Title: **Utility of Polymer-Coated Urea as a Fall-Applied N Fertilizer Option for Corn and Wheat**

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Objectives and Relevance:

Convenience, favorable soil conditions at the time of application, reduced equipment and labor demand, lower cost of nitrogen (N) fertilizer, and the ability to plant earlier in the spring following fall-applied N applications has favored fall-applied N in Missouri. Fall-applied N is particularly useful in conditions that limit nitrification especially in fine- to medium-textured soils (Bundy, 1986). However, fertilizer applications in the fall may increase risk of leaching under certain soil and weather conditions. Best management practices based on economic returns and N loss via subsurface drainage included fall N with nitrapyrin (N-serve), spring preplant and split applications of anhydrous ammonia in Minnesota (Randall et al., 2003 a, 2003b). However, claypan soils in Missouri have relatively lower N leaching losses due to poor drainage through the subsoil clay layer. Farmers and custom applicators utilize weather stations that report soil temperatures at the 6 in. depth to time fall-applied anhydrous ammonia. Recently, supply of anhydrous ammonia for fall application has been limited to prepaid customers and regulations on anhydrous ammonia and ammonium nitrate may further affect availability of these N fertilizer sources. Alternatives for fall-applied N fertilizer need to be evaluated for their effects on corn and wheat performance to determine if they are cost-effective.

In two years of corn research, polymer coated urea (PCU) that was fall surface-applied for no-till corn had grain yields similar to anhydrous ammonia, but surface-applied PCU in the fall or as early preplant had lower returns than anhydrous ammonia (Nelson and Motavalli, 2007b). However, deep placement of fall-applied PCU increased yield 16 bu/acre more than deep banded urea, 28 bu/acre greater than broadcast applied PCU, and 8 bu/acre greater than anhydrous ammonia (Randall, personal communication). Nitrogen release in Missouri over the winter was less than 30% for fall applied PCU applications and there was more consistent N release when PCU was deep banded than when surface applied (Nelson and Motavalli, 2007b). Reduced efficiency of surface applied PCU may be due to denitrification losses over the winter months during freeze-thaw events. Deep banding PCU should improve efficiency and make it a cost-effective alternative to applying anhydrous ammonia. In Minnesota, soils remain frozen during the winter; however, no field research has evaluated corn response to deep banded PCU as an alternative to anhydrous ammonia in Missouri in soils that go through several freeze-thaw cycles. No research has evaluated fall strip tillage and N fertilizer management systems in Missouri. Finally, no research has compared deep banded PCU with anhydrous ammonia plus N-serve.

Wheat research in MO has evaluated application timings (Medeiros et al., 2005) and fall compared to split applications of PCU (Nelson and Motavalli, 2007a). Applications of PCU later than February resulted in grain yields less than other N sources (Medeiros et al., 2005). In four years of research, fall-applied PCU had the greatest N uptake and grain yields when compared to fall-applied urea alone (Nelson and Motavalli, 2007a). No research has evaluated fall application timings of PCU compared with other N sources to determine if a single fall application at the time of planting wheat or later had yields similar or greater than standard applications of ammonium nitrate. A single fall application would save farmers application cost

of a split application in the fall and spring. Spring applications of N on wheat are usually challenging due to wet conditions and risk of N loss. In addition, research is needed to evaluate the response of wheat to blends of urea and PCU.

The objectives of this research are to: 1) evaluate yield response of early and late fall-applied PCU compared with non-coated urea and anhydrous ammonia with and without N-serve for corn and 2) evaluate the effect of fall-applied timings of PCU and blends of PCU with non-coated urea on wheat yields when compared to non-coated urea and ammonium nitrate.

Procedures:

- Objective 1: *Evaluate yield response of early and late fall-applied PCU compared with non-coated urea and anhydrous ammonia with and without N-serve for corn.*

  Two field trials with three replications will be established at the Greenley Research Center using a high yielding, high protein corn hybrid. One trial will follow soybean residue and the other following red clover. Treatments will include PCU and urea broadcast surface applied and deep banded using a Yetter strip till equipped with high residue Maverick with rolling basket and dry fertilizer application tubes. Nitrogen treatments will be applied in early and late fall, and prior to planting. An untreated and standard anhydrous treatment at 125 lbs N/acre will be included as a control. The N application rate was reduced to determine the most efficient N sources. Grain yields will be determined and grain collected and evaluated for starch, protein, and oil. A gross margin will be calculated for each treatment to compare relative returns of fall compared with preplant treatments.

