that contain the N, P, and even elemental S-containing fertilizers, for application to alkaline soils so the soil adjacent to the granule will also be acidified slightly and allow enhanced P uptake when the crop roots intercept the granules. Yet another example is the foliar application of soluble Fe fertilizer compounds to Fe-deficient crops grown in high pH soils where the Fe^{3+} ions of the Fe fertilizer react so fast with soil that the nutrient is tied up and unavailable to plants. This is why soil applied Fe fertilizers often do not successfully correct Fe deficiencies. By avoiding the soil and applying the Fe to the leaves, the small amount of plant-required Fe is successfully introduced into the crop.

Next time you have soil samples taken on your fields, take time to note what the pH values are in your results. It is useful to compare these values to previous soil test pH values and determine if there is a trend of soil pH change. By monitoring the pH values regularly (every 2 to 3 years) in a field, you may consider action to raise the pH of the soil from acidic to near neutral pH values by liming. Increased nutrient availability and improved crop growth can be achieved when adding liming material to an excessively acidic soil. This can be especially important for crops requiring neutral pH, such as legume forages or pulses, as the *Rhizobia* species bacteria do not nodulate and fix N effectively under pH values less than 5.5.

—TLJ—

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Abbreviations: N = nitrogen; NH_4^+ = ammonium; P = phosphorus; K = potassium; S = sulfur.

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ARE YOU OVERLOOKING MAGNESIUM?

In most discussions of plant nutrition, the importance of magnesium (Mg) is too often overlooked. Since an adequate supply of Mg is required for many key reactions in plants, both yield and quality will suffer when it is lacking.

The yellowing of older leaves is the classic Mg deficiency symptom. Up to one-third of the total plant Mg is found in the chloroplasts. Leaf chloroplasts are where sunlight is converted to chemical energy (sugars) through the process of photosynthesis. The appearance of yellow leaves from a lack of Mg is more common with high light intensity than in cloudy or shaded conditions.

When plants are lacking in adequate Mg, many growth processes are stunted before any visible damage can be seen. For example, under low-Mg conditions, plants are not able to properly transport sucrose from the leaves to the rest of the plant. Consequently, root growth is stunted and overall plant growth is reduced, long before any symptoms are noticeable. Similarly, proper development of seeds and fruit can be disrupted by a lack of sucrose transport in low Mg conditions.

Magnesium in most soils is present in various minerals and clays. Depending on the parent material that formed a particular soil and the types of clay present, Mg may be in abundant supply or may be lacking. Plant-available Mg is generally held on soil cation exchange sites and it can be easily measured through routine soil testing.

When the Mg supply is inadequate, there are many excellent sources that can be used to meet crop demands. They are commonly divided into two classes: soluble sources and semi-soluble sources. Depending on your location, the availability and price of the different products may vary. Some common North American sources are listed below.

Soluble Magnesium Sources

Kieserite: $MgSO_4{\bullet}H_2O$; 15% Mg

Magnesium Chloride: $MgCl_2$; 25% Mg

Langbeinite: $2MgSO_4{\bullet}K_2SO_4$; 11% Mg

Magnesium Nitrate: $Mg(NO_3)_2$; 13% Mg

Magnesium Sulfate (Epsom salt): $MgSO_4{\bullet}7H_2O$; 9% Mg

Magnesium Thiosulfate: MgS_2O_3; 4% Mg

Various foliar sprays

Semi-soluble Magnesium Sources

Dolomite: $MgCO_3{\bullet}CaCO_3$; 6 to 20% Mg

Hydrated Dolomite: $MgO{\bullet}CaO/MgO{\bullet}Ca(OH)_2$; 18 to 20% Mg

Magnesium Oxide: MgO; 56% Mg

Struvite: $MgNH_4PO_4{\bullet}6H_2O$; 10% Mg

Two recent articles in *Better Crops with Plant Food* magazine feature more information Mg. You can find them at this website: >www.ipni.net/bettercrops<.

—RLM—

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NOT ALL FERTILIZER BANDS PLAY THE SAME SONG

The often used expression, “Same song, different verse,” refers to something that is practically the same as something else. So often, P and K are used in the same sentence when people talk about banded fertilizer applications, as if both were different verses of the same song. Actually, P and K fertilizer bands play different “songs” because they behave differently in soil.

One of the primary reasons fertilizer is banded is to increase short-term efficiency of use by the plant. Bands of P are known to cause an increase in root proliferation, as are bands of N. Bands of K, however, do not have this effect. This means that bands of P will be explored more thoroughly by root systems than bands of K. The implication, of course, is that applying P and K together in a band will help make better use of the concentrated K supply, due to the increased root growth caused by P.

Bands of K may not remain as concentrated in soils over time as bands of P. There are a couple of reasons for this. First, crops like corn and soybean take up more K than P during the season. Corn takes up about two-and-a-half times as much K as P while soybeans take up about twice as much (expressed as K_2O and P_2O_5). Secondly, K moves more in soils than does P, causing bands of K to become more diffuse over time relative to P. So, greater uptake combined with greater mobility limits the longevity of concentrated bands of K.

