

Spring 2015, No. 1

HUMAN HEALTH DEPENDS ON SOIL FERTILITY

2015 is the International Year of Soils. Organizations around the world are drawing attention to the critical role that soils play in sustaining human health. Most of our food is grown on soil. The soil's fertility determines a large part of the nutritional value of that food.

Human nutrition remains in crisis. While world hunger has declined by 21 percent since 1990, at least 805 million people still go hungry. Among children under five, 161 million are estimated to be stunted, having low height for their age. Micronutrient deficiencies due to lack of dietary vitamins and minerals affect around 2 billion people, with multiple adverse health impacts, often impairing both physical and mental development of children.

Plants play an important role in concentrating nutrients that are sparse in soils. They do this for many nutrient elements important to living organisms, including nitrogen (N), sulfur (S), phosphorus (P), potassium (K), selenium (Se), iodine (I), zinc (Zn), and boron. Most plant nutrients are human nutrients too.

Fertilizing crops can boost the nutritive value of food. The nutrients Zn, I, S, and Se increase in concentration and availability in edible plant parts when they are applied as fertilizers, and they can play important roles in human health. Field experiments have shown that soil-applied Zn can increase the Zn concentration in wheat grain by 80 percent, and combinations of soil and foliar applications can increase it more than three-fold. Adding I to irrigation water in China and Mongolia led to dramatic gains in human health, including a 50% decrease in infant mortality.

In the more humid parts of sub-Saharan Africa, there are large areas where the human diet is deficient in the S-containing amino acids. This deficiency arises from a low protein intake, which may also be due to soil S deficiency. A survey of Zambian maize grain conducted in 2012 revealed a median S concentration equivalent to only 60% of critical deficiency levels. Plant-available Se is also very low in many soils in Zambia, Malawi, Rwanda, Burundi, and other sub-Saharan African countries. In programs addressing the N, P and K shortages of the soils of sub-Saharan Africa, S and Se need strong additional consideration.

Decades of experience and research in Finland have documented strong benefits to human Se status from programs of enrichment of fertilizers with Se starting in the 1980s. Outcomes included a doubling of the human serum Se levels, and, while other factors were also involved, the mortality rates from heart disease decreased by about two-thirds from 1982 to 1997.

Adding lime to acid soils can increase the calcium and magnesium content of foods. These two nutrients are involved in protection against diseases like rickets.

Diversity in cropping systems is also important. Pulses provide more micronutrients than cereal grains. In many areas, increases in the yields and production of pulses have not kept pace with the increases in cereals. A notable exception is the growth of soybean cultivation in Bangladesh, expanding from near zero in 1980 to over 100,000 acres in 2010. As crop advisers and crop managers, we need to continue asking ourselves whether our cropping systems are meeting the nutritional needs of our ultimate customers, the whole human family.

The composition of soils influences the composition of crops, in turn influencing the quality of food and its contribution to human nutrition, and ultimately, human health. Many opportunities remain to improve human nutrition by fertilizing crops responsibly, and by promoting diversity in crop rotations.

– TWB –

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USING COVER CROPS TO IMPROVE THE SUCCESS OF CROPPING SYSTEMS

Cover crops are used to reduce soil erosion, improve soil structure, conserve and build up crop nutrients, and help control weeds, insect, and crop disease pests. They are typically grown in the idle season between normal spring planted crops. For example, in a corn-soybean rotation, cover crops may be grown after harvest of the soybeans in the fall, through the winter, and into the early spring before planting corn.

There are many different types of cover crops. But usually they are a legume (e.g., clover), a small grain cereal (e.g., rye or oats), or a mixture of a legume and a small grain cereal. The cover crop needs to be regionally adapted to achieve sufficient growth in the fall before winter to provide adequate ground cover to control water or wind erosion until the subsequent harvested crop is planted and established. For example, a warm season legume or annual grass may be unable to establish and grow in a cooler or temperate climate. However, a cool season legume or small grain cereal might grow well as a cover crop during the cool winter period between warm season crops. Another useful feature of a successful cover crop is that it is easily terminated, or suppressed before planting of the next harvested crop.

