Society Science

Should Soil Testing Services Measure Soil Biological Activity?

Healthy soils are needed so that agriculture can continue working for us by producing abundant food, feed, and fiber in the face of climate change and rising input costs. A key question these days is “how should we measure the health of soil?” A seminal indicator is the breath (respiration) of soil. Like us, soil is living and therefore breathes—and the more it breathes, the more it needs to be fed. But the more it’s fed, the more work the soil is also able to do.

This is the message of an open access article in *Agricultural and Environmental Letters* by USDA-ARS soil scientist, Alan Franzluebbers from Raleigh, NC. As a USDA professor in the Department of Soil Science at North Carolina State University, Franzluebbers is working with graduate students and other researchers across the Mid-Atlantic region to define the indicators of healthy soil. A test that allows dried soil to breathe for a short period following rewetting is producing strong indications of how well soil offers crops nitrogen that is de-mineralized from organic matter. Soil that has been fed a robust, diverse diet of crops and been kept intact with conservation tillage works hard to provide sufficient nitrogen to crops. In contrast, not knowing how much nitrogen is really available often leads to over-application of fertilizer and environmental degradation.


Nitrogen, Harvest Moisture, and Cultivar Selection Effects on Rough Rice and Milling Yields

Proper on-farm practices in Mid-South rice production are key to optimizing production and profitability. As 85% of rice is produced for human consumption, it’s critical that milling yields (i.e., milled and head rice yield; HRY) are considered when developing management practices. Fertilizer nitrogen (N) and harvest moisture content (HMC) are important factors for maximizing rice yields; however, data is lacking on the interaction of these factors with modern hybrid and pure-line cultivars.

In a study in the March–April 2016 issue of *Agronomy Journal*, researchers reported the response of rice cultivars during a three-year study in Arkansas where rice was fertilized at five N rates and grain harvested at high (220–240 g kg⁻¹), medium (180–200 g kg⁻¹), and low (140–160 g kg⁻¹) HMC. At N rates required to maximize rough rice yields, milling yields were 98 to 99.9% of the maximum milling yield within most cultivar-HMC combinations. The exception was the pure-line cultivar, Wells, harvested at low HMC.

In general, applying N at rates needed to maximize rough rice yield and harvesting at high and medium HMC led to near-maximum HRYs. In contrast, rice harvested at low N rates and HMC reduced HRY. Understanding cultivar-specific interactions with fertilizer N rates and HMC will ensure best management practices are implemented that produce optimal rough rice and milling yields. This, in turn, will minimize over-application of N, which does not improve rice yields, but could have negative impacts on the environment.


A sample of healthy farm soil. Photo courtesy of the Chesapeake Bay Program.

Rice. Photo by Kathleen Phillips, Texas A&M AgriLife Research.
**Fertilizer Deep Placement Increases Rice Production**

Fertilizer deep placement (FDP) has been widely recognized as an effective nutrient management practice that increases rice productivity, improves nitrogen (N) use efficiency, and reduces N losses and fertilizer N use. In southern Bangladesh, particularly tidal flood-affected areas, water control is ineffective both on rain-fed and irrigated lands, thereby affecting N management.

In the March–April 2016 issue of *Agronomy Journal*, experiments were conducted in 115 farmers’ fields in southern Bangladesh across 35 sub-districts in eight districts and over nine contiguous rice growing seasons during 2009–2012. The experiments compared the effects of fertilizer deep placement (FDP) of urea briquettes (UB) and nitrogen–phosphorus–potassium briquettes (NPK) with farmers’ broadcast prilled urea (PU) on rice yields, N use efficiency, and net economic returns. In addition, broadcast PU and FDP UB treatments were tested in 440 demonstration plots and 1,395 crop-cuts across eight districts during 2009–2010.

Fertilizer deep placement significantly increased grain yields and net economic returns across all rice-growing seasons and years compared with PU, with average yield increases of 21 to 31% during the wet season and 11 to 17% during the dry season. In addition, N savings with FDP was 33 to 44% and 28 to 35% during the wet and dry seasons, respectively. Deep placement of one 2.4 g NPK briquette for the wet season (44 kg N ha⁻¹) and two briquettes (88 kg N ha⁻¹) for the dry season is more profitable (yield, N use efficiency, and labor savings) than other fertilizer management practices for southern Bangladesh. Fertilizer deep placement also provided the greatest benefit during the rain-fed, wet season, where farmers have little or no control over water management and timing of N application.


