Dry nitrogen fertilizer quality: Impact on spreading variability

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Collaborator: Newell Kitchen, USDA Ag Research Service, Columbia, MO

Objective & Relevance:
This proposal addresses the Stakeholder Topic of Interest "Mechanical Research" and the sub-topics:

- Spreading / application technologies
- Evaluation of quality differences in fertilizer materials and the impact of the differences on crop production due to spreading variability.

Our objective is to evaluate spread pattern of dry nitrogen fertilizer (urea, ammonium nitrate, other urea-based products like SuperU and ESN) applied to corn, wheat, and fescue fields in Missouri. Cotton could also be included at the request of the Fertilizer & Ag Lime Council.

Dry nitrogen fertilizer makes up 40 to 50% of the total nitrogen fertilizer used in Missouri. Although this proportion is lower than in the past, due mainly to regulations on ammonium nitrate, dry nitrogen will remain important for several reasons:

1. It is more suited, by far, for application to grass than liquid or gas.
2. It is the fastest application option–especially important when the time window is small, as with in-season N applications to corn
3. It has lower transport cost than liquid (higher analysis)

Most dry fertilizer in Missouri is applied using spinner spreaders. These spreaders are very efficient in spreading fertilizer. However, broken granules will not travel as far as intact granules when applied with a spinner spreader. When poor quality fertilizer with lots of broken granules is applied using a spinner spreader, the small particles all fall near the path of the spreader. This results in a high N rate near the path of the spreader and a low N rate midway between passes. We have seen lots of streaks in aerial photographs of Missouri corn fields that are 40 to 80 feet in width and appear to correspond to poor fertilizer distribution patterns from nitrogen applied with spinner spreaders (see photo). The severity of this problem is not well known, but needs to be so that we know how hard to work to fix it.

Procedures:

1. Standard fertilizer trap pans will be set up in a number of production fields receiving dry N each year.
   a. We will coordinate with producers and retailers who would like to cooperate in this project.
   b. Corn, wheat, and grass fields will be used. Cotton could be added for extra cost.
   c. Different applicators and different N fertilizer sources will be represented.
   d. We will weigh the fertilizer caught in each pan and determine distribution.
   e. Each pan will be located with both a global positioning system (GPS) and a flag.
   f. The location of the applicator's path will be recorded with GPS in the applicator.
2. At the time of the fertilizer application, a fertilizer sampling tube will be used to take samples from the applicator's bin and particle size distribution will be measured.
3. We will analyze how particle size distribution affects spread pattern.
4. We will also analyze how fertilizer type and applicator type affects spread pattern.
5. Near harvest time, corn yield will be determined in selected fields at points corresponding to trap pan locations.
   a. Either hand harvest or yield map depending on spread pattern observed.
   b. Target fields with non-uniform N applications or where N loss may have occurred.
6. May also collect harvest observations or yield measurements in wheat and grass–more difficult, so fewer will be done.
7. The relationship between spread pattern and yield variability will be analyzed.

Current status and importance of dry nitrogen fertilizer quality:

Changes in the dry N supply

Price spikes in North American natural gas production from 2000-2010 resulted in many U.S. N fertilizer factories being idled. To meet demand for N fertilizer, imports increased. Urea imports in 2011 were 4 times higher than during the 1995-2000 period. One result was that the physical quality of urea available to U.S. farmers went down. The urea had to go through many more augers between manufacture and application, resulting in more breakdown of prills/granules.

Ammonium nitrate import levels did not change, but Agrium's move away from manufacturing ammonium nitrate in North America in 2006 meant that imports made up a higher proportion of the supply. Quality issues similar to those for urea became more frequent.

How big is the problem?

The size of the problem is based more on how much yield is lost, or other production problems occur (lodging of wheat, for example), than on how often spread is uneven. We are not aware that anyone has done any research to put numbers on the cost of uneven applications of dry N. We will attempt to make a start at answering this problem by collecting spatial yield data in fields where we find uneven N distribution. We will also measure how often the spread is uneven–it's an easier question to answer.

Potential solutions

Premium urea products like SuperU and ESN are one potential solution. These products are marketed based on their ability to reduce volatile ammonia loss and wet-weather N loss. They may be able to bring additional value due to better spread patterns. My experience with both is that they are large, hard, and uniform.

