FINAL REPORT 2005

Use of Slow-Release N Fertilizer to Control Nitrogen Losses Due to Spatial and Climatic Differences in Soil Moisture Conditions and Drainage

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Summary:

Research was conducted in 2004 and 2005 in Missouri with the objectives of examining the agronomic performance and cost-effectiveness of polymer-coated urea compared to conventional N fertilizer sources under different soil moisture and drainage conditions and of assessing environmental N losses under these conditions. Among the findings of this study were:

- Soil nitrous oxide (N_2O) gas efflux was generally lower with application of polymer-coated urea compared to conventional urea. This decrease in gaseous N loss was affected by differences in soil water content due to the relatively wet (2004) and dry (2005) growing seasons experienced during this research and the use of artificial drainage and/or irrigation. Gaseous losses of nitrous oxide can be a significant proportion of N loss after N fertilizer applications in claypan soils and possibly in other soils with restrictive subsoil layers that affect soil moisture conditions.
- Data collected from soil suction lysimeters positioned at different soil depths suggests that application of the polymer-coated urea compared to conventional urea delayed nitrate leaching in 2004 within the soil profile above the claypan subsoil.
- Among the drainage and irrigation treatments examined for this research, application of polymer-coated urea did not have significantly higher corn grain yields compared to conventional urea in either 2004 or 2005.
- Based on the limited data from this research, use of polymer-coated urea would only be cost-effective if an economic value is placed on reductions in environmental N losses and incentive payments or cost-share were provided for use of the product.

Materials and Methods:

A two-year field trial was started in 2004 utilizing the University of Missouri Drainage and Subirrigation (MUDS) trial at the MU Ross Jones Farm in Northeast Missouri. Treatments consisted of 150 ft long plots planted to corn containing treatments of: i) no drainage or subirrigation, ii) drainage with tile drains spaced 20 ft apart and no subirrigation, iii) drainage with tile drains spaced 20 ft apart and subirrigation, and iv) no drainage and overhead sprinkler irrigation according to the Woodruff irrigation scheduling chart . The drainage/irrigation plots were then split into N fertilizer treatments of either broadcast pre-plant-applied urea or polymer-coated urea (ESN®, Agrium, Inc.) at rates of 0, 125, and 250 lbs N/acre. Each treatment combination had 4 replications. All corn plots were chisel plowed in the fall and N treatments incorporated in the spring with a field cultivator.

Changes in soil volumetric water content and temperature due the effects of drainage and irrigation over the growing season were continuously monitored in two replicates of the field experiment using Campbell Scientific data loggers and soil moisture and temperature sensors. The sensors were installed at depths of 6 and 18 inches in the middle between drainage tile lines and in the control and high rate of urea fertilizer.

The fate of applied fertilizer N was monitored by periodic soil sampling to determine changes in soil inorganic N (NH_4^+-N and NO_3^--N) by depth, by NO_3^--N analysis of water samples collected from suction lysimeters installed at depths of 6 and 18 inches, and by measurement of nitrous oxide (N_2O) gas flux. Soil N_2O gas was collected using small sealed chambers fitted with rubber septa inserted into PVC collars in the soil. The head space gas was collected from the chambers in the different treatments and analyzed by gas chromatography (GC). Crop N recovery of applied fertilizer N due to the treatments was determined by measurement of total aboveground biomass (silage) at two different times during the season and at physiological maturity and by total N tissue analysis.

Results:

Rainfall during the 2004 cropping year was above average in the spring and consistent throughout the summer (Fig. 1A). In contrast, cumulative rainfall during the growing season in 2005 was relatively lower than in 2004 and an extended drought was experienced after the middle of June (Fig. 1B).

Due to this difference in annual rainfall, corn grain yield response to added N fertilizer and drainage and irrigation treatments varied between the two years. In 2004, grain yields averaged approximately 94 bu/acre higher than the check plots receiving no N fertilizer across all drainage and irrigation treatments (Fig. 2A). In addition, the plots in 2004 with drainage generally outyielded the non-drained plots by 23 to 31 bu/acre. Yield increases due to use of polymer-coated urea compared to conventional urea N fertilizer ranged from an average of 14 to 20 bu/acre in the plots with no drainage or supplemental irrigation, but these yield increases were not statistically significant at $P < 0.05$ (Fig. 2A).