**Corn Hybrid Responses to N Fertilization over Five Decades**

Higher corn yields will be necessary to meet the increasing demands of an expanding world population for feed, fiber, and fuel; however, efforts to increase yields must also minimize the environmental impacts of nitrogen (N) fertilization. Much can be gained from examining the responses of historical corn hybrids to N additions, including insights into potential ways to improve future corn hybrids.

In the March–April 2016 issue of *Agronomy Journal*, researchers report on a multi-year study of the responses to fertilizer N rates of popular hybrids from a five-decade period (1960s–2000s). The research team found that hybrid productivity and nitrogen use efficiency increased across the period studied; however, the agronomically optimal N rate did not change. Grain yield also increased by 65%, but total plant N uptake increased by only 19%, indicating less N uptake in relation to yield increase.

Most N use efficiency measures indicated improvements in N use, and the portion of total plant N uptake accumulated by silking was the same across all eras. Grain N concentrations, however, were 24% lower during the 2000s compared to the 1960s. This research shows that corn hybrid development across the 50-year period has significantly improved productivity. At the same time, decreased grain N concentrations, limited differences in plant N uptake, similar yields when no N is applied, and similar optimal N rates among hybrids from different eras indicates that the soil–plant–N relationship has not changed.


In southern Bangladesh, fertilizer deep placement (left) significantly increased grain yields and net economic returns across all rice-growing seasons and years compared with broadcast prilled urea (right).

A new study in *Agronomy Journal* reports that hybrid productivity and nitrogen use efficiency have increased over a five-decade period (1960s–2000s); however, the agronomically optimal N rate has not changed.
Soybean Cultivar and Input Use Decisions

Increased soybean commodity prices in recent years have growers interested in switching to an aggressive input-based approach instead of utilizing a traditional active management system based on integrated pest management principles. Many of these high-input systems are being adopted in an attempt to increase yield despite limited validation. Furthermore, little is known about how these high-input systems interact with other agronomic management decisions, including cultivar selection.

In the March–April 2016 issue of *Crop Science*, researchers report on a three-year study from 19 locations across nine states in the Midwest and Mid-South where many soybean cultivars were grown under three different input systems to determine their effect on soybean yield.

The researchers found that cultivar selection rarely interacted with the different input systems to affect yield. The high-input systems did increase yield on average, but the yield increase was not significant enough to cover the cost of the inputs.

For soybean growers interested in developing high-input based systems, cultivar selection and input choices can remain as independent management decisions. However, these results also further support the active use of scouting and making input decisions based on sound integrated pest management principles instead of prophylactic applications.


Decomposition of Tree Legume Fractions in a Silvopastoral System

Intense weathering in warm and humid regions reduces the soil’s capacity to provide adequate nutrients to sustain pasture productivity. External nitrogen (N) inputs become necessary, but economic reasons preclude the use of N fertilizer in most cases. Tree legumes, which can be grown in silvopasture systems, are a viable source of N. They also provide other ecosystem services.

 Decomposition of leaves and stems on the ground is one of the pathways of N return in silvopasture systems. A study in an upcoming issue of *Crop Science* evaluated two such systems with different tree legume species: *Mimosa caesalpiniofia* Benth. (sabia) and *Gliricidia sepium* (Jacq.) Kunth ex Walp. (gliricidia). Decomposition of leaves and stems with different circumferences were also analyzed.

In general, leaves decomposed faster than branches, and leaf disappearance rates for gliricidia were greater than for sabia. Gliricidia stem decomposition rates also outpaced those of sabia. The N disappearance rate in gliricidia was inversely proportional to branch circumference and lower in thicker stems. Leaf N mineralization resulted in an annual contribution of 65 and 42 kg N from gliricidia and sabia, respectively. The differences in concentration and decomposition rates of the various fractions indicate distinct capacities for recycling nutrients among these species.


Field trial in East Troy, WI in June 2014 depicting six soybean cultivars grown under three different input systems.

