1. Title: Nitrogen dynamics of standard and enhanced urea fertilizer in corn

2. Investigator: James H. Houx III and Felix B. Fritschi, Univ. of Missouri

3. Objectives and Relevance to the Missouri Fertilizer and Lime Industry:

The overall objective of this project is to evaluate different Urea-N management products on the fate of fertilizer N and corn yields.

Specifically, we will:

1) Evaluate corn yield response to fertilization with standard and enhanced urea products (Agrotain, Nutrisphere, and ESN).
2) Examine timing and quantity of corn fertilizer N uptake, fertilizer N use efficiency, and residual fertilizer N recovery in the soil for these product classes using ^{15}N tracer techniques.

Concerns about illegal uses of anhydrous ammonia and ammonium nitrate may make urea a more suitable N fertilizer choice in the future. Urea is more concentrated than most N sources and thus may be more economical to apply. However, urea is subject to volatilization losses that in extreme circumstances can be as much as 50% (Harrison and Webb, 2001). To combat N losses from urea, manufacturers have developed additives and specialty N fertilizer products designed to inhibit N losses and prolong the N release period. These characteristics may reduce leaching and nitrate runoff, and may reduce emissions of N-containing greenhouse gases. Further, they may offer producers some flexibility in their N management decisions.

The use of these products is increasing. Sales of Agrium Advanced Technologies' ESN (polymer coated urea) were up 60% in the past year and now accounts for over 60% of the unit's profit (Agrium, 2008). Sales at SFP inc., the Belton, MO maker of Nutrisphere (a proprietary polymer that inhibits volatilization and nitrification), rose 700% from 2004-2007 (kcstar.com.pressreleases) and Agrotain Intl. Inc. in St. Louis, MO announced on November 28, 2008 that Agrotain (a urease inhibitor) was approved for use in the European Union.

If properly marketed in Missouri, manufacturers and retailers may have the opportunity to increase sales of these products. However, while these products make sense theoretically, successful application in field settings is not guaranteed. Climate, soils, and site variations can affect the activity of these products and make research results inconsistent. This makes drawing inferences about their effectiveness difficult and does little to improve consumer confidence. Therefore, research is proposed to evaluate corn yield and trace urea-N (via ^{15}N labeling) during the growing season when these product classes are used.

Nitrogen-15 is a stable isotope that can serve as an excellent tool to determine the fate of fertilizer in cropping systems. The natural abundance (~0.37%) of ^{15}N is very low and adding N fertilizer enriched in ^{15}N% results in ^{15}N concentrations that are greater than the natural abundance in plants and soils. Using ^{15}N, researchers can determine how much and when applied N is released and what is taken up by the plant, retained in the soil, or lost from the system. This information cannot be determined with N rate trials or side-by-side product comparisons. Thus, this design will provide detailed information to address questions arising about yield differences or inconsistencies among treatments.

4. Procedures:

Main Treatments*: (6 treatments to evaluate product effect on yield)*

1) Zero fertilizer N
2) Urea (^{15}N microplot)
3) Agrotain treated urea (^{15}N microplot)
4) Polymer coated urea (^{15}N microplot)
5) Nutrisphere treated urea
6) ESN urea
7) 28% UAN

Microplots: *(to evaluate N fate and balance)*

Main treatments 2, 3, and 4 above will have a 4 m^2 microplot embedded within the larger yield plots.

Cultural Practices: This study will be conducted as a 3-yr field study at the Bradford Research and Extension Center in Columbia, MO. The experiment will be initiated in spring 2009. Fertilization of P and K will be conducted according to soil test results and N fertilization will be uniform across all main treatments as surface-applied urea at planting. N will be applied at rates equivalent to 150 lbs N/acre. This rate should allow for differences in N release, uptake, and loss to affect yield. Higher N rates may not allow us to delineate treatment differences due to N source. Microplots will be embedded in the larger plots and non-enriched fertilizer will be substituted with ^{15}N-enriched urea.

Design: Each treatment will be replicated four times in a randomized complete block design. Each main treatment will be applied to 20'x100' plots to allow for destructive plant sampling throughout the study. From these plots, tissue N analysis, final yield, and soil N samples will be taken. Within the 20'x100' plot of treatments 2, 3, and 4 outlined above, a microplot will be delineated for fertilizer tracing. Microplots are standard research units and are necessary due to costs of ^{15}N-enriched fertilizer. We propose to apply ^{15}N-enriched urea (1.0 atom% excess) to 4-m^2 microplots within the main treatment plots. Thus, we will be able to determine corn fertilizer uptake efficiency, residual soil fertilizer N, and N loss.

Measurements: Corn yield will be determined for every treatment in 20'x100'plots. Crop growth and development will be measured 5 times over the course of each growing season and plant samples will be collected at selected time points for determination of tissue N levels. Plants will be sampled in all treatments in the main plots (not labeled with ^{15}N) as well as the microplots where applicable. Samples collected at harvest will allow us to determine full season fertilizer use efficiency, amount of plant N derived from fertilizer, and amount of fertilizer N removed from the field with the grain. Soil samples will be taken to determine ^{15}N remaining in the soil, and construct a fertilizer N balance.

