Title: Nitrogen Fertilizer Management of Temporarily Flooded Soils to Improve Corn Production and Reduce Environmental N Loss

Investigators: Peter Motavalli, Dept. of Soil, Environ., and Atmos. Sci., Univ. of Missouri
Kelly Nelson, Div. of Plant Sciences, Univ. of Missouri, Novelty, MO
Ranjith Udawatta, Dept. of Soil, Environ., and Atmos. Sci., Univ. of Missouri

Objectives and Relevance:
Corn production losses due to temporarily flooded or saturated soils are a persistent problem in Missouri and can occur in both upland and low-lying areas. During 2011, the combination of rain and snowmelt temporarily flooded 207,000 acres of agricultural land, resulting in $176 million in lost revenue in Missouri. Row crop agriculture in floodplain soils in the Missouri and Mississippi River Basins as well as its tributaries in Missouri are highly productive systems and represent a large land area in the state of Missouri. For example, 67% of the Upper Mississippi River Basin is in managed agricultural land covering an area of approximately 4.9 million acres (Hey et al., 2009).

The extent to which flooding injures corn is determined by several factors including: 1) timing of flooding during the life cycle of corn, 2) frequency and duration of flooding, and 3) air-soil temperatures during flooding (Belford et al., 1985). Corn younger than about V6 is more susceptible to ponding damage partly because the corn plant’s growing point remains below ground until about V6 (Nielsen, 2011). Other impacts of flooding that affect corn growth after flooding include deposition of mud and crop residues on plants, sand deposition, formation of soil crusts, and development of plant diseases.

Nitrogen deficiencies and losses due to flooding may occur because of denitrification and leaching losses as well as reduced crop N uptake resulting from low oxygen levels in flooded soils. Denitrification rates under saturated soil conditions in Illinois ranged from 1 to 2% per day at soil temperatures less than 55 ºF, and up to 5% per day at soil temperatures greater than 65 ºF (Hoeft, 2004). Yield losses with flooding have also been reduced in plots treated with high N fertilizer rates compared to those of low N fertilizer applications (Ritter and Beer, 1969). Little is known if enhanced efficiency N fertilizers such as polymer-coated urea (PCU) or addition of a nitrification inhibitor may reduce N loss with short-term flooding and improve recovery of corn after flooding. Previous research funded by the Missouri Fertilizer and Aglime program has shown that application of PCU in lower landscape positions in upland agricultural fields where soils are generally wetter had over a 20 bu/acre increase in grain yield compared to the yield of conventional urea and an estimated gross profit increase of between $20 to $260/acre with use of PCU (Noellsch et al., 2009).

Development of an N fertilizer strategy for temporarily flooded or saturated soils may help to increase corn production and reduce environmental N loss. This strategy may include N fertilizer recommendations combined with economic cost-benefit analysis for both pre-flood and post-flood conditions.

The proposed objectives of this study are to: 1) determine the effects of duration of flooding on corn growth and N use efficiency (NUE), 2) assess the use of different N sources including PCU and nitrification inhibitor and a post-flood N fertilizer treatment, and 3) evaluate the economic costs and benefits of using these fertilizer sources under different flooding conditions.
Procedures:

- A three-year field experiment will be established in 2012 at the Greenley Experiment Station on a poorly-drained claypan soil. The experimental design will be a randomized complete block split plot design with 3 replications. Main plots will include flooding treatments of 0, 24, 48 and 72 hours of flooding accomplished by setting up berms and use of supplemental flood irrigation. The flooding will occur after the V6 stage. Subplots will consist of N fertilizer treatments of a control or 150 lbs N/acre as pre-plant-applied urea, PCU (ESN®, Agrium, Inc), urea plus N-Serve nitrification inhibitor. These subplots will measure 15 x 60 ft. After the flooding treatment, the subplot will be divided into two plots of 30 ft length and one plot will be treated with a post-flood broadcast application of N fertilizer (urea + urease inhibitor (Agrotain®, Koch Agronomic Services). All pre-plant N fertilizer treatments will be incorporated.

- Soil conditions during the flooding will be measured by determination of changes in soil redox potential (Eh), soil pH and soil temperature at the soil surface using hand-held meters.