In the short-term, corn and soybean plants themselves redistribute K in soils to a greater extent than P. This occurs for a couple of reasons. First, K leaches from plant residue and unlike P, does not require microbial decomposition to be released. This means that K in the plant is returned to the soil more quickly than P. Secondly, a greater proportion of the K taken up by the above-ground plant biomass exists in the plant residues returned to the field. For corn, about 80% of the total K taken up is in the stover, compared to only about 30% for P. For soybean, the percentages are 45% for K and 20% for P. A lot of the K leached from plants occurs during senescence, before crop harvest, meaning that most of the K is redistributed into the crop row. Consequently, plants become effective redistributors of K in the soil, moving it from throughout the root zone and concentrating it to the row, particularly at the soil surface. While P is also redistributed in this manner, it is not done so to the degree that K is.

Just how long P and K bands will last in soil depends upon many factors. Soil mineral composition, rooting depth, environmental conditions, and soil wetting and drying cycles are but some of the many factors at play. To gain an idea of how long bands will last under a specific set of conditions, on-farm monitoring through soil testing is suggested. Select areas can be monitored frequently to gain a sense for band longevity, remembering that if bands are placed near crop rows, concentration of K by the plant may overwhelm detection of lower rates of banded K.

So the next time P and K bands are assumed to be the same, remember that they really have very different characteristics, both in the soil and in the way they interact with plants. Bands of P and K really do play different songs.

—TSM—

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

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PRECISION COTTON FARMING IN THE SOUTH

At the recent 10th International Conference on Precision Agriculture, Daniel Mooney from the University of Tennessee discussed the results of a 2009 survey of southern cotton farmers. Growers in 12 states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia) were surveyed regarding their attitudes toward, and use of, precision farming technologies. A total of 1,692 surveys were returned, of which 63% identified themselves as precision farming adopters, indicating that they had used information gathering technology, variable-rate management, or GPS guidance.

Grid and zone soil sampling were the two most widely used information-gathering technologies being used by southern cotton farmers (46% of respondents). Yield monitors with GPS, soil survey maps, and aerial photography were the next most commonly used information gathering technologies (15% to 20%). Least used by adopters were yield monitoring without a GPS, satellite imagery, handheld GPS/PDA, COTMAN plant mapping, digitized mapping, and electrical conductivity (less than 10%).

A yield monitor with GPS was the technology most frequently used to make variable-rate fertility or lime decisions. Handheld GPS units and electrical conductivity were also used to make fertilizer and lime decisions, while GreenSeeker optical sensors and aerial/satellite imagery were used most commonly for growth regulator and harvest aid decisions. Of the growers using variable-rate fertilization, 36% were using it to apply N, 73% for P, and 76% for K. Ninety-two percent of the respondents using a variable-rate management plan were varying lime application rates. Fifty-three and 69% reported a decrease in inputs after adopting variable-rate fertilizer and lime management plans, respectively. Conversely, 29 and 18% of the respondents experienced an increase in inputs using variable-rate fertilizer and lime, respectively.

Nearly half of respondents (47%) reported having adopted GPS guidance. Divided into guidance categories, one-third of adopters used GPS auto-steer technology, while one-quarter used GPS light-bar technology. Adopters used guidance for an average of 2.5 different field activities including spraying (79%), planting (63%), and tillage (59%) operations. One of the main reasons cited for adopting a guidance system was to improve overall input efficiency and an overwhelming majority (88%) indicated that guidance had met their expectations. Sixty-one percent of growers did not see any fertilizer cost savings as a result of using GPS guidance. However, just over half of the respondents reported chemical input savings of at least $5/A.

Nine out of 10 adopters believed precision farming would be profitable in the future. For non-adopters, 60% agreed that precision agriculture technologies have a profitable future in southern cotton farming. Findings from this survey will be useful to university extension and industry personnel in developing outreach efforts to support growers making decisions regarding precision farming technologies. The complete survey and accompanying publications can be accessed at: >http://economics.ag.utk.edu/precisionagpubs.html<.

–SBP–

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Abbreviations: GPS = global positioning system; N = nitrogen; P = phosphorus; K = potassium.

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WHAT IS THE BEST NITROGEN RATE FOR YOUR FIELD?

Most farmers strive to implement a cropping system and nutrient management strategy that will allow them to capture favorable growing conditions which at least meet historic average crop yield potential. The fertilizer N rate chosen has traditionally depended on results from land grant university research and extension replicated studies, which may span several years and environmental conditions. In the past, many such public studies were nearby, but in recent times, because of declining budgets and program cuts, farmers have had fewer such studies to rely on in guiding their N rate selections.