Soil structure improvement is a result of addition of plant residues to the soil for maintaining or increasing soil humus content. This contribution is from both the cover crop roots and shoots. The decaying roots of the cover crops leave root channels that facilitate the growth of subsequent crop roots. Some cover crop mixtures include taproot plant species that can help break up shallow compact subsoil layers, caused by natural soil forming processes, or as a result of tillage or wheel traffic induced compaction. For example, turnip or radish species that have robust taproots can be included in a cover crop mixture for sub-soiling of compact soils.

Cover crops can enhance soil nutrient status in several ways. The cover crop takes up and stores nutrients that may otherwise be susceptible to over-winter losses from leaching (i.e., nitrates, sulfates and chlorides), and or denitrification losses of nitrate. Physical acquisition of plant nutrients from subsoil layers, and movement to the soil surface or topsoil in cover crop shoots and roots may occur. This can, over a number of years, effectively enrich topsoil with low mobility soil macronutrients such as phosphorus, potassium, calcium and magnesium, and low soil mobility micronutrients (e.g., copper, zinc, manganese, and iron). Finally, the cover crop may help increase the pool of more easily available nutrients (labile) as the nutrients from cover crop residues may be more easily mineralized for crop uptake than those from more stable soil organic matter.

Weed, insect and crop disease pests can be reduced in a cropping system using cover crops. This can be accomplished by growing a cover crop that is a poor, or non-host, for insect and fungal pathogens that adversely affect harvested crops. The presence of cover crop residues can cover the soil surface and suppress weed seed germination and emergence before the subsequent crop is planted, emerges and becomes established.

It is advised that you check with local crop advisers as to what cover crop species or mixtures of species are locally adapted to and successful in your specific region, and as part of the cropping system you practice.

– TLJ –

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

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INTERNATIONAL YEAR OF SOILS: MODIFYING SOIL TO IMPROVE CROP PRODUCTIVITY

The essential link between productive soil and humans has been clear since the beginning of agriculture. However, our food crops come from only a sliver of the world's land area (12%). There is room for limited expansion of crop production in some countries, but much of the earth is covered by urban settlements, forests, and environmentally protected areas that are not appropriate for agricultural expansion. Proper stewardship of our current agricultural land is vital to long-term food sustainability.

The earliest recorded agriculture describes attempts to improve soil properties and crop productivity through application of manures, ash, minerals, and other amendments. Our understanding of the scientific principles underlying plant growth has greatly improved, but the fundamental effort to eliminate soil constraints to food production remains the same after thousands of years.

Soil physical properties have a major impact on root growth and development. Compacted soils have reduced water-holding capacity and can form a brick-like barrier that roots cannot penetrate. Soil crusts prevent rainfall from entering the soil and crusty soils are prone to excessive water runoff. Coarse-textured and low-organic matter soils generally retain less plant-available water, and crops growing in these soils may be more susceptible to drought stress.

Soil chemical properties often are a key factor in determining crop productivity. There are very few soils in the world that contain all of the essential plant nutrients in the proper concentration. The modern fertilizer industry helps farmers to identify and eliminate any limiting nutritional factors. Addition of plant nutrients prevents the depletion and degradation of agricultural land that occurs when crops are repeatedly harvested without replacing the nutrients back into the soil.

Many soil chemical properties can limit plant growth if left unmanaged. Soil acidity is one of the largest global constraints to plant growth. Although soil acidity is relatively simple to remedy, it remains untreated in vast areas of the world. Other soil chemical issues that hinder plant growth include excessive salinity, and pollution from poor municipal and industrial waste management.

The importance of biological activity in supporting crop productivity is too often overlooked. Soil microorganisms are responsible for regulating the availability of many of the essential plant nutrients. Nitrogen fixation by bacteria living within the roots of some plants provides vital support to important cropping systems and rotations. The contribution of mycorrhizal fungi to root health is clear, but not fully understood. Similarly, the intricate exchange of chemical signals between plant roots and soil microbes plays an important role in supporting plant growth.