In 2005, some yield advantage was observed with drainage, but, in general the largest response occurred when irrigation was applied (Fig. 2B and 3). Yield increases to added N fertilizer under overhead or subirrigation ranged from 72 to 165 bu/acre. No significant yield differences were observed between polymer-coated and conventional urea (Fig. 2B and 3). One possible reason for the lack of differences between the two N fertilizer sources is that all N fertilizer treatments were incorporated after application which may have reduced potential ammonia volatilization that may occur when conventional urea is surface-applied.

Nitrate-N levels contained in suction lysimeter water samples in 2004 at depths of 6 and 18 inches were highly variable and collection of samples only began 60 days after the N fertilizer was applied (DAN) since insufficient water was in the soil to enter the suction lysimeters until that date (Fig. 4). Despite the high variability in NO_3^--N contained in the water samples, the NO_3^--N was generally higher in the urea-treated plots compared to the polymer-coated urea in the beginning of the season (60, 68 and 85 DAN) and then lower later in the season (139 and 158 DAN).

Fig. 5A & B shows the relative rate of gaseous N_2O loss or efflux resulting from the different N fertilizer treatments in the overhead irrigated treatment over the 2004 and 2005 growing seasons. In general, application of the polymer-coated urea (ESN) resulted in lower N_2O efflux, especially at peak loss times. In other research at the Greenley Experiment Station, we have observed that most N_2O gas loss occurred within 40 days after N fertilizer application. However, in this research, peak N_2O gas losses often occurred between 30 to 60 days after N fertilizer application (Fig. 5A & B).

Table 1 shows a comparison of the relative N_2O gas efflux in 2004 at a June sampling date when peak activity occurred. Soil N_2O efflux was generally not significantly different among the drainage/irrigation and N fertilizer treatments. However, in the overhead irrigated plots, significantly higher N_2O efflux occurred in the urea-treated plots compared to the polymer-coated urea-treated plots. Loss of N_2O was affected by changes in soil temperature and soil water content that occurred due to rainfall and the different drainage and irrigation treatments. In general, these rates of N_2O loss in these claypan soils are much higher than those rates reported in the research literature for soils without subsoil restrictive layers.

Based on the limited data from this research, use of polymer-coated urea did not result in increased economic value over conventional urea because of higher yields. However, use of enhanced efficiency fertilizers, such as polymer-coated urea, may be cost-effective if a sufficient economic value is placed on reductions in environmental N losses. Currently, Missouri is offering incentive payments for use of some treated N fertilizer products. With funding from the Missouri Fertilizer and Aglime, we are also currently conducting research to compare other N fertilizer management practices, such as variable source application, to determine if use of polymer-coated urea can be cost-effective.

Outreach and Training:

One M.S. graduate student is receiving her training working on this project for her thesis research in soil science. The research results have been presented to Missouri growers and agricultural professionals at the 2004 and 2005 Greenley Center Field Days in Northeast Missouri and at the American Society of Agronomy National Meetings in 2005. Several workshops on drainage and irrigation practices have also been conducted at the field site.

Table 1. The effects of drainage/irrigation and N fertilizer source on soil N_2O flux on 17 June, 2004.

Fertilizer treatment	Drainage/Irrigation treatment: No drainage, No irrigation	Drainage, No irrigation	No drainage Overhead irrigation	Controlled drainage Subirrigation	$DMRT_{(0.05)}$
	$g\ N_2O\text{-}N\ ha^{-1}\ day^{-1}$				
Control	22.30	55.63	67.23	33.17	NS†
ESN††	162.20	106.69	223.56	68.98	NS
Urea	32.08	56.03	642.01	37.87	NS
$DMRT_{(0.05)}$	NS	NS	2.93	NS	

†NS = Not statistically significant
††N fertilizer sources were applied at 250 lb N/acre

