The Kansas City Consensus – 2013

A remarkable group of 160 scientists, agronomists, agricultural extension agents, certified crop advisors, seed and fertilizer industry representatives, regulatory agency representatives, non-government organization (NGO) scientists, and farmers met in Kansas City on August 13-15 to address their common concerns about how modern agriculture can meet the growing demand for nutritious and affordable food and biofuels while minimizing unintended environmental impacts. This conference[1] focused on nitrogen (N) in fertilizers and manures. All crops and animals need N, but unintentional leakage of N out of farms causes significant pollution of air and water. Sub-optimal nitrogen use efficiency (NUE)[2] in agriculture is largely responsible for these N losses. Improving NUE presents an opportunity for reducing both environmental impacts and farming costs. The main question posed to this group was:

What are the technical, economic, and social impediments and opportunities for increased nitrogen use efficiency in crop and animal production systems?

The following consensus statement emerged from the conference:

<u>Technology and knowledge:</u>

1. The "4-R Nutrient Stewardship" concept – applying the *Right* source of nutrients at the *Right* rate, *Right* time, and *Right* place – provides a sound framework for optimizing NUE and minimizing N losses to the environment.
2. Because much of the N taken up by crop plants comes from mineralization of N from soil organic matter and crop residue, which is affected by weather and variation within fields, determining the right rate and timing of N applications will always be challenging. Climate change is likely to add to this challenge, as weather extremes become more common, further complicating N management and efforts to reduce N losses.
3. No biological system is 100% efficient; some leakage of N from crop and animal production systems is inevitable. However, losses can be minimized by good science-based management, including integration of natural and social sciences to develop sound policies for food security and environmental protection.
4. N use efficiency and effectiveness have been increasing during the last several decades, especially in developed countries. This progress is due, in part, to increased crop yields and livestock production through improved irrigation and water management, improved crop varieties and animal breeds, use of controlled-release fertilizers and urease and nitrification inhibitors, improved soil and plant testing to match nutrient applications with crop demands,

---

[1] Cosponsored by the Soil Science Society of America and the American Geophysical Union and supported by a grant from the National Science Foundation to the Woods Hole Research Center and by contributions from the International Plant Nutrition Institute and The Fertilizer Institute.

[2] Agronomists use a number of definitions and metrics for NUE, such as "the percent of applied N fertilizer recovered by the plant", which is <40% as a global average and typically about 50% in the USA. Some of the remainder stays in the soil, replenishing soil fertility, and some is washed away to rivers, lakes, estuaries, and groundwater, or is emitted from the soil in gaseous forms. More technical definitions of NUE can be found in Snyder and Bruulsema (2007, http://info.ipni.net/L2ES8) and Cassman et al. (1996, *Field Crops Research* 47:1-2).

use of cover crops, improved nutrition management of livestock, and increasing availability of decision support tools. However, much room for further improvement remains.

5. New technological developments and outreach will further help farmers improve NUE, but technology alone is not the only or perhaps not even the most important factor for near-term improvements in NUE and mitigating N losses. Many effective current technologies are not utilized because of economic and social barriers to their adoption.

Economic and social impediments and opportunities:

6. Economic signals regarding the cost of N fertilizers are mixed. Fertilizer costs provide significant economic incentive to improve NUE, but the economic risk of applying too little N is also high. Application of ample N is often viewed as providing an important economic margin of safety, equivalent to relatively inexpensive insurance.
7. A lack of visible, quantifiable, or tangible local consequences of N losses from farming operations often makes the urgency for further improvements of NUE a difficult sell.
8. Uncertainties in seasonal fertilizer supply, lack of trust in and confusion over government or university recommendations, and unclear advantages and credits impede more widespread adoption of participation in NUE and best management practice (BMP) programs.
9. Most US farmers currently get most of their information about NUE management practices from fertilizer, seed, and feed retailers and crop and livestock advisors, which, in some cases, could put sales goals and reducing nutrient use at odds. However, retailers and advisors also sell a variety of products and information, including those that could improve NUE.
10. Most farmers have significant demands on their time and labor. The case for learning and adopting NUE innovations must be compelling and should be relatively easily implemented.
11. While young farmers are increasingly well-educated and amenable to new technologies and internet-based information, resistance to changing tried and true practices used by current and previous generations remains important.

Recommendations and opportunities for improvements:

12. Potential solutions to the problem of N loss to the environment include a combination of government and private sector incentives, crop insurance, regulations, and outreach efforts to encourage adoption of BMPs that would improve NUE. These solutions should be targeted first where NUE is low and N loss is high.
13. Partnerships are needed among industry, universities, governments, NGOs, crop advisors, and farmers to demonstrate the most current, economically-feasible, and effective BMPs. It is imperative that the private sector retailers and advisors who provide farmers with products and information are fully engaged with the continuing education and outreach efforts of the Soil Science Society of America, the American Society of Agronomy (including Certified Crop Advisers), and other NGOs. Dissemination of up-to-date, science-based nutrient recommendations via trusted advisors will help speed technology adoption and improve field implementation. Greater trust in nutrient management recommendations means lower perceived risk, which affords less need for applying additional N for "insurance" purposes.

