On-Farm Rescue Nitrogen Applications for Corn

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Objective & Relevance:
I see a need to do a thorough on-farm study of corn yield response to rescue nitrogen applications. I have observed nitrogen-deficient corn due to wet weather and N loss somewhere in Missouri nearly every year over the past 20 years. The scale of N loss has increased recently, with widespread deficiences seen in Missouri and adjacent states in 2008, 2009, and 2010. I also saw many N-deficient fields in 2011 and 2013. About 340 aerial photos of N-deficient fields from 2008-2010 can be seen in the Nitrogen Loss Aerial Photo Galleries on my N loss web page:
http://plantsci.missouri.edu/nutrientmanagement/nitrogen/loss.htm

I have cobbled together 5 on-farm studies of rescue N between 1998 and 2010, and Wayne Flanary has conducted another. Average yield response to rescue N in these six studies was 34 bushels/acre. It's clear from these preliminary results that rescue N can be a highly profitable practice, but I am not aware of anyone who has done a systematic study of this question. The objective of the proposed research is to study the yield response of fully fertilized production corn fields to rescue N applications when N loss is suspected.

Procedures:
- Experiments will be conducted in production cornfields in Missouri where the full intended rate of N fertilizer was applied before planting. If there are no areas in Missouri with excess spring rainfall and N deficiency, experiments will either be conducted in neighboring states where these conditions exist, or be deferred for a year. I welcome input from the Fertilizer and Ag Lime Council on which of these options is preferable.
- Experimental fields will be chosen based on the existence of visible N deficiency symptoms.
- Treatments will be field-length strips of N fertilizer alternating with strips that do not receive fertilizer. At least 3 pairs of strips will be included in each field.
  - The base design will be strips receiving 50 lb N/acre
  - In fields where high levels of N stress are seen, some or all strips may receive higher rates of N
  - When time and logistics allow, and the cooperating producer is interested, strips of variable-rate N may be used
    - These could be based on either canopy reflectance sensors (I have 5 sets which will be available to this project) or on aerial photos (I have developed a method to predict N need from aerial photos)
    - These could replace the flat-rate strips, or be used in addition to the flat-rate strips
  - Nitrogen treatments will be applied with whatever equipment and N source is most available and affordable for each field from the following:
    - Urea applied with a ground machine (spinner or air-boom)
    - UAN solution applied with a sprayer equipped with drops to well below ear height
    - Urea applied with an airplane

- When possible, the level of N stress will be measured at the time of N application with either aerial photos, canopy reflectance sensors, or a hand-held chlorophyll meter. We will then relate N stress level to the size of the yield response.

Current status and importance of rescue nitrogen applications to corn:

- Results from the five rescue N experiments in that I have helped to organize, plus one that Wayne Flanary conducted in northwest Missouri, are shown in Table 1. Key points that have been learned in this set of impromptu experiments are:
  - Response to rescue N can be highly profitable. Average response over all experiments was 34 bushels/acre. This indicates that in fact a large proportion of the nitrogen supplied before planting had been lost.
  - The worse the corn looks, the more it responds. In the two fields with areas where I classified stress as "high", yield response to rescue N was 57 bushels/acre in both cases.
  - Large yield responses can occur with N applications as late as tasseling. In 2010, all 3 tests had the rescue N applied at the tasseling stage and in the most stressed areas, yield responses ranged from 42 to 57 bushels/acre.

Rescue N trial	Year	Stage	Yield response (bu/acre) to N when stress level was:		
			Low	Medium	High
1	1998	V8		23	57
2	2004	V8		50	
3	2005	V14	-2	30	
4	2010	VT	17	42	
5	2010	VT	28	54	57
6	2010	VT	8		
Average			**13**	**40**	**57**

Table 1. Results from on-farm rescue N experiments over the past 17 years. Yield response to rescue N was highest in the areas with highest visible N stress, and was high even when rescue N was applied at the tassel (VT) stage.

- An aerial photo of rescue N trial 3 (from Table 1) is shown in Figure 1. In areas with visible N stress, the 100-foot strips with rescue N are clearly visible, and a highly profitable yield response was observed. In areas without visible N stress, the rescue N strips are not visible and no yield response was found.
- Surprisingly little research has been done given the size of the problem.
- Farmers and fertilizer dealers have reacted by investing a tremendous amount of money into high-clearance N application equipment over the past 5 years.

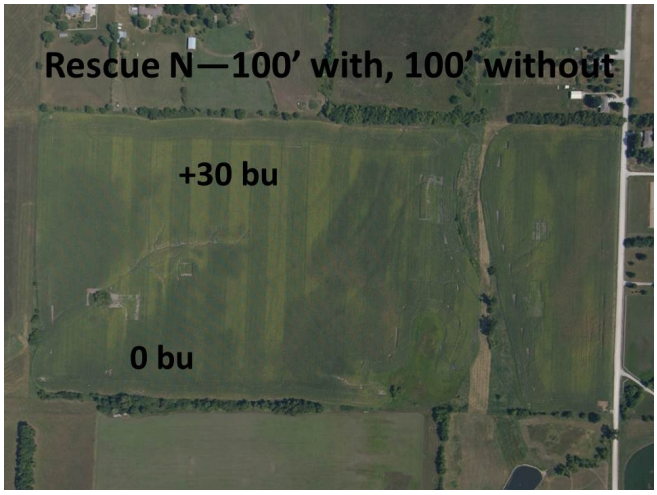

Figure 1. Rescue N experiment from 2005. 12 gal per acre of 32% UAN solution (40 lb N/acre) was dribbled between rows on June 29.