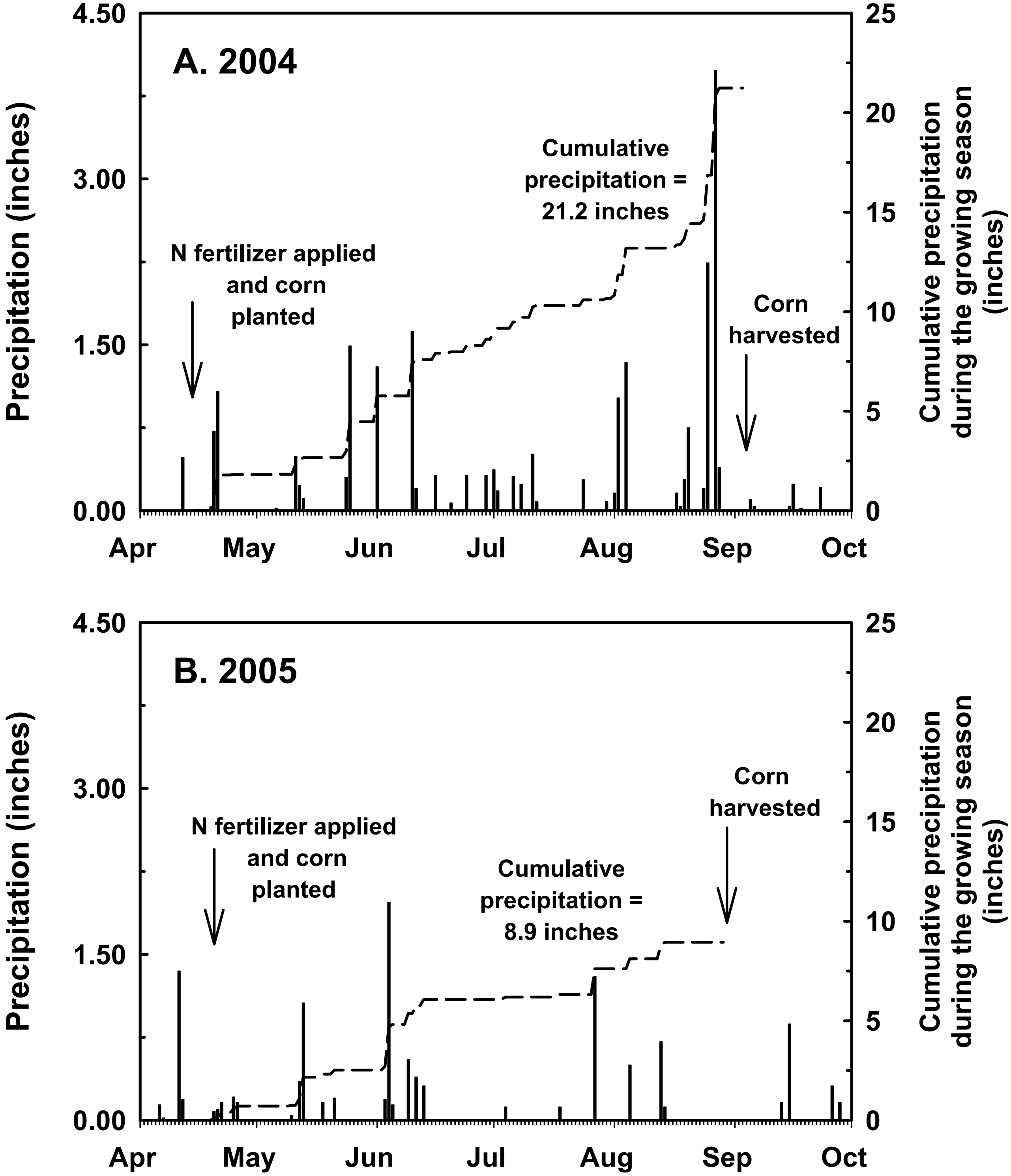

Fig. 1 A & B. Daily and cumulative rainfall at the Ross Jones Farm during the A) 2004 and B) 2005 cropping seasons.