5. Current Status and Importance of Research Area:

Delaying N applications to corn until planting offers producers a good opportunity to apply N closer to when crop uptake occurs. This could substantially reduce losses associated with fall or early spring N applications (leaching, volatilizations, erosion), thus reducing N fertilizer requirements and environmental degradation associated with N loss. Despite this, urea applied near planting can still be subject to significant volatilization and leaching losses before plant uptake and can be toxic to developing seedlings. In these situations, the use of N management products may be justified. These products differ in the mechanisms by which they reduce N losses and as a result may not perform equally under any given set environmental conditions.

The urease inhibitor in Agrotain, N-(n-butyl) thiophosporic triamide (NBPT), has been demonstrated to reduce urea volatilization (Gioachhini et al., 2002; Hou et al., 2006) and may increase N recovery and plant uptake. Agrotain claims that urea losses can be delayed an average of 2-3 weeks relative to nontreated urea. Because volatilization increases with temperature and soil moisture, losses could be significant in the weeks following corn planting. Agrotain could be ideally suited for the N application timing proposed for this research.

The active ingredient in Nutrisphere is described as a maleic-itaconic co-polymer that protects nitrogen in urea against volatilization and nitrification. Because of its proprietary nature, less is known about how this product works. Several studies suggest that Nutrisphere works. However, Enochs et al. (2008), question nutrisphere's urease inhibition in a recently completed study so it is unclear if this product performs as suggested. The Nutrisphere label states that it protects against nitrification so, Nutrisphere may also reduce N leaching losses. However, research on nitrification inhibitors indicates that they may affect the timing of leaching losses but may not reduce the overall amount of leaching losses (Walters and Malzer,1990a; Gioachhini et al., 2002). If a delayed release of mineralized N results, plant uptake in the application year can be less and more carryover of N into subsequent years results (Walters and Malzer, 1990b). This may or may not be desirable.

Specialty products such as polymer coated urea (PCU) are being researched for use in row-crop agriculture. Polymer coatings retard N release from urea granules by physically preventing granule dissolution thus reducing both volatilization and nitrification. Nitrogen release from PCU's is governed by temperature and moisture so release during dry periods can be less than desired. ESN, a polymer coated urea product from Agrium, is designed to release N as the crop needs it. Agrium suggests spring applications of ESN and applications near planting may be ideal.

This study will allow us to evaluate commercially available N-management products for surface-applied urea to no-till corn. Most studies evaluating these types of products use yield as the assay parameter. Our main treatment plots will be suitable for measuring yield and determining treatment differences. Although yield is absolute, it does little to explain the fate of fertilizer N. Using the stable isotope nitrogen-15 will allow us to trace the fate of fertilizer N when urease and/or nitrification inhibitors are used and when polymer coating is applied to urea. By tracing the fate of N when using these products, we can ascertain whether these products reduce N losses and contribute N to plant yield.

6. Timetable for Proposed Research:

Spring 2009	Planting, fertilizer treatment establishments, and general management of corn.
Summer 2009	Sample soil and corn for ^{15}N analysis
Fall 2009	Harvest plots; sample soil for ^{15}N retention.
2010	Repeat planting and treatments as in 2009
2011	Repeat planting and treatments as in 2010

This proposal is a three year project schedule to commence in spring 2009.

7. Strategy for Application and Transfer of Knowledge:

Results of this study will be disseminated at appropriate annual field days and workshops. The information gained from this project will be presented at annual meetings of professional societies (such as American Society of Agronomy, Crop Science Society, Soil Science Society) and will be published in a refereed journal.

8. Proposed Budget:

Category	Year 1	Year 2	Year 3	Total
Personnel				
Research Associate (40%)	$13,600	$14,144	$14,710	$42,454
Benefits	$4,304	$4,611	$4,859	$13,774
Analytical cost (soil and plant N and ^{15}N analysis)	$3,000	$3,000	$3,000	$9,000
^{15}N fertilizer purchase, formulation, and field supplies	$4,500	$4,500	$4,500	$13,500
Travel	$1,000	$1,000	$1,000	$3,000
Total	$26,404	$27,255	$28,069	$81,728

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PUBLICATIONS:

Houx JH, HE Garrett, RL McGraw. 2008. Applications of black walnut husks can improve orchardgrass and red clover yields in silvopasture and alley cropping plantings. Agrofor. Syst. 73(3):181-187.

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Publications:
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Selected Refereed Publications:

Fritschi, F.B., and J.D. Ray. 2007. Genotypic variation in soybean chlorophyll content, a/b ratio and leaf N. Photosynthetica 45:92-98.

Ray, J.D., **F.B. Fritschi**, and L.G. Heatherly. 2006. Large early season fertilizer N application affects protein and oil concentration in soybean seed. Field Crops Res. 99:67-74.

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