Expected economic impact:
Over the past seven years, we have experienced wet springs over large areas of Missouri and the midwest, leading to widespread N loss, N deficiency, and yield loss. A Missouri field where the producer lost about $45,000 due to N deficiency is shown in Figure 2. Yield was 170 bushels in the dark green areas of the field and 80 bushels in the yellow-green areas.

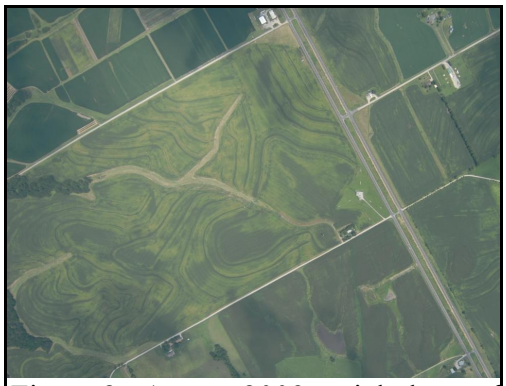

Figure 2. August 2009 aerial photo of a Missouri field with severe N deficiency due to fertilizer loss. About $45,000 was lost due to N deficiency in this field.

Based on data from fields like the one in Figure 2, 4500 aerial photos, and 6000 miles of August windshield survey, I estimate that Missouri corn producers have lost about 300 million bushels of potential yield due to N deficiency, with a value of about $1.2 billion at current prices. Much of this loss could have been recovered with rescue N applications. Better understanding of how to identify and quantify N stress (as I hope to do with aerial photos and other tools) will help corn producers make good decisions about when to invest in rescue N, and will increase their profitability.

Timetable:

Feb-March 2015	Calls to fertilizer retailers over a range of geographies to explain the project and discuss their possible interest
April 2015	Begin tracking rainfall maps to identify areas with the highest risk of N loss
May 2015	Followup calls to fertilizer retailers in affected areas
June 2015	Visit candidate fields for rescue N trials, select based on visible N stress and logistical details (yield monitor, suitable N applicator), acquire aerial photos, apply rescue N treatments (with untreated areas between them)
Sept-Oct 2015	Harvest trial areas with a yield-mapping combine
Nov-Dec 2015	Analyze yield maps, determine yield responses to rescue N, analyze relationship between yield response and aerial photos, write report
Feb-Dec 2016	Repeat 2015 activities
Feb-Dec 2017	Repeat 2016 activities, write final report

Strategy for application/transfer of knowledge:

- Written and oral (presentation) educational materials will be developed to promote understanding and application of results.
- Written materials will include newsletter articles, press releases, my web page, and farm press articles–I am regularly used as a source by many ag journalists.
- Presentations will be used in Extension meetings and conferences, sent to regional Extension Agronomists for their use, and shared with anyone who requests them.

Budget:

Fertilizer and application costs	$10,000
Aerial photos	2,000
Research specialist salary	15,000
Benefits	5,000
Total year 1	**$32,000**
Total year 2	**$32,000**
Total year 3	**$32,000**
3-year total budget	**$96,000**

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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
- 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

Recent Research Publications

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

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.

Recent Extension Publications

Ehmke, Tanner. 2014. What's driving adoption of in-season nitrogen? Crops & Soils Nov-Dec 2014 cover story. Using information from Peter Scharf.

Anderson, Barb. 2014. Tools apply inputs with precision. Progressive Farmer, Sept. 2014. Using information from Peter Scharf.

Johnston, Gene. 2014. Primer on Nitrogen: Rethink Fertilizer Rates, Tech. Agriculture.com, May 9, 2014. http://www.agriculture.com/crops/corn/production/primer-nitrogen-rethink-fertilizer_137-ar43281

Pocock, John. 2014. Nitrogen Adjustment. Progressive Farmer, February 2014. Using information from Peter Scharf.

Herrold, Benjamin. 2014. Nitrogen plan among early planting decisions. Missouri Farmer Today. Using information from Peter Scharf.

Harris, Tyler. 2014. Wetter springs change nitrogen application. Farm Progress, February 2014. Using information from Peter Scharf.

Gegg-Naeger, Betty. 2014. N management in wet/dry years requires planning. Mid-America Farmer-Grower, April 11, 2014. Using information from Peter Scharf.

Birchmier, Kacey. 2014. Evaluate your fertility plan for 2014. Agriculture.com, March 6, 2014. Using information from Peter Scharf.

Olson, Joan. 2014. Changing weather patterns impact nitrogen management. Missouri Ruralist, February 6, 2014. Using information from Peter Scharf.

Geist, Linda. 2014. Crop sensors improve nitrogen application. University of Missouri Press Release, August 2014, based on presentation and demonstration at the MU Ag Technology Fair. Ran in Farm Progress, Missouri Ruralist, Bolivar Herald, Big Yield, AgWired, High Plains Journal.