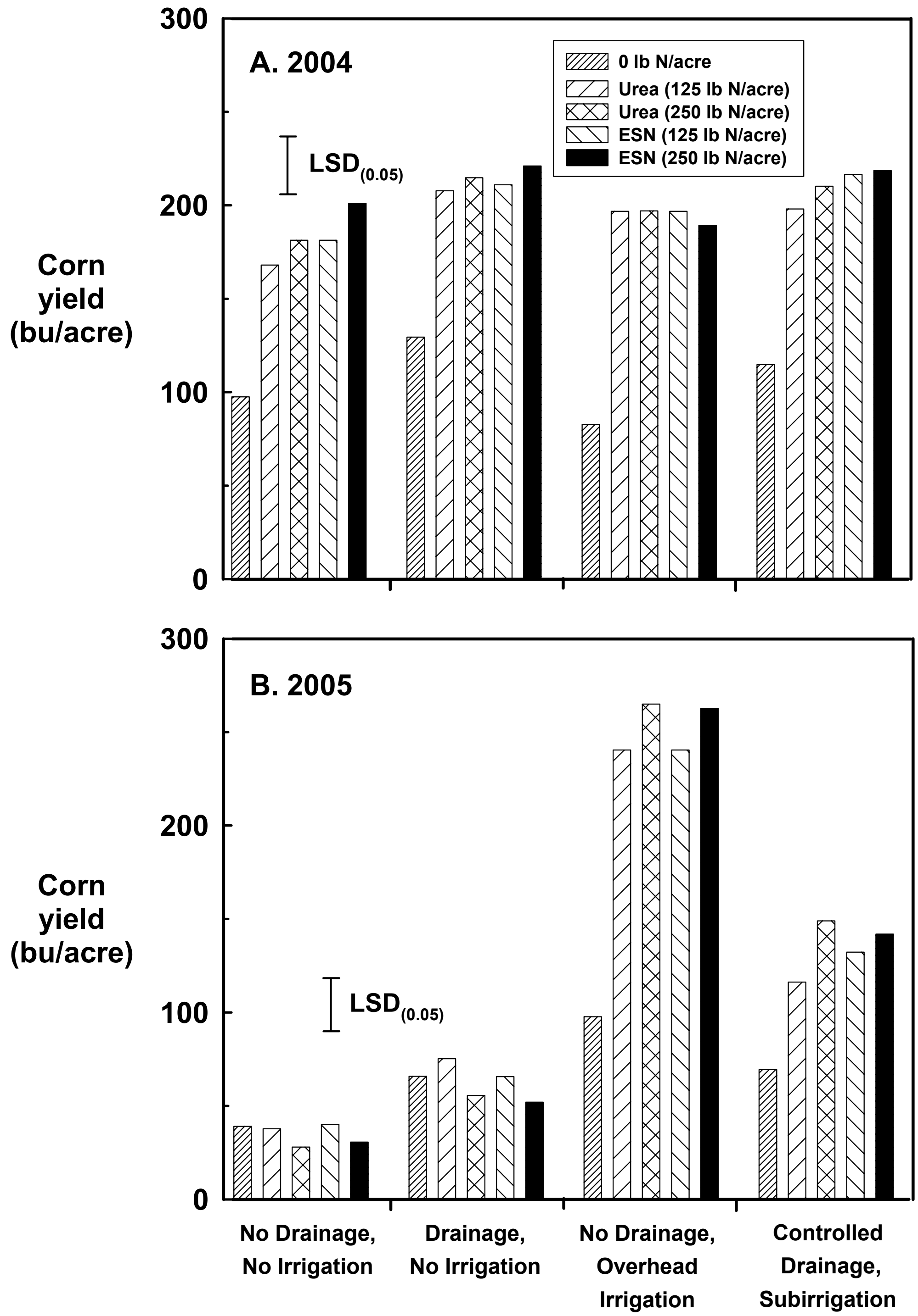

Fig. 2A & B. Corn grain yield response in A) 2004 and B) 2005 to different application rates of conventional and polymer-coated urea (ESN) under different drainage and irrigation treatments.

Fig. 3. Comparison of corn ears in 2005 to different application rates of conventional and polymer-coated urea (ESN) under different drainage and irrigation treatments.