Another potential solution is air boom spreaders. Dust can't be thrown, but it can be blown. But how evenly can they spread dusty material? Numbers are needed. But many retailers are moving away from air boom spreaders due to maintenance issues. Unless the spread advantage is pronounced, and the yield loss is substantial, this solution may not be viable.

Natural gas prices have dropped and new urea production is under construction in the U.S. More good-quality urea will be available. Will this better physical quality will bring enough value to make it worth deliberately sourcing from these facilities? Paying a premium for higher quality product? Checking product quality on delivery with a hand-held screening device?

We will attempt to get information that will help to assess all three of these solutions.

Poor distribution of nitrogen fertilizer may be costing Missouri crop producers a substantial amount of money. We need to understand the extent of the problem and how uniform or non-uniform current dry nitrogen applications are. Then we will know how much effort or expense is justified to improve distribution patterns of dry N fertilizers.

Timetable:

February 2016	Make contacts with producers and retailers to arrange fields where tests will be conducted
March-April 2016	Measure dry nitrogen fertilizer distribution patterns during normal nitrogen application operations of cooperating producers/retailers. Sample fertilizer from the applicator's box in each test field. Measure particle size distribution of fertilizer sample with SGN box.
June 2016	Pre-harvest observations at wheat fields; possible hand-harvest.
Summer 2016	Analyze fertilizer distribution patterns. Provide and discuss report with each cooperating producer and/or retailer.
September 2016	Harvest corn at fertilizer trap pan locations.
Oct-Nov 2016	Analyze yield data relationship to localized N rate.
Dec 20016	Progress report.
March-Nov 2017	Repeat March-Dec 2016
Dec 2017	Final report.
Jan-Feb 2018	Develop educational programs, present results.

Strategy for application/transfer of knowledge:

1. Written and oral (presentation) educational materials will be developed to promote understanding and application of results.
2. Written materials will include newsletter and farm press articles and press releases.
3. Presentations will be used in Extension meetings, sent to regional Extension Agronomists for their use, and shared with anyone who requests them.

Budget:

Research Specialist time	$19,500
Benefits @ 33%	6,500
Student worker(s) to make catch pans	2,000
Materials for fertilizer catch pans	2,000
Sieves and fertilizer probe	600
Field supplies and mileage	2,000
Total year 1	**$32,600**
Research Specialist time	$19,500
Benefits @ 33%	6,500
Field supplies and mileage	2,000
Total year 2	**$28,000**
2-year total budget	**$60,600**

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2015 serving as Past Chair, Soil Fertility and Plant Nutrition Division, Soil Science Society of America

Research and Extension education interests

- developing, evaluating, and promoting tools to predict crop N needs, including variable-rate N management
- evaluating N management alternatives including source and timing
- long-term protection of the soil resource
- minimizing environmental impacts of agricultural nutrients
- economic comparisons of production alternatives

Education

Degree	*Date*	*Institution*	*Major*
Ph.D.	May 1993	Virginia Polytechnic Inst. and State University	Crop & Soil Environmental Sciences
M.S.	July 1988	Virginia Polytechnic Inst. and State University	Agronomy
B.S.	August 1982	University of Wisconsin	Biochemistry, Genetics

Selected Recent Research Publications

Oliveira, L.F. and **P.C. Scharf**. 2014. Diurnal variability in reflectance measurements from cotton. Crop Sci. 54:1769-1781.

Necpalova, M., R.P. Anex, A.N. Kravchenko, W.A. Dick, M.J. Helmers, M.B. Villamil, E.J. Kladivko, J.G. Lauer, E.D. Nafziger, J.E. Sawyer, **P.C. Scharf**, and J.S. Strock. 2014. What does it take to detect a change in soil carbon stock? A regional comparison of minimum detectable difference and experiment duration in the North-Central United States. J. Soil Water Cons. 69(6):517-531, doi:10.2489

Oliveira, L.F., **P.C. Scharf**, E.D. Vories, S.T. Drummond, D. Dunn, W.E. Stevens, K.F. Bronson, N.R. Benson, and V.C. Hubbard. 2013. Calibrating canopy reflectance sensors to predict optimal mid-season nitrogen rate for cotton. Soil Sci. Soc. Am. J. 77:173-183.