- Changes in soil inorganic N content (ammonium + nitrate) before and after flooding will be assessed by soil sampling to a depth of 8 inches using a stainless steel push probe and analysis of a 2 M KCl extract using a Lachat QuikChem automated ion analyzer.

- Assessment of potential soil denitrification losses with the different N fertilizer and flooding treatments will be determined using an acetylene inhibition technique and measurement of evolved nitrous oxide gas using a gas chromatograph.

- Corn yields will be determined using a two-row combine and N uptake determined by harvesting two rows for silage dry weight yield. Total N of silage tissue will be performed using a LECO Carbon:Nitrogen Analyzer and the combustion method.

- Gross profit differences between use of the urea versus PCU and nitrification inhibitor and post-flood N treatment will be calculated by calculating the difference in value from any differences in grain yield minus any differences in fertilizer cost and application method for each fertilizer product.

Current Status and Importance of Research:

Corn production losses due to temporarily flooded or saturated soils are a problem in Missouri because of the large area of floodplain and poorly-drained soils in the state. In addition, the incidence of excessive rainfall events in the Midwest region has increased over 30% from 1958 to 2007 (Karl et al., 2009) and is predicted to increase more in the future. Moreover, these heavier rain events are expected to occur more often during the spring and the fall period is predicted to become drier (Takle, 2011). Extensive research has been conducted to examine the physiological effects of flooding on corn growth, but few studies have examined the use of various strategies to manage N fertilizer to reduce corn production losses, lower environmental N loss and improve corn flood recovery, especially under conditions in Missouri. Some guidance on the economic costs and benefits of using different N fertilization strategies would also be helpful for facilitating producer decision-making. Use of enhanced efficiency fertilizer products may be one management option that may reduce the risks of N loss under flooding and extensive research in Missouri has indicated that the advantages of use of polymer-coated urea in reducing N losses are primarily under relatively wet conditions in upland soils due to differences in rainfall or irrigation (Nelson et al., 2009) or in landscape position (Noellsch et al., 2009).
However, whether these N fertilizer sources work under more prolonged periods of saturation have not been tested under agricultural conditions in Missouri.

**Expected Economic Impact**

Estimated revenue losses due to flooding of agricultural land in Missouri during 2011 were $176 million. These losses do not include the costs of lost agricultural inputs, such as seed, applied N fertilizer and pesticides, and subsequent costs for remediation of flooded land and potential environmental damage. Development of an effective N fertilization strategy for lands that are often temporarily flooded or saturated may reduce overall crop production losses and lower risk associated with flooding or saturation. Previous research in Missouri has indicated that use of enhanced efficiency fertilizers, such as PCU, compared to conventional N fertilizer sources, such as urea, are often agronomically and economically optimized in low-lying field areas which are relatively wetter compared to other landscape positions. However, little information is available if these fertilizer sources are effective when the landscape is flooded for longer durations. The relatively higher cost of the enhanced efficiency fertilizers and insufficient research-based information for how and when they are best used for the environmental conditions of Missouri may be disincentives for their use. However, our previous research has shown a gross profit increase of between $20 to $260/acre with use of PCU compared to use of conventional urea, but only in relatively lower-lying areas of farm fields. Little or no information is available on possible use of these enhanced efficiency fertilizers in floodplain soils where productivity and risk of N loss is relatively high. This research will provide more economic information on use of enhanced efficiency fertilizers so that growers can make informed decisions on use of these materials in temporarily flooded areas which includes the large extent of productive floodplain soils in Missouri.

**Timetable for Proposed Research:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb/March, 2012</td>
<td>Establish field experiment area</td>
</tr>
<tr>
<td>April-May, 2012</td>
<td>Apply N treatments and plant corn</td>
</tr>
<tr>
<td>April-Sept., 2012</td>
<td>Sample soils</td>
</tr>
<tr>
<td>Sept./Oct, 2012</td>
<td>Harvest experiments</td>
</tr>
<tr>
<td>November, 2012</td>
<td>Analyze research results</td>
</tr>
<tr>
<td>December, 2012</td>
<td>Submit annual progress report</td>
</tr>
<tr>
<td>Feb-Nov, 2013</td>
<td>Same as 2012</td>
</tr>
<tr>
<td>December 2013</td>
<td>Submit annual progress report</td>
</tr>
<tr>
<td>Feb-Nov, 2014</td>
<td>Same as 2012</td>
</tr>
<tr>
<td>December 2014</td>
<td>Submit final report</td>
</tr>
</tbody>
</table>

