Reducing Greenhouse Gas Emissions from Stored Manure

As livestock production intensifies—that is, more animals are kept on fewer farms—larger amounts of manure are stored for many months to prevent nutrient contamination of ground and surface waters, and so that manure can be applied during the growing season. However, manure storage units have little oxygen, promoting production of the greenhouse gas (GHG) methane. Methane is estimated to be 86 times more powerful than CO₂ (over 20 years) in contributing to climate change.

In the January–February 2016 issue of the Journal of Environmental Quality, researchers report how changes in manure management on New York dairy farms since 1992 have affected GHG emissions. The authors also estimated the costs of reducing future GHG emissions. They found that despite multiple efficiency improvements, the shift from daily spreading of manure to storing liquid manure has doubled dairy farm GHG emissions since 1992.

Fortunately, methane is easily combusted to CO₂, greatly reducing its effect on climate, and some farms have covered their manure storage units to capture and flare the methane gas. The authors found that covering and flaring methane from most storage units would reduce GHG emissions from manure by 62% at a cost of $13 Mg CO₂e⁻¹, which is within the range currently paid in carbon markets.


Soil–Water Interactions Control Phosphorus Loss in Cranberry Floodwaters

Commercial production of cranberries is increasingly seen as a potential source of phosphorus (P) in lakes receiving floodwater discharge. Given growing pressures to mitigate phosphorus (P) losses in key cranberry production regions, there is strong interest in understanding the processes that control phosphorus loss from cranberry farms.

In a study in the January–February 2016 issue of the Journal of Environmental Quality, researchers with the USDA-ARS and University of Massachusetts showed that increases in floodwater P were consistent with the transport of dissolved P in soil water, as well as the mobilization of particulate P in ditches. Although patterns were generally pervasive across the study sites, magnitudes of P loss varied widely, ranging from less than 0.8 to as high as 4.7 kg P ha⁻¹.

As P loss was greatest for older cranberry bogs during the harvest flood, a first goal in remedial management should be to curtail P losses in non-renovated bogs during the cranberry harvest. This could possibly be achieved by capitalizing on the sorption capacity of Fe-rich bog soils or focusing on moments of disproportionately high P export. Other promising activities include amending floodwater with Ca-based materials that remove P from solution and produce a relatively insoluble Ca-P mineral.

scribed this growth best. This means that while unmanaged
plants don’t grow as fast as crops, they also don’t grow as
slowly as natural solute transport rates alone would pre-
dict. Expressed mathematically, their growth diminishes to
the power of 0.82, Hunt found. (Linear growth, in contrast,
gets a power value of 1).

The definition of these relationships through percolation
theory now opens up many other possibilities. Being able
to relate the linear growth rates of plants to soil water flow
velocities, for example, may allow primary productivity to
be predicted from evapotranspiration rates across ecosys-
tems, Hunt says.

Percolation theory may also aid the modeling of chemi-
cal signaling in soil: How long it takes for a chemical emit-
ted by a fungal hypha, for instance, to reach a root tip 100
µm away. Others have used diffusion to explain this, but
diffusion is too slow, Hunt says. What’s needed is a model
that accounts for pore water flow.

“If you want to understand the rates at which [organ-
isms] communicate with each other, how these commu-
ication networks develop, and so on, you need to know
the fundamental timescales of the movement of things in
porous media,” he says. “And porous media should be
treated as networks, which the living, biological networks
are exploiting to their advantage.”

The fundamental physics aren’t novel, he adds; other
fields, such as petroleum engineering, have embraced mod-
els of networks and connectivity for years. Hunt hopes that
soil physics will now do the same.

“This is very important technology transfer,” he says.
“So I’m more a messenger than a creator.”

M. Fisher, Features Editor for ASA, CSSA, and SSSA

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This article is part of a special section in Vadose
Zone Journal on “Soil as Complex Systems.”
Tapping the Genetic Potential of the USDA Sorghum Germplasm Collection

A wealth of genetic diversity and valuable traits exist in sorghum germplasm collections, in particular those from the species’ center of origin in present-day Sudan and Ethiopia. However, sorghum is a short-day plant, and much of the USDA’s sorghum germplasm collection flowers too late or is too tall to be exploited for seed production in temperate zone environments.