Nathan, M.V., Y. Sun, and **P.C. Scharf**. 2012. Evaluation of Modified Mehlich and Sikora buffer methods as an alternative to Modified Woodruff Buffer in determining lime requirement for Missouri soils. Comm. Soil Sci. Plant Anal. 43:496-505.

Dudenhoeffer, C.J., K.A. Nelson, P.P. Motavalli, D. Dunn, W.E. Stevens, K.W. Goyne, M. Nathan, and **P.C. Scharf**. 2012. Corn production as affected by phosphorus enhancers, phosphorus source and lime. J. Agric. Sci. 4:137-143.

Bronson, K.F., A. Malapati, T.A. Wheeler, C.M. Brown, R.K. Taylor, **P.C. Scharf**, and E.M. Barnes. 2012. Use of nitrogen calibration ramps and canopy reflectance on farmers' irrigated cotton fields. Soil Sci. Soc. Am. J. 76:1060-1067.

Scharf, P.C., D.K. Shannon, H.L. Palm, K.A. Sudduth, S.T. Drummond, N.R. Kitchen, L.J. Mueller, V.C. Hubbard, and L.F. Oliveira. 2011. Sensor-based nitrogen applications out-performed producer-chosen rates for corn in on-farm demonstrations. Agron. J. 103:1683-1691.

Selected Recent Extension Publications

Scharf, Peter. 2015. Managing Nitrogen in Crop Production. American Society of Agronomy, Madison, WI.

Scharf, Peter. 2015. Losing and replacing nitrogen. Integrated Pest and Crop Management, July 5, 2015. Also ran in Ag Professional, July 10, 2015.

Researchers find value in in-season N. Pioneer Agronomy alerts, posted June 2015. Using information from **Peter Scharf**.

Gullickson, Gil. 2015. More wet and cool weather likely coming; here's what to do. Agriculture.com, June 25, 2015. Using information from **Peter Scharf**.

Watch corn for nitrogen loss. Farm Progress, June 22, 2015. Using information from **Peter Scharf**.

Steever, Tom. New tool determines where nitrogen is most needed. Brownfield Ag News, Jun 15, 2015. Using information from **Peter Scharf**.

Harker, Julie. New nitrogen tool–NVision Ag. Brownfield Ag News, Jun 11, 2015. Using information from **Peter Scharf**.

Nystrom, Brandon. 2015. Nitrogen loss in 2015. AgriGold newsletter, June 2015. Using information from **Peter Scharf**.

Spend wisely now to avoid late-season troubles. Agriculture.com, June 3, 2015. Using information from **Peter Scharf**.

Herrold, Benjamin. 2015. Time trials: new program to help with N decisions. Iowa Farmer Today, April 9, 2015. Using information from **Peter Scharf**.

Hein, Treena. 2015. Improving late nitrogen application. Top Crop Manager, April 2015. Using information from **Peter Scharf**.

Gegg-Naeger, Betty. 2015. Benefits of urea. Mid-America Farmer Grower, April 3, 2015. Using information from **Peter Scharf**.

Winsor, Susan. 2015. 2 tools help cut nitrogen costs. Corn and Soybean Digest, March 25, 2015. Using information from **Peter Scharf**.

Herrold, Benjamin. 2014. Farmers guard against nitrogen loss with best practices. Missouri Farmer Today, Dec 31, 2014. Using information from **Peter Scharf**.

Geist, Linda. 2013. Topsoil lost to rainfall costs farmers money. University of Missouri press release using information from **Peter Scharf**. Ran in Missouri Farmer Today, Missouri Ruralist, The Crop Site, Agriculture.com, WFSAg.com, and North Carolina Cooperative Extension.

Burden, Mike. 2013. Our most precious resource: Taking the long view for sustaining Missouri's soils. Using information from **Peter Scharf**. University of Missouri CAFNR News, May 10, 2013. Also ran in Agriculture is America.