**Strategy for Application/Transfer of Knowledge:**

The information developed from this research will useful for Missouri farmers to make informed decisions on N fertilizer management in soils that are vulnerable to temporary flooding or which have already been flooded. This information will be incorporated into research and extension publications, workshops and annual field days to provide additional information to farmers on effective N fertilizer management practices. This project will also provide an opportunity for the training of a graduate student in preparation for a possible future professional career in a soil fertility and plant nutrition-related field in the private or public sector.
### Proposed Budget:

<table>
<thead>
<tr>
<th>CATEGORIES</th>
<th>YEAR ONE</th>
<th>YEAR TWO</th>
<th>YEAR THREE</th>
<th>TOTAL</th>
</tr>
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<tr>
<td><strong>A. Salaries</strong></td>
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<td></td>
<td></td>
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<tr>
<td>M.S. or Ph.D. Graduate Research</td>
<td>$16,726</td>
<td>$17,228</td>
<td>$17,745</td>
<td>$51,699</td>
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<tr>
<td>Assistant (50%)</td>
<td></td>
<td></td>
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<td><strong>B. Fringe Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fringe for graduate student</td>
<td>$2,402</td>
<td>$2,474</td>
<td>$2,548</td>
<td>$7,424</td>
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<tr>
<td><strong>TOTAL SALARIES AND FRINGE BENEFITS</strong></td>
<td>$19,128</td>
<td>$19,702</td>
<td>$20,293</td>
<td>$59,123</td>
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<tr>
<td><strong>C. Travel</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Travel to field site</td>
<td>$672</td>
<td>$672</td>
<td>$672</td>
<td>$2,016</td>
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<tr>
<td>Travel to professional meeting</td>
<td>$0</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$2,000</td>
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<tr>
<td><strong>TOTAL TRAVEL COSTS</strong></td>
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<td>$1,672</td>
<td>$1,672</td>
<td>$4,016</td>
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<tr>
<td><strong>D. Equipment</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL EQUIPMENT COSTS</strong></td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>E. Other Direct Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory reagents and supplies</td>
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<tr>
<td>Field supplies</td>
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<td>$2,000</td>
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<tr>
<td>Soil analysis</td>
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<td>$500</td>
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<tr>
<td>Publications/Documentation</td>
<td>$0</td>
<td>$500</td>
<td>$500</td>
<td>$1,000</td>
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<tr>
<td><strong>TOTAL OTHER DIRECT COSTS</strong></td>
<td>$4,500</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$14,500</td>
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<tr>
<td><strong>TOTAL REQUEST</strong></td>
<td>$24,300</td>
<td>$26,374</td>
<td>$26,965</td>
<td>$77,639</td>
</tr>
</tbody>
</table>

**Justification:**

Salaries and Fringe Benefits: Funds are requested for support of a graduate research assistant (50% time) based on set rates at the University of Missouri. Fringe benefits for the graduate student cover the cost of health insurance.

Travel: Covers cost of travel to Greenley Farm and to farm site at a rate of 48 ¢/mile. In the second year, $1,000 and in the third year $1,000 are requested to cover cost of travel and board for one researcher to attend a professional conference for presentation of results.

Laboratory Reagents and Supplies: Covers cost of laboratory reagents, sample containers, and other materials used in soil and plant tissue analyses.

Field Supplies: Cost of fertilizer, seed, plot preparation, planting, weed control and harvesting, soil samplers, flags, pots and other field supplies and operations.

Soil Analysis: Covers cost of drying, grinding and analysis of soil samples at the University of Missouri Soil and Plant Testing Laboratory.

Publications/Documentation: Defrays cost of publication and documentation of results and conclusions.
Resume of PETER P. MOTAVALLI

Professor, Soil Nutrient Management                          Telephone: (573) 884-3212
Dept. of Soil, Environmental and Atmospheric Sci.            FAX: (573) 884-5070
School of Natural Resources                                  E-mail: motavallip@missouri.edu
University of Missouri-Columbia                             Dept. of Soil, Environmental and Atmospheric Sci.
302 ABNR Bldg.                                               University of Missouri-Columbia
Columbia, MO 65211 USA                                       302 ABNR Bldg.