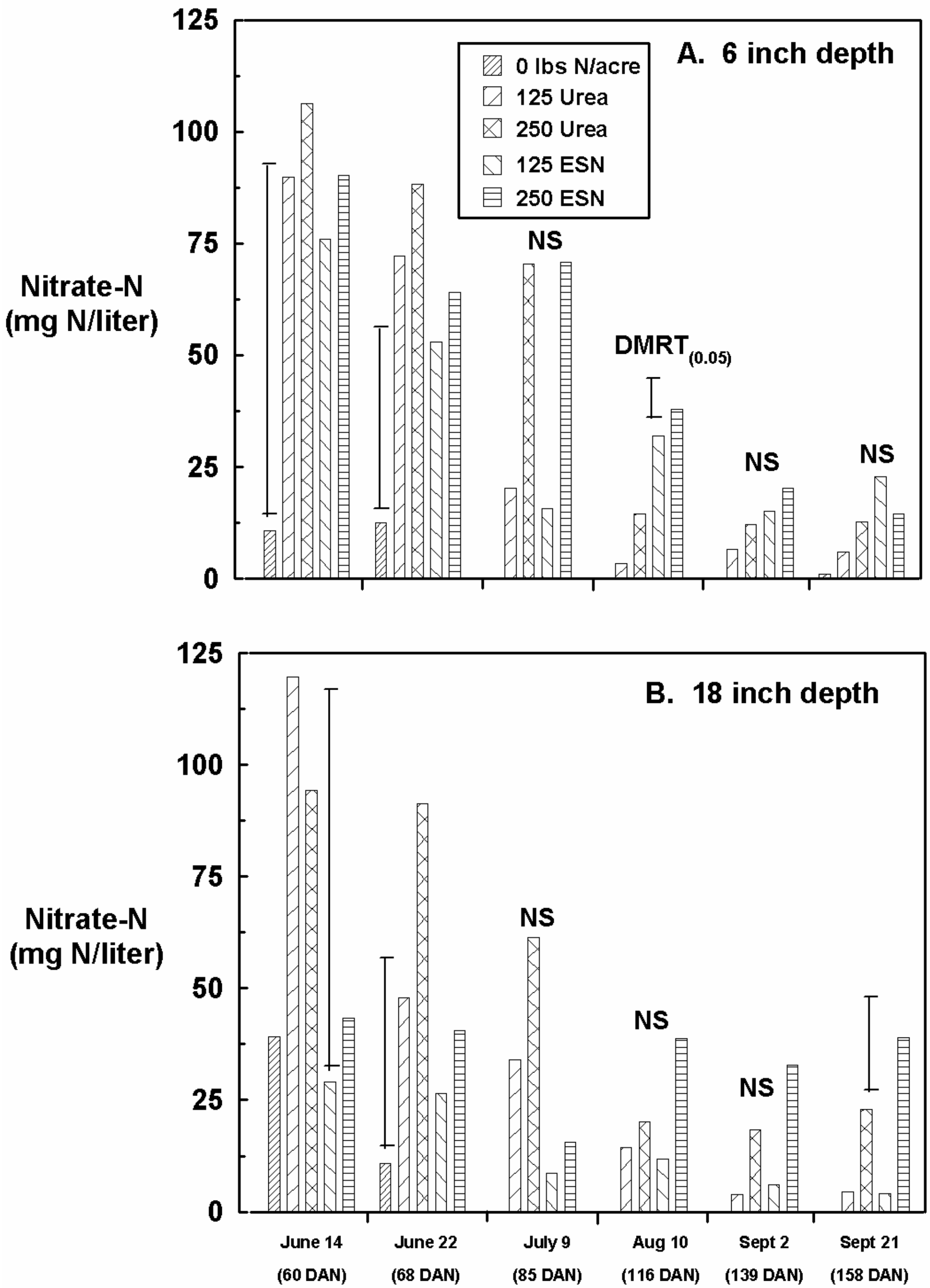

Fig. 4. Nitrate-N contained in water samples collected from suction lysimeters installed in 2004 at A) the 6 inch depth and B) the 18 inch depth in plots receiving different rates of conventional or polymer-coated urea (ESN). The values are averaged over the drainage/irrigation treatments. DAN = days after N fertilizer applied.