Building upon the success of the historical TAES-USDA Sorghum Conversion Program, a team of public- and private-sector scientists launched a renewed effort to “convert” accessions from the USDA’s Sudanese and Ethiopian collections into plants adapted to temperate zones. This was accomplished by introgressing day-neutral flowering alleles and dwarf-height genes into exotic backgrounds.

To this end, a conventional backcrossing approach was augmented with genomic-assisted selection; specifically, the team used genotyping by sequencing to reduce the number of backcross generations needed to recover the tropical genome in an adapted genetic background. The greatest hindrance to recovering the exotic genome in a short, early-flowering genotype was linkage drag flanking the introgressed flowering and dwarfing recessive alleles; this was reduced, but not eliminated, by genomic-assisted selection.

The resulting registered material, published in the January 2016 issue of the Journal of Plant Registrations, contains germplasm with highly desirable breeding values and new sources of B lines that may help expand the narrow genetic base observed in female parents of hybrid sorghum breeding programs.


Soil Factors Affect Efficiency of Borehole Thermal Energy Storage

Geothermal energy systems harness the heat of the earth while solar energy uses the power of the sun. Borehole thermal energy storage (BTES) systems combine the two, generating energy with solar panels during summer and storing it in the subsurface for use in winter. The first North American community to install a BTES system, in 2007, was the Drake Landing Solar Community in Alberta, Canada.

Specifically, BTES systems capture heat in summer by circulating water through solar panels and then into an underground network of pipes to transfer the heat to the subsurface. During the winter, cold water is circulated through the same pipe network to extract the stored heat. A challenge facing BTES in community-scale applications is the relatively low efficiency of these heat extraction processes. A study in the January 2016 issue of Vadose Zone Journal used the Drake Landing community to better understand fluid flow and heat transport processes in soil to improve system efficiency.

The authors found that an established, heat and moisture flow modeling package, TOUGH2, was an effective tool for predicting how subsurface hydrological and thermal properties affect BTES system efficiency. For example, the model showed that heat extraction efficiency decreases with increasing soil thermal conductivity, which allows heat energy to move away from pipes more easily, resulting in a lower thermal gradient and lower heating of water during winter. Extraction efficiency also drops with increasing groundwater flow and soil permeability for the same reason. Unsaturated soils, on the other hand, are more efficient at transferring heat because the lower soil water content leads to lower thermal conductivity.

Adapted from Catolico, N., S. Ge, and J.S. McCartney. 2016. Numerical modeling of a soil-borehole thermal energy storage system. Vadose Zone J. 15(1). View the full article online at http://dx.doi.org/doi:10.2136/vzj2015.05.0078.
Study Examines Change in Soybean Physiological Traits with Yield Improvements

Plant breeding makes important contributions to increased production of food and fiber. Examining the physiological traits related to specific plant functions in soybean cultivars released over time may help characterize the impact of breeding on cultivar development and inform the design of future breeding strategies.

In an open access paper in the January–February 2016 issue of *Crop Science*, researchers report on changes in physiological traits in soybean that occurred in cultivars released from the 1920s through 2010. The research evaluated genetic differences in pollen germination, leaf chlorophyll content, electrolyte leakage, antioxidant capacity and leaf canopy temperature among the genotypes. It also examined whether changes in these traits occurred over time, and if they were associated with increased seed yield.

This study provided evidence that canopy temperature and chlorophyll content changed over time, along with changes in maturity, plant height, lodging, and disease resistance. The changes were also associated with improvements in seed yield.

The relationships between seed yield and canopy temperature and leaf chlorophyll content suggest that these traits should be intentionally selected for in plant breeding programs, possibly using a high-throughput evaluation process, as a means to improve genetic gain.