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EDUCATION AND PROFESSIONAL EXPERIENCE

Education

Brigham Young University	BS	1984	Agronomy
University of Missouri	MS	1986	Agronomy
Colorado State University	PhD	1990	Agronomy/Soil Science

Professional Employment

2003-present Adjunct Professor (2014), Associate Professor, University of Missouri

1996-present Soil Scientist, USDA-ARS, Cropping Systems and Water Quality Research Unit, Columbia, MO

1990-1996 Research Assistant Professor, Soil and Atmospheric Sciences Dept, University of Missouri

Professional Summary

Dr. Kitchen Recognized for his research in integrated agricultural systems as related to precision agriculture systems, soil and water quality in agroecosystems, and nutrient management for improved fertilizer use efficiency. His research is documented in more than 270 technical publications (including 85 peer-reviewed journal articles, 8 book chapters, and 38 invited papers). He developed soil management and agronomic solutions to the issues associated with within-field soil-landscape variability and nutrient management for improved soil and water quality. He has attracted grant throughout his career supporting leading-edge research, recognized as important by stakeholders and government agencies. In all, has been the PI or Co-PI for grants totaling over $10 million. Examples of research contribution include: 1) Initiating some of the earliest work relating spatially-measured soil and landscape data obtained by automated sensors to soil physical and chemical characteristics and crop productivity; 2) Producing new concepts, methodology, and tools for delineating within-field management zones; 3) Establishing relationships of cropping practices on ground and surface water quality for poorly-drained U.S. Midwest soils; 4) Developing new strategies and procedures for variable-rate N application in crop production; 5) Pioneering a plan and implementing at field-scale a precision agriculture system that encompasses carefully-prioritized grain crop production and environmental goals; and 6) Developing bioenergy management practices for degraded soil landscapes. He has advised graduate degree programs for 12 M.S. (Spautz, Fridgen,Williams, Myers, Roberts, Landers, Allphin, Easterby, Randall, Weeresakara, Bean, Gossel), and 6 Ph.D. (Hughes, Jung, Jiang, Myers, Boardman, Ransom,) students, and advised or co-advised three post doctorates. His stature is foremost evidenced by his election to serve in 2011

as President of the American Society of Agronomy (ASA). ASA serves ~7,000 scientific and ~13,000 practicing agronomists.

PROFESSIONAL HONORS AND AWARDS

American Society of Agronomy President, 2011
Fellow, Soil Science Society of America, 2008
Fellow, American Society of Agronomy, 2007
Robert E. Wagner Potash and Phosphate Institute Award (Jr. Scientist), 2003
USDA Outstanding Performance Award, 2001, 2004, 2005, 2011, 2014, 2015