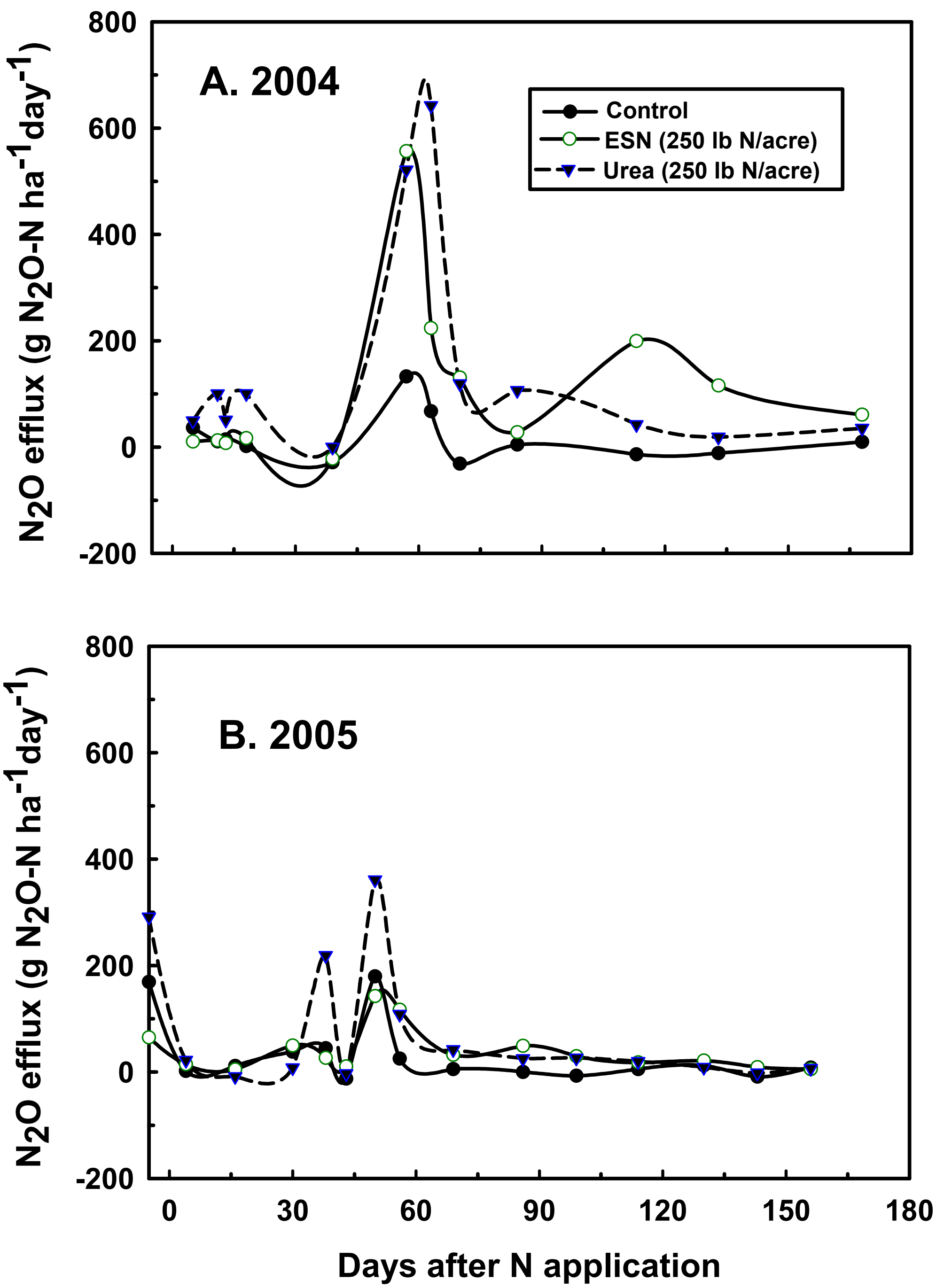

Fig. 5A & B. Nitrous oxide gas efflux in A) 2004 and B) 2005 with different N fertilizer sources at the 250 lb N/acre rate in the overhead irrigated treatment.