EDUCATION:

Ph.D., 1989, Soil Fertility and Plant Nutrition              Cornell University, Ithaca, NY
M.S., 1984, Soil Fertility and Plant Nutrition               University of Wisconsin, Madison, WI
B.S., 1982, Agronomy                                         University of Wisconsin, Madison, WI
B.S.F.S., 1978, Foreign Service                               Georgetown University, Washington, DC

RESEARCH, EXTENSION AND TEACHING EXPERIENCE:

University of Missour, Columbia, MO (Mar., 1999 – present). Professor of Soil Nutrient
Management in the Dept. of Soil, Environmental and Atmospheric Sci.

University of Guam, Mangilao, GU (Aug., 1994 – Mar., 1999). Associate Professor of Soil
Science in the Agricultural Experiment Station, College of Agriculture and Life Sciences.

Colorado State University, Ft. Collins, CO and North Carolina State University, Raleigh, NC
Colorado State University and Department of Soil Science at North Carolina State University.

SELECTED PUBLICATIONS

carbon and total nitrogen under conservation management practices in the Central Claypan
Region, Missouri, USA. Geoderma. 167:188-196.

reflectometer and soil water dynamics for an agroforestry practice. Agroforestry Systems.

macropore geometry and related parameters for an arable field. Geoderma. 160:244-251.

response to pre-plant and foliar-applied potassium chloride with Strobilurin fungicides.

incorporation on soil chemistry, germination and seedling growth. Environmental and
Experimental Botany. 69:113-120.

agricultural watersheds with agroforestry and grass contour buffer strips. Agroforest. Syst.


**PROFESSIONAL ORGANIZATIONS:**

Soil Science Society of America
American Society of Agronomy

**SELECTED AWARDS AND FELLOWSHIPS:**

2000 - present Adjunct Assistant Professor, Division of Plant Sciences, Univ. of Missouri
2001 - 2006 Member of Editorial Board, Journal of Plant Nutrition
2002 - 2003 New Faculty Teaching Scholar, University of Missouri
2003 Junior Faculty Research Award, Gamma Sigma Delta
2003 Chair of USDA Regional Committee on Soil Organic Matter (NCR 59)
2004 Outstanding Teaching Award, CAFNR, Univ. of Missouri
2004 Chair of Environmental Quality Division (A-5), Amer. Soc. of Agronomy
2008 - present Associate Editor, Soil Science Society of America Journal
2009 Maxine Christopher Shutz Award for Distinguished Teaching, University of Missouri
RESUME OF KELLY A. NELSON

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Division of Plant Sciences
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Email: nelsonke@missouri.edu
http://aes.missouri.edu/greenley/research/index.stm

EDUCATION AND TRAINING

- B.S. Plant Science, Dep. of Agronomy, Univ. of Missouri (1995)

APPOINTMENTS

- Research Agronomist & Associate Professor, Univ. of Missouri, Novelty, MO (2007-present)
- Research Agronomist & Assistant Professor, Univ. of Missouri, Novelty, MO (2000-2006)
- Teaching Assistant, Michigan State Univ., East Lansing, MI (1996)

OTHER EXPERIENCE

- Research Technician, Ciba Crop Protection, Lee’s Summit, MO (1994)
- Integrated Pest Management, Gypsy Moth Technician, Univ. of Missouri, Columbia, MO (1992)

HONORS AND AWARDS

- Citation of Merit, Mizzou Alumni Association of the University of Missouri (2010)
- ASABE Blue Ribbon Award, Circular Publication, Questions and answers about drainage water management for the Midwest, American Society of Agricultural and Biological Engineers (2007)
- Junior Faculty Award, Gamma Sigma Delta, Honor Society of Agriculture (2005)

SCHOLARLY SOCIETIES

- Sigma Xi
- Gamma Sigma Delta
- Honor Society of Phi Kappa Phi
- Golden Key National Honor Society
- Phi Eta Sigma Honor Society