Ideally, one could match the applied N rate in perfect synchronization with crop uptake demand, with a perfect knowledge of soil N release. However, we recognize that a sizeable portion of the N that plants take up comes from the soil, as microbes breakdown organic matter and organic N is converted to ammonium and then nitrate forms; the forms essential for plant nutrition. Unfortunately, we still can't predict the amount of N that will become available, and when it will become available, from the full soil profile or rooting volume; especially across an entire growing season. Yes, there are some soil N tests which have met with moderate success, but their use and success in the field under differing conditions and geographies have been limited.

If recent local research results on similar soils and cropping system conditions are not available, then a plan should be developed to evaluate existing N rates against alternative N rates: both above and below the current practices. As crop yield potential is raised with improved genetics, questions are being asked about the potential need for higher N rates (or changes in timing and placement). To help answer these questions, some leading farmers are partnering with their crop advisers and fertilizer dealers to establish N rate tests on their own farms. Such N rate comparisons can provide valuable information, but they should be repeated over several years, and they should be randomized and not just simple side-by-side contrasts. Treatment randomization is important because unseen gradients in soil fertility, moisture holding capacity, and internal drainage in many fields can skew the results in side-by-side comparisons and mislead interpretations.

Sensor technologies are also available, which detect the greenness of the crop (e.g. corn, wheat) during the growing season, and which reflect the N nutritional status. Such monitoring can allow one to adjust to conditions of improved yield potential (e.g. favorable weather) or to adapt to conditions that may have caused unmeasured volatile, leaching, runoff, and drainage losses of N. The calibration for these "N sensing" applications should be locally or regionally based. Several university and USDA research programs have made progress with such calibrations. Farmers, crop advisers, Extension agents, and fertilizer dealers are increasingly employing the technologies where they have been proven economically feasible.

Field-average hind-sight or "post-mortem" evaluations of N sufficiency are important, but replicated tests to evaluate the crop response under different N rates and different management systems are considered more valuable, especially when coupled with monitoring of plant N status during the growing season. Use of yield potential alone is no longer considered the best approach in determining the N rate for a given field. Consider ways to evaluate the performance of your N management program by partnering with others who are skilled in on-farm evaluations. Such tests can help instill confidence in the fertilizer N management program, and help ensure that both economic and environmental protection goals are achieved.

—CSS—

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CONSIDERING CHLORIDE FOR WHEAT

Chloride (Cl^-) has been formally recognized as a plant nutrient since the 1950s. It is classified as a micronutrient, but plants may take-up as much Cl^- as secondary elements such as S. Concentrations of Cl^- in wheat flagleaf and corn earleaf at flowering are commonly in the range of 0.25 to 1%.

Chloride is involved in several important roles in plants, including,

- Photosynthesis and enzyme activation
- Transport of other nutrients in the plant
- Stomatal activity
- Accelerated plant development
- Reduced lodging

Chloride is an anion and is therefore mobile in the soil. It can be leached from the soil profile where internal soil drainage is good. Chloride may be supplied to soils from several external sources, including fertilizer input, atmospheric deposition, and irrigation water. Thus, low soil Cl^- level is favored where: 1) there is limited application of Cl^--bearing fertilizer such as muriate of potash (KCl); 2) where there is low atmospheric Cl^- deposition (deposition is highest in coastal regions and decreases inland), and 3) in non-irrigated conditions. These conditions are met across much of the Great Plains.

Response of wheat to Cl^- fertilization has been observed throughout the Great Plains from Texas to Canada. Much has been reported over the past 20 years or so on work from this region. A recent update and summary of Cl^- work in Kansas was published in a 2009 *Better Crops* magazine article (Vol. 93, No. 4). It is generally accepted that there is little difference in performance among Cl^- sources on winter wheat, and that topdress and preplant applications are effective. However, where there is potential for leaching, topdress application in the spring may be advantageous.

Increases in wheat yield from Cl^- fertilization are usually due to either a classical nutrient response and/or suppression of fungal diseases. Under low soil Cl^- conditions, some varieties may exhibit Cl^- deficiency symptoms, sometimes referred to as physiological leaf spot syndrome. These symptoms are similar in appearance to tanspot or septoria, but are not caused by a pathogen. The absence of leaf spotting does not always mean that Cl^- is not deficient since spotting is dependent upon wheat variety. Chloride has been shown to reduce the severity of several root and foliar diseases. In one Texas study, leaf rust infection of the flag leaf was reduced from 68 to 27% by topdressing with 40 lb Cl^-/A as muriate of potash.

Whether or not wheat will respond to Cl^- usually depends upon soil Cl^- level, disease pressure, plant Cl^-, and variety. Response to Cl^- is likely when soil Cl^- levels are less than 45 lb/A from 2-ft. deep soil samples. Kansas State University recommends 10 lb Cl^-/A application when the soil level is 30 to 45 lb/A, and 20 lb application when soil level is below 30 lb/A. It has been shown that some varieties are much more responsive to Cl^- than others.

Chloride response in wheat can ultimately be expressed in terms of increased yield, higher test weights, and greater kernel plumpness. Therefore, it is worth considering the need for Cl^- on the upcoming wheat crop.

— WMS—

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