- Objective 2: *Evaluate the effects of fall-applied timings of PCU and blends of PCU with non-coated urea on wheat yields when compared to non-coated urea and ammonium nitrate.*

  A no-till field trial will be established at the Greenley Research Center with five replications. Research will be in a factorial arrangement of N source and rate (polymer coated urea at 75 and 100 lbs N/a, urea at 75 and 100 lbs N/a, and ammonium nitrate at 75 and 100 lbs N/a, PCU 75%:urea 25% at 75 and 100 lbs N/a, and PCU 50%:urea 50% at 75 and 100 lbs N/a), and application timing (October, November, December, January, February, March, April). Grain yields will be determined and PCU N release will be monitored for individual application timings using mesh bags placed on the soil surface.

Current Status and Importance:

Availability of ammonium nitrate and anhydrous may be limited in the future. The slow-release properties of polymer coated urea have appealing characteristics for corn producers in watersheds with the potential of surface water runoff or soils with high leaching potential. Alternatives to anhydrous for corn need to be evaluated while a single fall applied N application for wheat would reduce application costs for farmers. Finally, incentive payments through the Conservation Security Program were available to producers in Missouri utilizing coated urea technology and additional research is needed on this enhanced efficiency N source. This could impact over 1.8 million acres in qualified watersheds (NRCS, 2005).

Expected Economic Impact

Fall applied anhydrous is applied in upstate Missouri due to convenience, favorable soil conditions at the time of application, reduced equipment and labor demand, reduced cost of N

fertilizer, and the ability to plant earlier in the spring following fall applied N applications. Supply of anhydrous ammonia during the fall has been limited and research in MN and IA has indicated deep banding strip till systems have increased yield when compared with anhydrous ammonia. Increased competition in the fall applied N market may help farmers have an alternative N source and a reliable supply of N in the fall. Strip-till as a fall and early preplant management system for PCU may make this N source more cost-effective than anhydrous ammonia. A single application of N in the fall for wheat would reduce application costs associated with a typical split application system used in upstate Missouri and increase total N uptake.

Timetable:

October-December 2007	Prepare treatments, plot preparation, and apply fall application timings for corn and wheat studies
April-September 2008	Apply preplant N treatments soil sample in the spring and prior to harvest.
September 2008	Harvest
Oct-Dec 2008	Analyze and summarize results
2009	Repeat 2008 procedures
2010	Repeat 2008 procedures

Strategy for Application/Transfer of Knowledge:

Transfer of knowledge will be mainly via written and oral educational programs, including press releases, newsletter articles, radio interviews, television interviews, and conferences. On-site field days will provide a forum for farmers and agriculture professionals to learn about on-going research results.

References:

Bundy, L.G. 1986. Timing nitrogen applications to maximize fertilizer efficiency and crop response in conventional corn production. J. Fertilizer Issues. 3:99-106.

Medeiros, J.A.S., P. Scharf, and L. Mueller. 2005. Making urea work in no-till. Abstr. Am. Soc. Agron. Madison, WI. [non-paginated CD-ROM].

Motavalli, P.P., K.A. Nelson, S.A. Anderson, and 2005. Variable source application of polymer coated urea. Abstr. Am. Soc. Agron. Madison, WI. [non-paginated CD-ROM].

Nelson, K.A. and P.P. Motavalli. 2007. Fall applied polymer coated urea for wheat. Abstr. Am. Soc. Agron. Madison, WI. [non-paginated CD-ROM].

Nelson, K.A. and P.P. Motavalli. 2007. Nitrogen management using reduced rates of polymer coated urea in corn. Greenley Research Center Field Day Report. pp. 43-48.

NRCS. 2005. Conservation Security Program Watersheds FY-2005. http://www.nrcs.usda.gov/programs/csp/2005_CSP_WS/index.html. Accessed 7 December 2005.

Randall, G.W., J.A. Vetsch, and J.R. Huffman. 2003a. Corn production on a subsurface-drained mollisol as affected by time of nitrogen application and nitrapyrin. Agron. J. 95:1213-1219.

Randall, G.W., J.A. Vetsch, and J.R. Huffman. 2003b. Nitrate losses in subsurface drainage from a corn-soybean rotation as affected by time of nitrogen application and use of nitrapyrin. J. Environ. Qual. 32:1764-1772.