SELECTED JOURNAL PUBLICATIONS DURING THE LAST FOUR YEARS

1. Thompson, L.J., Ferguson, R.B., Kitchen, N.R., Franzen, D.W., and Mamo, M. Model and sensor-based recommendation approaches for in-season nitrogen management in corn. Agron. J. 107:2020–2030. 2015.
2. Kitchen, N.R., Blanchard, P.E., Lerch, R.N. 2015. Long-term agroecosystem research in the Central Mississippi River Basin: hydrogeologic controls and crop management influence on nitrates in loess and fractured glacial till. J. Environ. Quality. 44:58-70.
3. Lerch, R.N., Kitchen, N.R., Baffaut, C., Vories, E.D. 2015. Long-term agroecosystem research in the Central Mississippi River Basin: Goodwater Creek Experimental Watershed and regional nutrient water quality data. J. Environ.Quality. 44:37-43.
4. Sadler, E.J., Lerch, R.N., Kitchen, N.R., Anderson, S.H., Baffaut, C., Sudduth, K.A., Prato, A.A., Kremer, R.J., Vories, E.D., Myers, D.B., Broz, R., Miles, R.J., Young, J. 2015. Long-term agroecosystem research in the Central Mississippi River Basin: introduction, establishment, and overview. J. Environ. Quality. 44:3-12.
5. Dolginow, J.P., Massey, R.E., Kitchen, N.R., Myers, D.B., and Sudduth, K.A. 2014. A stochastic approach for predicting the profitability of bioenergy grasses. Agron. J. 106:2137-2145. doi:10.2134/agronj14.0110.
6. Chung, S.O., Sudduth, K.A., Drummond, S.T., and Kitchen, N.R. 2013. Spatial variability of soil properties using nested variograms at multiple scales. J. of Biosys. Engineering. 39(4):377-388.
7. Sudduth, K.A., Myers, D.B., Kitchen, N.R., and Drummond, S.T. Modeling soil electrical conductivity-depth relationships with data from proximal and penetrating ECa sensors. Geoderma 199:12-21. 2013.
8. Chaudhary, V.P., Sudduth, K.A., Kitchen, N.R., and Kremer, R.J. Reflectance spectroscopy detects management and landscape differences in soil carbon and nitrogen. Soil Science Society of America J. 76(2):597-606. 2012.
9. Venterra, R.T., Halvorson, A.D., Kitchen, N.R., Liebig, M.A., Del Grosso, S.J., Cavigelli, M.A., Motavalli, P.P., Nelson, K.A., Spokas, K.A., Singh, B.P., Stewart, C.E., Ranaivoson, A., Strock, J., and Collins, H.P. Technical challenges and opportunities for mitigating nitrous oxide emissions from fertilized cropping systems. Frontiers in Ecology and the Environ 10(10) 562-570. 2012.
10. Sadler, E.J., Sudduth, K.A., Lerch, R.N., Baffaut, C., and Kitchen, N. R. A simple index explains annual atrazine transport from surface runoff-prone watersheds in the North-central USA. J. Hydrological Processes DOI: 10.1002/hyp.9544 (published online 11/5/2012). 2012.
11. Tremblay, N., Bouroubi, M.Y., Bélec, C., Mullen, R., Kitchen, N.R., Thomason, W., Ebelhar, S., Mengel, D., Raun, B., Francis, D., Vories, E.D., and Ortiz-Monasterio, I. Corn response to nitrogen is influenced by soil texture and weather. Agronomy Journal 104(6): 1658-1671. 2012.
12. Mugdal, A, Baffaut, C, Anderson, SH, Sadler, EJ, Kitchen, NR, Sudduth, KA, and Lerch, RN. Using APEX to develop and validate physically-based indices for the delineation of critical management areas. J. of Soil and Water Conservation 67: 284-299. 2012.
13. Tremblay, N, Bouroubi, MY, Bélec, C, Mullen, R, Kitchen, NR, Thomason, W, Ebelhar, S, Mengel, D, Raun, B, Francis, D, Vories, ED, and Ortiz-Monasterio, I. Corn response to nitrogen is influenced by soil texture and weather. Agronomy Journal 104(6): 1658-1671. 2012.
14. Sheridan, AH, Kitchen, NR, Sudduth, KA, and Drummond, ST. Corn hybrid growth stage influence on crop reflectance sensing. Agronomy J. 104:158-164. 2012.

15. Landers, GW, Thompson, AL, Kitchen, NR, and Massey, RE. Comparative breakeven analysis of annual grain and perennial switchgrass cropping systems. Agron. J. 104:639-648. 2012.
16. Roberts, DF, Ferguson, RB, Kitchen, NR, Adamchuk, VI, and Shanahan, JF. Relationships between soil-based management zones and canopy sensing for corn nitrogen management. Agron. J. 104:119-129.
17. Myers, DB, Kitchen, NR, Sudduth, KA, Miles, RJ, Sadler, EJ, and Grunwald, S. Peak functions for modeling high resolution soil profile data Geoderma. 166(1): 74-83. 2011.
18. Scharf, PC, Shannon, DK, Palm, HL, Sudduth, KA, Drummond, ST, Kitchen, NR, Mueller, LJ, Hubbard, VC, and Oliveira, LF. Sensor-based nitrogen application out-performed producer-chosen rates for corn in on-farm demonstrations. Agronomy Journal. 103(6):1683-1691. 2011.
19. Delgado, JA, Secchi, S Groffman, P, Nearing, MA, Goddard, T, Reicosky, Lal, R, Salon, P, Kitchen, NR, Rice, C, Towery, D. Conservation practices to mitigate and adapt to the effects of climate change. J. Soil and Water Conserv. 66 (4): 118-129. 2011.