Livestock grazing on a silvopasture system of *Gliricidia sepium* and *Brachiaria decumbens* in Pernambuco, Brazil. Photo by Jose Dubeux.
Salinity Pulses Reduce Wetland Nitrate Removal

Coastal estuarine wetlands often represent the last line of defense for removing excess nutrients from river water prior to them reaching the coastal zone, where they may contribute to algal blooms and hypoxia. Wetlands typically exhibit a high capacity for nitrate removal via denitrification, but this microbe-mediated process may be sensitive to fluctuating salinities.

In the March–April 2016 issue of the *Soil Science Society of America Journal*, researchers report on a laboratory study investigating the impacts of varying concentrations of salinity pulses on denitrification rates in freshwater and salt marsh soils from coastal Louisiana, USA.

The team found that a pulse of freshwater into salt marsh soils can suppress denitrification by 98% for more than 11 days. In freshwater marsh soils, on the other hand, a brackish water (15 ppt) pulse accelerated denitrification (75% increase) while a saline water (35 ppt) pulse suppressed it by 73%.

Given that hypoxia in the adjacent Gulf of Mexico is largely attributed to excess nitrate from the Mississippi River, it’s vital to understand how events such as storm surges or the opening of freshwater river diversion structures may affect a coastal wetland’s ability to serve as a nitrate sink. This information will help coastal managers maximize denitrification efficiency.


Improving Spectroscopy of Soils with Mathematical Subtractions

Minor components of soils, such as soil organic matter (SOM) and pollutants, can play important roles in soil functions. Since its first application to soil samples in the mid-20th century, Fourier transform infrared (FTIR) spectroscopy is increasingly utilized for analysis of SOM and other minor components.

However, the dominant mineral component of most soils can severely limit FTIR resolution of SOM. Spectral subtraction is an established technique for isolating specific components of multicomponent spectra and, as such, is a powerful tool to improve and expand the potential of spectroscopy of soil samples, yet its use in such samples can be contentious.

In the January–February 2016 issue of the *Soil Science Society of America Journal*, researchers review the history, limitations, and potential of spectral subtractions in soil samples to extend the versatility of FTIR spectroscopy to this field. To maximize the utility of spectral subtraction, and avoid its misuse, consideration must be given to the general and soil-specific limitations of FTIR and subtractions as well as specific experimental objectives. The role of spectral subtractions in FTIR of soils can be confusing because of differing perceptions on the objectives of its use. This tends to reflect a gap between how FTIR spectroscopy has been traditionally used for chemically simple samples and their more recent application to complex samples like soils. Limitations of FTIR as a method and the complexity of SOM should not be conflated with issues specific to spectral subtractions, which allow quantitative applications of FTIR in soil samples. Spectral subtractions can help extend the utility of FTIR as one more tool in the soil scientist’s toolkit.

Dissipation of Excreted vs. Fortified Antimicrobials during Manure Composting

Livestock operations across North America use antimicrobials to treat and prevent infections in cattle and promote growth. Land application of manure containing these antimicrobials increases the risk of selecting for antimicrobial-resistant bacteria.

In a recent, open access paper in the *Journal of Environmental Quality*, researchers studied the effectiveness of composting for attenuating chlortetracycline, sulfamethazine, and tylosin in beef cattle manure destined for land application. Results showed that first-order degradation of the antimicrobials dissipated 85 to 99% of the initial concentrations after 30 days of composting. This indicates that composting can effectively reduce environmental loading of these compounds.

The study also found that chlortetracycline dissipated faster when it was already present in the manure (excreted) of animals fed the antimicrobial (time to 50% dissipation, DT50 = 12 d) than when it was added to manure that originally contained no antimicrobial (mean DT50 = 6 d). This latter process, called fortification, is widely employed in dissipation studies because of its relative ease and affordability.

In contrast, fortified sulfamethazine (DT50 = 7 d) and tylosin (1.5 d) dissipated faster than their excreted counterparts (9 and 12 d, respectively). Therefore, fortified antimicrobials may not accurately reflect the dissipation of excreted antimicrobials in manure.


Early Microbial Establishment on Growing Root Surfaces

Bacteria in the soil play a major role in cycling nutrients, breaking down organic matter, and fixing nitrogen. And roots are important to microbial life in soil because they provide organic carbon to microbes living in the deeper soil; hence, it is imperative to understand the interaction between bacteria and root surfaces. These interactions are exceedingly complex, so any mathematical treatment of these processes must be complex enough to capture some of this ecological complexity.