We are fortunate to live in an age when we understand these soil factors that limit plant growth and have the ability to manage them. Nutrient limitations can be eliminated through proper fertilization. Soil acidity or alkalinity is easily modified through use of appropriate amendments. Converting to no-tillage practices, or sub-soil tillage can often help improve soil physical properties. Conservation of soil organic matter and crop rotation may improve soil biological activity.

Soil stewardship is fundamental to modern agriculture. Every farming decision should be one that maintains or improves essential soil resources.

– RLM –

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WHEN 1 + 1 = 3

1 + 1 = 3? No, this isn't "one weird trick" or "doctors hate this man" gimmick that plague the margins on your webpages. It's just the wonder of nature revealing itself. One thing about science is that it is surprising. It challenges your assumptions and reminds you that you are a mere mortal in a vast universe.

My universe is that of soils and plants, and specifically, how plants respond to the nutrients in the soil and in the fertilizers we apply. Most of the studies I read look at plant responses to one nutrient, and of those, nitrogen (N) gets the most attention. But occasionally, or more accurately, rarely, I come across a study that looks at two or more nutrients. And that's when the simple mathematical laws of addition don't always work.

Take a thirty-year study from Kansas. Looking at corn grain yield response on a soil that was deficient in both N and phosphorus (P). The study compared yield responses to N applied alone, P applied alone, and N and P both applied. The average increase in yield (bu/A) was 60 bu/A for N, 23 bu/A for P, but 115 bu/A for N+P. Did you see it? The wonder of nature? Let's break it down.

We might expect that when N and P were applied together, the yield response would be the same as the responses to N and P added together. Instead the response was more than that.

Increase in corn grain yield (bu/A):

N alone: 60

P alone: 23

N + P together: 60 + 23 = ~~83~~ 115

(Source: Schelegel et al. 1996. *J. Prod. Agric.* 9:114-118)

What happened was an interaction. To quote from the widely read book *Soil Fertility and Fertilizers*, "An interaction takes place when the response of two or more inputs used in combination is unequal to the sum of their individual responses." Unequal is right. The increase in yield in this study was actually 115 bu/A, which was 32 bu/A more than the sum of the yield increases from the individual nutrients. This is an example of a positive interaction.

And now a four-year study from Ohio looking at corn grain yield on a soil deficient in both N and potassium (K). The study looked at yield increases from only increasing the soil test level of K, only applying N, or doing both. The results:

Increase in corn grain yield (bu/A):

Only increasing soil test K: 2

Only applying N: 59

Increasing soil test K + applying N: 2 + 59 = ~~61~~ 95

(Source: Johnson et al. 1997. *Better Crops.* 81(2):3-5)

Again, we see the wonder of a positive interaction, where correcting two nutrient deficiencies at the same time resulted in a greater yield increase than when the responses to each nutrient were simply added together.

I've picked two examples that were great at showing 1+1=3. It doesn't always work that way. Sometimes 1+1=1, when adding two needed nutrients doesn't perform any better than just adding one (a negative interaction), and sometimes 1+1 does in fact equal 2 (no interaction). Interactions aren't guaranteed, and when they do happen, they don't always put a "3" in the universe. Sometimes you get a "1."

So often, when I hear people talking about the 4Rs, they refer to the "right source, rate, time, and place" of a single nutrient. But the way nature bends 1+1 reminds us to think more broadly and to apply the 4R principles to all nutrients that plants need and to manage them the best we can to achieve that wondrous "3."

–TSM –

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SENSOR-BASED NITROGEN FERTILIZATION FOR COTTON

Managing nitrogen (N) for cotton in the southern U.S. is challenging due to spatial and temporal variability in plant available N. This variability results in many areas of the field being over-fertilized, while others are under-fertilized, when using a single N rate for the entire field. Crop sensors are effective N management tools that can help growers adjust for spatial and temporal variability when making N fertilizer decisions for cotton.

Crop sensors measure reflected light at wavelengths that correspond to crop greenness and biomass. Various wavelengths are combined mathematically to create vegetation indices (VI's) that have greater utility in determining N fertilizer requirements than single wavelengths. The normalized difference vegetation index (NDVI) is one of the most common and has been used successfully to determine N fertilizer requirements for wheat and corn in several states.