Study Compares Performance, Quality Traits of Hulled and Bread Wheats

Einkorn (*Triticum monococcum* L.), emmer (*T. dicoccum* L.), and spelt (*T. spelta* L.) are Old World, hulled wheats that were among the first domesticated crops. Emmer was the main cereal crop in Egypt at the time of the Pharaohs, for example, while spelt was a major cereal of the Alemannians in Germany, Austria, and Switzerland between the 12th and 19th centuries.

Although einkorn, emmer, and spelt were eventually replaced by higher-yielding bread and durum wheats, they are now attracting renewed interest as food grains. As reported in the January–February 2016 issue of *Crop Science*, scientists in Germany performed a large field trial to deliver the key facts about hulled wheats to farmers, millers, and bakers.

What the team found is that mean grain yields of spelt, emmer, and einkorn were 37, 55, and 62% lower, respectively, than yields of bread wheat. Furthermore, einkorn, emmer, and spelt plants were 30 cm taller than bread and durum wheat. Consequently, farmers should aim at reducing the plant height of hulled wheats to avoid lodging.

Despite their high protein content, hulled wheats also had low protein quality from a classical bread wheat point of view. However, adapting classical baking procedures enables the production of high quality breads from einkorn, emmer, and spelt, in addition to the development of alternative products like breakfast cereals and excellent specialty breads.


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Expression of Water-conserving Trait in Maize Varies at High Temperature

Drought is often the most important stress behind yield losses. Recent research has identified a water-conservation trait for drought conditions, in which plants show limited transpiration under low relative humidity, which commonly occurs with hot, midday temperatures. In fact, one demonstrated advantage of DuPont Pioneer’s AQUAmax maize hybrids is their expression of the limited-transpiration trait. However, previous studies of the trait were performed at 32°C (90°F), a lower temperature than what maize crops commonly experience under low humidity at midday.

A study in the January–February 2016 issue of Crop Science was undertaken to determine expression of the water-conservation trait at higher temperatures. Twelve hybrids that had previously been shown to express the trait were found to sustain expression at temperatures up to 36°C At 38°C, however, five hybrids lost the ability to conserve water under low atmospheric relative humidity. The remaining seven hybrids continued to express the trait.

The differential expression among hybrids at high temperature makes it possible for further refining the selection of hybrids based on the temperature and drought conditions of specific geographical areas. This fine-tuning, in turn, will allow both for yield increases and optimum use of water.


Clover Nitrogen May Not Improve Organic Dry Bean Yield

Cover crops contribute to nitrogen (N) cycling on 1.8 million ha of grain and oilseed production in the United States. But the magnitude and timeframe over which cover crops alter soil inorganic N depends on many factors. A recent open access paper in the January–February 2016 issue of Agronomy Journal studied the impact of cover crops on N cycling in organic dry beans and on methods used to measure N.

Cover crop C:N ratios and N content were the most consistent factors influencing soil N. Medium red clover increased soil N, for example, and sometimes the N content of dry beans; however yield was not improved. Cereal rye, oilseed radish, and the ambient cover of weeds were also studied.

In their studies of methods, the authors found a positive correlation between the KCL soil extraction and ion exchange, resin strip methods for measuring soil inorganic N. However, soil extractions were more likely to detect the effect of the cover crop, while the use of resin strips was constrained by cultivation. Relative chlorophyll readings did not correlate with soil extractions.

Overall, the authors report that a cover crop’s contribution to soil N cycling may not increase dry bean yield. Regarding methods, KCl soil extractions proved the most practical for measuring N in field studies in organic systems.


Left: The experimental setup used by the authors to study expression of the limited transpiration trait at high temperatures.

Left: Fall cover crop stands of oilseed radish, medium red clover, cereal rye, and no cover crop control. Cover crops were planted preceding dry beans in Michigan. Right: Ion exchange resin strips were used to continuously monitor inorganic nitrogen availability in organic dry beans following the incorporation of cover crops. Photos by Erin Hill.