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Managing nutrients, water, and energy for producing more food with low pollution (MoFoLoPo); What would success look like?

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Synthetic nitrogen (N) fertilizer has enabled modern agriculture to greatly improve human nutrition during the 20th century, but it has also created unintended human health and environmental pollution challenges for the 21st century. Averaged globally, about half of the fertilizer-N applied to farms is removed with the crops, while the other half remains in the soil or is lost from farmers' fields, resulting in water and air pollution. As human population continues to grow and food security improves in the developing world, the dual development goals of producing more nutritious food with low pollution will require both technological and socio-economic innovations in agriculture.

A World Café session describing the challenges of nitrogen management in food production was held at the 16th National Conference and Global Forum on Science, Policy and the Environment. Organized by the U.S. National Council on Science and the Environment (NCSE) in January 2016, the overall conference theme was the Food, Energy, Water Nexus. With support from a National Science Foundation Research Coordination Network grant, Eric Davidson and Rachel Nifong, University of Maryland Center for Environmental Science, and Jill Baron, U. S. Geological Survey, brought together scientists and practitioners to address the topic: Managing Nutrients, Water, and Energy for Producing More Food with Low Pollution (MoFoLoPo); What Would Success Look Like?

The World Café session explored what success for the highly complex problem looks like from the perspectives of several stakeholders. Two case studies of nitrogen management in agriculture were presented, one from nitrogen poor small household agriculture in sub-Saharan Africa, and one from nitrogen rich irrigated corn agriculture in the central U. S. A panel discussion followed that included views of nitrogen management in the U. S. from a range of practitioners representing farming (Brandon Hunnicut, Hunnicut Farms) and dairy (Jon Slutsky, La Luna Dairy), contrasted with experiences from sub-Saharan Africa. The audience also heard from several advisers about methods that are being applied toward sustainable agriculture, including education (Deanna Osmond, North Carolina State University), precision agriculture (John McGuire, S2 Partners, LLC), and science-based metrics and benchmarks designed to enable an alliance of partners in food commodity chain networks to chart progress on nutrient management (Allison Thomson, U. S. Field-to-Market Alliance for Sustainable Agriculture). While it is clear that partnerships across sectors and among stakeholders will be needed to achieve progress, it is less clear whether the potential partners envision success in the same way.

The case studies were presented to demonstrate how management of nutrients, water, and energy are inextricably linked in both small-scale and large-scale food production, and that science-based solutions to improve the efficiency of nutrient use can optimize food production while minimizing pollution. Cheryl Palm and Pedro Sanchez of the Agriculture and Food

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Security Center at Columbia University spoke about breaking the cycle of low nutrient inputs to crops, low crop yields, and poor health in sub-Saharan Africa. A holistic, stepwise approach to improving crop yields begins with subsidized access to fertilizers and improved crop seeds for rural farming households. Thereafter, nitrogen use efficiency can be improved by building up soil organic matter with organic inputs from animal manures, green manures such as legume cover crops or trees, or composts. Water use efficiency in this rainfed region is a critical component of increasing crop yields, and can be increased up to 25% with soil management practices such as modified tillage, crop residue management, and soil nutrient status.

At the opposite end of the agricultural spectrum, Richard Ferguson of the University of Nebraska presented results of efforts to reduce nitrogen loss to groundwater in intensively managed irrigated corn systems in the central U. S. Groundwater nitrogen contamination in exceedance of safe drinking water standards was noted in 1961 and the area of contamination has increased over time. Groundwater management areas, established by the State of Nebraska, rely on local governance to implement fertilizer application restrictions and practices to reduce the severity of NO_3–N contamination. Best management practices, including nitrogen fertilizer applications at the right rate, right source, right timing, and right placement (the 4Rs), are helping irrigated crop growers optimize input use efficiency and profitability, while minimizing environmental impact. A new effort in on-farm research showed that N additions could be reduced below traditional extension recommendations for irrigated corn in Nebraska by 20–25% without a significant decrease in crop yield by using sensors to detect crop nutritional needs.

The World Café session ended with a discussion by Eric Davidson of what it will take to achieve the goals of producing more food with low pollution. Whether irrigated or rain-fed, and whether large-scale and intensive or small-scale and subsistence-oriented, the nexus of food, water, and energy is inherently related to nutrient management. A range of approaches is needed in order to move world agriculture toward more sustainable practices, including technical, regulatory, financial, and social tools. Efficiencies can be achieved along the entire supply chain from producers of crops and livestock to reduction in food waste and altered dietary habits of consumers. Demand for food to improve nourishment of a growing human population ensures that the global N cycle will remain intensified relative to the pre-industrial era, but knowledge-based agriculture can limit the unintended environmental consequences of food production while pursuing the quest for sustainable development.

A summary paper of the World Café session is available: Davidson, EA, RL Nifong, RB Ferguson, C Palm, DL Osmond, JS Baron. 2016. Nutrients in the Nexus. Journal of Environmental Studies and Science, DOI 10.1007/s13412–016–0364 – y.

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