PROFESSIONAL ORGANIZATIONS

- American Society of Agronomy
- Crop Science Society of America
- Weed Science Society of America
- North Central Weed Science Society of America
SERVICE

- North Central Regional Drainage Committee (NCR-217) (2003-present); Secretary 2008-2009; Chair 2009-2010
- Missouri Agriculture Leaders of Tomorrow Class XIII (ALOT) (2008-2010)
- Missouri Livestock Symposium Committee (2001-present)
- Manuscript reviewer for nine peer-reviewed journals (2000-present)
- North Central Weed Science Society (1996-present); Membership Committee Chair (2006-2008); Finance Steering and Policy Committee (2009-present)
- Weed Science Society of America (1996-present); Extension Committee (2001-2003)
- Missouri Wind Resources (2006-present)

PUBLICATIONS:


Resume of RANJITH P. UDAWATTA

Associate Professor Research                      Tel: 573-882-4347,
Dept. of Soil, Environmental and Atmospheric Sci. Fax: 573-882-1997
302 Anheuser-Busch Natural Resources Building, e-mail: UdawattaR@missouri.edu
University of Missouri, Columbia, MO 65211, USA.

PROFESSIONAL PREPARATION
University of Missouri, Columbia, Missouri, USA Ph.D., Forestry-Soils August 1994
University of Philippines, Los Banos, Philippines Diploma* August 1989
International Atomic Authority Laboratory, Diploma** June 1988
Seibersdorf, Austria.
University of Florida, Gainesville, Florida, USA M.S., Soil Science July 1987
University of Peradeniya, Peradeniya, Sri Lanka. B.Sc., Agriculture October 1982
(*Design and analysis of experiments for MPTS research; ** Interregional training course
on the use of isotopes and radiation techniques in studies on soil/plant productivity with
emphasis on root studies)

APPOINTMENTS
University of Missouri, Columbia, Associate Professor- Research, September 2011 to date
University of Missouri, Columbia, Assistant Professor-Research, July 2005- August 2011
University of Missouri, Columbia, Research Associate, August 1994- June 2005
University of Missouri, Columbia, Graduate Research Assistant, 1990-1994
Forest Department, Sri Lanka, Research Office-Soil and Water, 1984-1990
Sri Lanka Standards Institute, Standards Officer, 1983-1984
University of Peradeniya, Assistant Lecturer, 1982-1983

SELECTED PUBLICATIONS (Total 65)
Most Closely Related to Project:
nitrogen losses in relation to forest, pasture, and row-crop landuse and precipitation
influences on sensor measured volumetric soil water content. Agroforest. Syst. 82: 61-75.
effects on water quality in grazed pastures. Agroforest. Syst. 79:81-87.
losses in runoff from three adjacent corn-soybean watersheds. Agric. Ecosyst. Environ.
Other Significant Publications:
Udawatta, R.P., and S. Jose. 2011. Carbon sequestration of agroforestry practices in


**PROFESSIONAL SERVICES**

He serves as a journal reviewer for over 12 journals.
Associate Editor Agroforestry Systems 2010-to-date

**MEMBERSHIP WITH PROFESSIONAL SOCIETIES**

Soil Science Society of America - since 1986; Agronomy Society of America - since 1986

**SYNERGISTIC ACTIVITIES:**

Dr. Udawatta conducts research understanding overall effects of conservation management practices on environmental quality. Several of his research topics exemplify long-term system level research that has resulted in creation of extensive research data bases from field and watershed scales. His scientific stature is best exemplified by appointment as Associate Editor (2010-2012) and Guest Editor for the Agroforestry Systems, six invited presentations, and four invitations to author/co-author book chapters.

**GRADUATE ADVISEES AND POSTDOCTORAL FELLOWS.**

Anomaa Senaviratne – Ph.D. Student; Major Advisor; APEX watershed model simulation to explain benefits of Agroforestry Practices

Bodh Paudel – MS student; Major Advisor; Currently a Ph.D. student at Washington State University

Sandeep Kumar – Ph.D. student; Co-Advisor; Currently a Postdoc Research Associate at Ohio State University

Sang Soo Lee - Ph.D. student; Committee member; Research Associate South Korea

Neal Bailey – M.S. student; Committee member; Currently a Ph.D. student at University of Missouri.