Proposed Budget:

CATEGORIES	YEAR ONE	YEAR TWO	YEAR THREE	TOTAL
A. Salaries				
M.S. Graduate Research Assistant (50%)	$13,823	$14,382	$14,670	$42,875
B. Fringe Benefits				
Fringe for graduate student	$1,900	$1,995	$2,095	$5,990
TOTAL SALARIES AND FRINGE BENEFITS	$15,723	$16,377	$16,765	$48,865
C. Travel				
Travel to field site	$623	$623	$623	$1,869
Travel to professional meeting	$0	$500	$500	$1,000
TOTAL TRAVEL COSTS	$623	$1,123	$1,123	$2,869
D. Equipment	$0	$0	$0	$0
TOTAL EQUIPMENT COSTS	$0	$0	$0	$0
E. Other Direct Costs				
Laboratory reagents and supplies	$1,000	$1,000	$1,000	$3,000
Field supplies	$1,500	$1,500	$1,500	$4,500
Soil processing and analysis	$2,000	$2,000	$2,000	$6,000
Publications/Documentation	$0	$500	$500	$1,000
TOTAL OTHER DIRECT COSTS	$4,500	$5,000	$5,000	$14,500
TOTAL REQUEST	$20,846	$22,500	$22,888	$66,234

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. If the graduate student does not require a third year then the requested funds will be used to partially fund a technician during that year.

Travel: Covers cost of travel to Greenley Farm at a rate of 44.5 ¢/mile. In the second and third years, $500 is 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 Processing and Analysis: Covers cost of drying, grinding and analysis of soil samples for ammonium and nitrate-N.

Publications/Documentation: Defrays cost of publication and documentation of results and conclusions.

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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 Missouri, Columbia, MO (Mar., 1999 – present). Associate Professor of Soil Nutrient Management in the Dept. of Soil, Environmental and Atmospheric Sci., School of Natural Resources.

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 (Feb., 1992 - Jul., 1994). Post-doctoral fellow at the Natural Resource Ecology Laboratory at Colorado State University and Department of Soil Science at North Carolina State University.

SELECTED PUBLICATIONS

Goyne, K.W., H.J. Jun, S.H. Anderson, and P.P. Motavalli. In press. Phosphorus and nitrogen sorption to soils in the presence of poultry litter-derived dissolved organic matter. J. Environ. Qual.

Unger, I., R.M. Muzika, P.P. Motavalli, and J. Kabrick. In press. Evaluation of continuous *in situ* monitoring of soil changes with varying flooding regimes. Comm. Soil Sci. Plant Anal.

Kim, H., J.W. Hummel, K.A. Sudduth, and P.P. Motavalli. 2007. Simultaneous analysis of soil macronutrients using ion-selective electrodes. Soil. Sci. Soc. Am. J. 71:1867-1877.

Fang, M., P.P. Motavalli, R.J. Kremer, and K.A. Nelson. 2007. Assessing changes in soil microbial communities and carbon mineralization in Bt and non-Bt corn residue-amended soils. Applied Soil Ecology 37:150-160.

Nelson, K. A., and Motavalli, P. P. 2007. Foliar potassium fertilizer sources affect weed control in soybean with glyphosate. Online. Crop Management doi:10.1094/CM-2007-0724-01-RS.

Pengthamkeerati, P., P.P. Motavalli, R.J. Kremer, and S. H. Anderson. 2006. Soil compaction and poultry litter effects on factors affecting nitrogen availability in a claypan soil. Soil Tillage Res. 91:109-119.

Udawatta, R.P., P.P. Motavalli, H.E. Garrett, and J.J. Krstansky. 2006. Soil nitrogen losses in runoff from three adjacent agricultural watersheds with claypan soils. Agric. Ecosys and Environ. 117:39-48.

Mungai, N.W. and P.P. Motavalli. 2006. Litter quality effects on soil carbon and nitrogen dynamics in temperate alley cropping systems. Applied Soil Ecology 31:32-42.

Pengthamkeerati, P., P.P. Motavalli, R.J. Kremer, and S. H. Anderson. 2005. Soil carbon dioxide efflux from a claypan soil affected by surface compaction and applications of poultry litter. Agric. Ecosys and Environ. 109:75-86.

Mungai, N.W., P.P. Motavalli, R.J. Kremer, and K.A. Nelson. 2005. Spatial variation of soil enzyme activities and microbial functional diversity in temperate alley cropping systems. Biol. Fertil. Soils 42:129-136.

Jung, W.K., N. R. Kitchen, K. A. Sudduth, R. J. Kremer, and P. P. Motavalli. 2005. Relationship of apparent soil electrical conductivity to claypan soil properties. Soil Sci. Soc. Am. J. 69:883-892.

Stevens, W.E., T. Gladbach, P.P. Motavalli and D. Dunn. 2005. Soil calcium-magnesium ratios and lime recommendations for cotton. J. Cotton Sci. 9:65-71.