Sensor-based N application strategies in cotton have not been developed as rapidly as in other crops. Part of the problem has been the failure of NDVI and other commonly used VI's to strongly correlate with crop N status and final lint yield to accurately determine a fertilizer N rate. However, researchers at Mississippi State University have recently identified a combined VI that exhibits a good relationship with leaf N and sensor measurements at critical cotton growth stages.

The MSU research team, led by Dr. Jac Varco, conducted a study between 2012 and 2014 where they evaluated a simplified canopy chlorophyll content index (SCCCI) for determining in-season N fertilization needs in cotton. The measured SCCCI was calibrated to historical crop growth and greenness and expressed as a fertilizer N equivalence. Fertilizer N requirements at pinhead to early square were then adjusted using the estimated fertilizer N equivalence. Detailed information on the calculation of SCCCI is reported in *Raper and Varco. 2015. Prec. Agric. 16:62-76.*

Benefits from the sensor-based applications were also observed as early as peak bloom, when leaf N contents in the VR-fertilized treatments were greater than in those receiving the highest constant N rate. Sensor-based, variable-rate N applications based on the SCCCI also resulted in higher lint yield per unit of applied N compared with standard grower or fixed-rate applications. This increase in N-use efficiency when utilizing sensor-based N management could be an important performance indicator as part of a 4R Nutrient Stewardship program.

Sensor-based, VRN fertilization of cotton can reduce over- and under-application; thus, improving fertilizer N use efficiency. Utilization of crop sensors and the combined VI, SCCCI, near early cotton squaring provides a viable indicator of crop N needs. However, more work is needed to develop properly calibrated algorithms that take into account cotton growth response to soil N availability and intuitive grower input to adjust minimum, maximum, and perceived optimum average field rates. To learn more about on-the-go cotton sensing and other topics in precision agriculture, make plans now to attend InfoAg 2015 scheduled for July 28-30, in St. Louis, MO. <www.infoag.org>

– SBP –

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PRE-PLANT SOIL NITRATE – MEANINGFUL OR MALARKEY?

The idea of using soil nitrate as a potentially meaningful crop nitrogen (N) management tool dates back to the early 1900s. A lot of work has been done in the last 25 to 30 years to correlate soil nitrate levels with crop N uptake, and to calibrate rates of N addition to satisfy crop nutritional requirements. Many state private and public laboratories—especially in colder and less humid regions (i.e., west of the Mississippi River)—provide soil sampling guidance, accurate nitrate analyses, and timely delivery of results. Skilled crop advisers in those respective regions often assist farmers in interpreting those test results and making adjustments to N applications that help satisfy season-long crop needs.

Most crop advisers know that the closer to planting time when the soil samples are taken, the more reliable the measured nitrate values may be for making potential adjustments in crop N rates. Many things can happen to residual nitrate that is measured in the soil profile near harvest time, and planting of the next crop. It is well-recognized that soil nitrate changes with soil wetting and drying. Soil microbes can use (immobilize) and render nitrate temporarily unavailable for root uptake, and nitrate can be converted and lost to the atmosphere as a gas under persistent warm and waterlogged conditions. Nitrate leaching beyond the crop root depth and groundwater contamination risks will rise when moisture levels exceed soil evaporation and crop transpiration. That helps explain why proper soil sampling depth (usually the root zone) is critical to correct soil nitrate interpretations.

Dips in crop prices, and uncertainties in the supply and price of N sources, are driving farmers and their advisers to use sharper pencils in their 4R N management decision-making. Scientists in Missouri, for example, have noted that pre-plant soil nitrate is most meaningful on 1) fields that have a prior-year manure application history, 2) following a drought year on fields with a high carry-over potential, and 3) following fall and early spring fertilizer N applications where excessive rainfall may have caused nitrate losses.

Nitrate drainage and runoff losses from fields to tributaries emptying into the Mississippi River have been a concern for decades, and now many states have developed challenging nutrient loss reduction strategies; to address associated algae blooms in local lakes, streams, and rivers and also the downstream low-oxygen (hypoxia) conditions in the Gulf of Mexico. Local hotspots of groundwater nitrate contamination are also a pressing concern in many states.