In the February 2016 issue of *Vadose Zone Journal*, researchers investigated these interactions, including root and bacterial growth and the adhesion of bacteria onto root surfaces. Bacteria colonize root surfaces to avail themselves of the nutrient-rich habitat. However, previous studies have ignored the effects of root growth on the ability of microbes to colonize root surfaces. Here, the authors explored the factors controlling colonization of growing roots. Their mathematical model describes the relative flows of root and bacterial cells moving past stationary soil particles and estimates the quantity of bacteria along the root surface.

The researchers found that movement of bacteria is controlled by convective transport due to root elongation, as opposed to movement along a concentration gradient (diffusion) or chemotaxis. But chemotaxis becomes the controlling phenomenon in non-growing or slowly growing roots.

The model also suggests that bacteria that stay attached can use carbon from the root surface and grow for longer periods than bacteria that are not attached. Attachment at the root tip eventually increases the overall colonization of soil next to mature, older roots and contributes to a greater dispersion of microbes in soil. The root tip provides many sites for bacterial growth when the density of bacteria are low, but bacterial attachment and growth depend both on characteristics of the root and the bacteria. Thus, bacterial density is much higher, for example, when roots grow slowly or if bacteria can attach more rapidly.

This research explains the relationship between bacterial attachment and growth of the root tip. These new findings have wide implications for understanding bacterial activity in soil, altering decomposition rates of organic matter, and cycling nutrients, all of which are needed to maintain a healthy environment for plant growth.


This paper is part of a special collection on “Soil as Complex Systems.”
Research and Application of Biochar in China

China is facing major environmental challenges, among which are soil contamination and quality deterioration, crop residue disposal other than field burning, and substantial agricultural greenhouse gas emissions. An innovative solution to these challenges is to convert agricultural byproducts into biochar and apply the biochar to farmland as a soil conditioner. Intensive scientific studies and pilot trials have been implemented in different regions of China to validate the agronomic and environmental benefits of soil biochar and to develop practical biochar fertilization programs.

The annual generation of crop residues in China is approximately 790 million tons, providing abundant feedstock for biochar production. Universities and research institutions across the nation have been organizing rigorous experiments and trials to optimize organic waste-based biochar production, to formulate different biochar fertilizers, and to design best biochar application practices for nurseries, vegetable gardens, corn fields, and rice paddies with diverse soil types and climate regimes. Pyrolysis equipment at mobile, small, and moderate scales has been developed. A number of companies are commercially producing biochar, bio-oil, and syngas from crop residues, animal manures, and biosolids.

This chapter in the book Agricultural and Environmental Applications of Biochar: Advances and Barriers provides an overview on (i) the state of the art of biochar production in China, (ii) the achieved agronomic benefits of biochar application in this country, (iii) the potential of biochar application in China for mitigating greenhouse gas emissions, (iv) biochar application for remediation of China contaminated soils, and (v) the major barriers to and the attained progress in biochar commercialization in China. The authors also identify the existing challenges and future directions for expanding biochar utilization in the country.


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Recommended Setback Distance between Manure Application and Leafy Green Crops

Land application of livestock manure is an important agriculture practice to recycle nutrients for crop fertilization. However, pathogens present in manure residues present concern for contamination of nearby fresh produce. While recommendations to assure produce safety regarding surface runoff have received considerable attention, risk-based recommendations to reduce produce contamination by bioaerosols originating from nearby land-applied manure residuals have not been well described.

In the March–April 2016 issue of the Journal of Environmental Quality, researchers report human health risks associated with deposition of bioaerosols from manure application sites onto downwind produce crops based upon field measurements and modeling. Their results show that risks of gastrointestinal infection from consumption of leafy green crops decrease with setback distance from manure-applied lands and delay before crop harvest. Considering an acceptable risk level of 1:10,000, these researchers recommend a minimum 160-m setback distance be provided between manure application areas and nearby leafy green crop production.

The results indicate that under certain conditions, bioaerosols emitted from manure application sites may present significant public health risks. These risks should be considered when managing manure residuals. Information generated in this study will allow farm operators, regulators, and other stakeholders to make informed decisions regarding land application practices and food crop production.


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