14. Localized policies, including regulations, incentives, and outreach, have been most effective when tailored to local conditions, administered and enforced by local entities, and where local "buy-in" has been obtained. This model should be facilitated in the future. More local examples of success stories of improving NUE and reducing N loss while maintaining good yield and profitability are needed. These examples should get more attention in local and national media.
15. Nutrient management should be tied to performance-based indicators, including clearly defined NUE indicators on the farm, with strong incentives for participation and reporting of data. Well defined environmental quality indicators downwind and downstream are also needed. Multiple stakeholder groups should be engaged in developing performance-based metrics, tied to monetary values where appropriate and feasible. Better estimates of costs and risks are needed for development of viable crop guarantee or insurance approaches.
16. On-farm participatory research, focused on using 4R concepts to increase yield and NUE and minimize N loss will help quantify and visually demonstrate opportunities, risks and rewards. Strategically designed and coordinated participatory research networks could provide cooperating farmers useful and trusted data that is specific to their climate-soil-management situation. Long-term monitoring provides a means of assessing progress.
17. Watershed-level research in agriculturally dominated landscapes is needed to understand the fates of N and to demonstrate the value of landscape-scale integration of management and/or regulatory governance. Interdisciplinary research should integrate agronomic, ecological, economic, and social science perspectives on food production, environmental impacts, and associated monetary and nonmonetary costs and tradeoffs for society. It will also require cooperation among institutions with different responsibilities and jurisdictions, often transcending traditional governance and institutional structures across affected geographic regions, such as the Ohio River Valley Water Sanitation Commission, the Mississippi River Basin Initiative, and the Chesapeake Bay Program.
18. Long-term sustainability depends upon innovative management of cropping systems, including intensification, perennialization, crop rotations and diversification, and landscape integration. Investments in research, education, extension, and human resources are essential for developing the knowledge and skills needed for such innovation and to achieve sustainability goals, but funding has been declining in the US. It is imperative that federal and state governments increase their support of knowledge-based agriculture.
19. Although N losses have many environmental impacts, such as climate change, stratospheric ozone depletion, air pollution, biodiversity loss, fisheries decline, and algal blooms, perhaps the most compelling argument to farming communities and to the broader public is the critical need to ensure clean drinking water for generations to come. While responses of surface water quality to mitigation efforts can be relatively rapid, there is often a significant lag time (decades to centuries, depending on the soil and groundwater conditions), between adoption of NUE mitigation efforts and changes in groundwater nitrate concentrations. A successful program in the Platte River Valley of Nebraska since the 1980s provides a stellar example that effective mitigation through outreach, cooperation, and regulation is possible.

Disclaimer: Signatories of this statement are expressing their personal views and not necessarily those of their institutional affiliations. Institutional affiliations are included only to help identify of the signatories and do not imply endorsement by the respective institutions.

Name	Title and/or certifications (e.g. CCA)	Institutional affiliation (optional)
Charles W. Rice	University Distinguished Professor	Kansas State University
Eric A. Davidson	Adjunct Senior Scientist	Woods Hole Research Center
Emma C. Suddick	Research Associate	Woods Hole Research Center
Mark B. David	Professor	University of Illinois at Urbana-Champaign
J. Mark Powell	PhD, Soil Scientist	
Harold M. van Es	Professor of Soil Science	Cornell University
Paul E. Fixen	Senior Vice President	International Plant Nutrition Institute
Linda Prokopy	Associate Professor of Natural Resource Planning	Purdue University
Jerry L. Hatfield	PhD, Plant Physiologist	
Ronald Gehl	Assistant Professor	North Carolina State University
Clifford S. Snyder	PhD, CCA	International Plant Nutrition Institute
Hans van Grinsven	PhD	PBL Netherland Environmental Assessment Agency
Lal Almas	Fulbright Scholar & Professor	West Texas A&M University
Michelle L. McCrackin	PhD	
Timothy Crews	Director of Research	The Land Institute
Deanna L. Osmond	Professor and Department Extension Leader	North Carolina State University
Nathan O. Nelson	Associate Professor	Kansas State University
Thomas F. Morris	Professor of Soil Science	University of Connecticut
Laura McCann	Associate Professor	University of Missouri
John J. Sloan	Watershed Scientist	National Great Rivers Research and Education Center
David R. Kanter	Graduate Student	Princeton University
Gurbir Singh	Research Lab Assistant, M.S. Soil, Environmental and Atmospheric Sciences	University of Missouri
Ray Dowbenko		Agrium
Kenneth G. Cassman	Robert B. Daugherty Professor of Agronomy	University of Nebraska
Thomas R. Fisher	Professor	Horn Point Lab, University of Maryland Center for Environmental Science
Otto C. Doering III	Director, Purdue Climate Change Research Center	Purdue University
Olga S. Walsh	PhD	Montana State University
C. Alan Rotz	PhD, Agricultural Engineer	
Richard B. Ferguson	Professor of Soil Science	University of Nebraska-Lincoln
David Mengel	Professor of Agronomy Certified Professional Agronomist/Soil Scientist	
Shannon L. Gomes	Soil Scientist, Crop Consultant, M.S. Soil Fertility	
Amy L. Shober	PhD, Assistant Professor and Extension Agent	University of Delaware
Michael Wolff	Graduate Student in Soils and Biogeochemistry	University of California, Davis
Tamie L. Veith	Agricultural Engineer	
J. Ivan Ortiz-Monasterio	Principal Scientist	
Dan B. Jaynes	Soil Scientist	