To know if there is unused nitrate in the root zone of crops planted this spring, would pre-plant soil nitrate testing be a wise choice? Soil testing labs, university research/extension specialists, and experienced crop advisers should be consulted to determine if pre-plant soil nitrate tests are meaningful for local crops and local conditions. Growers are reminded that regionally-proven, correlated, calibrated, and independently field-verified soil nitrate tests should not be cast aside in the face of the current excitement surrounding newer soil N tests. Coordinated evaluations of newer tests and tools,.... in varying geographies,..... with repeated and multiple N rates on the same areas (plots) over several years,..... will reveal the value of newer tests and tools, and their dependability.

While it is true that a point-in-time pre-plant soil nitrate test may be a relatively poor indicator of the season-long supply of available soil N, what would a test result showing 20 to 40 lb/A of soil nitrate-N this spring mean to your initial crop N fertilization rate and timing decisions? Is pre-plant soil nitrate testing right for you and your crops this year?

– CSS –

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COTTON NUTRITION AND FERTILIZATION

A major factor affecting both cotton yield and quality is the availability of adequate and balanced nutrition.

Soil nutrients are taken up by cotton in direct proportion to growth and temperature, with total nutrient uptake for nitrogen (N), phosphorus (P) and potassium (K) tracking cumulative heat units.

Nitrogen is essential for the development shoots, buds, leaves, roots, and bolls. Cotton takes up about 60 lb of N for each 480 lb bale produced, although it should be noted that N uptake figures can vary considerably. Uptake is limited early in the season prior to squaring, with the majority of N taken up after first bloom. A good N management scheme consists of three fundamental segments: 1) supply about 10 to 20% of the total seasonal N fertilizer need before bloom, 2) supply the remaining needed N during the 60 to 75 day boll development period, and 3) deplete soil N for an abrupt N deficiency to help mature the crop for harvest (*Hake et al., 1991. Cotton Physiology Today, Vol.2, No. 3*). Since cotton is an indeterminate perennial, too much N late in the season may cause excessive vegetative growth and should be avoided. When planning N fertilization other sources of N such as residual soil N and N in irrigation water should be accounted for.

Phosphorus is important in early root development, photosynthesis, cell division, energy transfer, early boll development, and hastening of maturity. About 25 to 30 lb of P_2O_5 is taken up per bale of cotton produced. Placement of P fertilizer is not as important as in the production of some other crops; however, banding P can be advantageous in some situations such as in reduced or no-till production or under compacted soil conditions. Insufficient P results in dwarfed plants, delayed fruiting and maturity, and reduced yield.

Potassium is an especially important nutrient in cotton production. It reduces the incidence and severity of wilt diseases, increases water use efficiency, and affects fiber properties like micronaire, length and strength. It is important in maintaining sufficient water pressure within the boll for fiber elongation, and for this reason bolls are a major sink for K. Cotton takes up about 60 lb of K_2O per bale. The need for K increases dramatically during early boll set, and about 70 percent of uptake occurs after first bloom. Potassium deficiency may be expressed as a full season deficiency, or it may not appear until late season since this is the period of greatest demand. A shortage of K compromises fiber quality and results in plants that are more susceptible to drought stress and diseases. Preplant applications of K fertilizer, and in some cases mid-season foliar applications, are effective in correcting deficiencies.

Recent work in Central and Gulf Coast areas of Texas has demonstrated the importance of cotton K nutrition (*Spiegelhauer et al., 2014. Great Plains Soil Fertility Conference, Vol. 15: 212-216*). In this work multiple rates of preplant banded (4 in. to side of row and 6 in. deep) and broadcast incorporated applications of K are being compared. Potassium application has had a considerable impact on both lint yield and quality in this study. For example, after considering yield and loan price (quality) from the 2013 season the average (two sites) return on investment from the banded 40 lb K_2O/A rate was US\$148.

Secondary elements and micronutrients may also be critical to profitable cotton production. For example, cotton responds to trace elements like zinc and boron where these nutrients are deficient.

Good nutrient management can result in higher cotton yields, improved fiber quality, greater water and nutrient use efficiency, and more profit. Soil and plant analyses, field history, and experience should all be considered when planning fertility programs.

– WMS –

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