Udawatta, R.P., P.P. Motavalli, and H.E. Garrett. 2004. Phosphorus loss and runoff characteristics in three adjacent agricultural watersheds with claypan soils. J. Environ. Qual. 33:1709-1719.

Motavalli, P.P, W.E. Stevens, and G. Hartwig. 2003. Remediation of subsoil compaction and compaction effects on corn N availability by deep tillage and application of poultry manure in a sandy-textured soil. Soil Tillage Res. 71:121-131.

Motavalli, P.P., S.H. Anderson, and P. Pengthamkeerati. 2003. Surface compaction and poultry litter effects on corn growth, nitrogen availability, and physical properties of a claypan soil. Field Crops Research 84:303-318.

Motavalli, P.P., S.H. Anderson, P. Pengthamkeerati, and C.J. Gantzer. 2003. Use of soil cone penetrometers to detect the effects of compaction and organic amendments in claypan soils. Soil Tillage Res. 74:103-114.

Motavalli, P. P. and R. J. Miles. 2002. Soil phosphorus fractions after 111 years of animal manure and fertilizer applications. Biol Fertil Soils 36: 35-42.

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

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Ph.D. Weed Science, Dep. of Crop and Soil Sci., Michigan State University, May 2000
M.S. Weed Science, Dep. of Crop and Soil Sci., Michigan State University, May 1997
B.S. Plant Science, Dep. of Agronomy, University of Missouri-Columbia, May 1995

PROFESSIONAL EXPERIENCE:

University of Missouri, Novelty, MO. June, 2000 to present. Research Agronomist and Associate Professor.
Michigan State University, East Lansing, MI. May, 1995 to May, 2000. Graduate Research Assistant.
Ciba Crop Protection, Lee's Summit, MO. May, 1994 to August, 1994. Research Technician.
MU Integrated Pest Management, Columbia, MO. May, 1992 to August, 1992. Gypsy Moth Trapper.
Nelson Family Farm, Skidmore, MO. 1980 to 1995. Farm operator and employee.

PUBLICATIONS:

Nelson, K.A., P.C. Scharf, W.E. Stevens, and B.A. Burdick. 2007. Rescue N applications for corn. Agron. J. In review.

Nelson, K.A., G.E. Rottinghaus, and T.E. Nelson. 2007. Effect of lactofen application timing on yield and isoflavone concentration in soybean seed. Agron. J. 99:645-649.

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Mungai, N.W., P.P. Motavalli, R.J. Kremer, and K.A. Nelson. 2005. Spatial variation of soil enzyme activities and microbial functional diversity in temperate alley cropping systems. Biol. Fertil. Soils. 42:129-136.

Donald, W.W., W.G. Johnson, and K.A. Nelson. 2004. Zone herbicide application controls annual weeds and reduces residual herbicide use in corn. Weed Sci. 52:821-833.

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Li, J., R.J. Smeda, K.A. Nelson, and F.E. Dayan. 2004. Mechanism of resistance to diphenyl ether herbicides in waterhemp (Amaranthus rudis). Weed. Sci. 52:333-338.

Dewell, R.A., W.G. Johnson, K.A. Nelson, J. Li, and J.D. Wait. 2003. Weed management in no-till, double-crop, glyphosate-resistant soybean grown on claypan soils. Plant Management Network News. Online. Crop Management doi:10.1094/CM2003-1205-01-RS.

Nelson, K.A., K. A. Renner, and R. Hammerschmidt. 2002. Cultivar and herbicide selection affects soybean development and the incidence of Sclerotinia stem rot. Agron. J. 94:1270-1281.

Nelson, K.A. and K. A. Renner. 2002. Yellow nutsedge (*Cyperus esculentus*) control and tuber production with glyphosate and ALS-inhibiting herbicides. Weed Technol. 16:512-519.

Nelson, K.A. and K. A. Renner. 2002. Yellow nutsedge (*Cyperus esculentus*) control and tuber yield with glyphosate and glufosinate. Weed Technol. 16:360-365.

Nelson, K.A., K. A. Renner, and R. Hammerschmidt. 2002. Effects of protoporphyrinogen oxidase inhibitors on soybean (*Glycine max* L.) growth response, *Sclerotinia sclerotiorum* disease development, and phytoalexin production by soybean. Weed Technol. 16:353-359.

Nelson, K.A. and K. A. Renner. 2001. Glyphosate-resistant and nonresistant soybean growth and development as affected by glyphosate and postemergence herbicide tank mixtures. Agron. J. 93:428-434.

PROFESSIONAL ACTIVITIES:

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

AWARDS:

2005: Gamma Sigma Delta Outstanding Junior Faculty Award