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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Losses of nitrogen (N) from N fertilizer applications to corn may reduce N use efficiency and thereby decrease corn yields and have possible negative effects on the environment. Among the major N loss processes are leaching and production of N gases, such as nitrous oxide (N_2O). The relative significance of these processes in claypan soils may vary due to annual differences in rainfall and temperature and the presence of a restrictive subsoil layer that reduces drainage. Production of N_2O gas after N fertilization may be relatively higher in claypan soils because more of this N gas is produced under wet soil conditions. Application of enhanced efficiency N fertilizers, such as slow release N fertilizer, may reduce N losses that would occur if conventional urea fertilizer was applied because its N release may be delayed during the early growing season when the risk of leaching and gaseous N losses is high.

The objective of this research was to examine the performance and cost-effectiveness of polymer-coated urea and conventional N fertilizers, and the relationship between soil N_2O flux, temperature, soil nitrate-N (NO_3^--N), and soil water content. A two-year field trial planted to corn was started in 2004 at the University of Missouri Ross Jones Farm in Northeast Missouri on a claypan soil. Treatments consisted of 150 ft long plots with: 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 irrigation. The plots were then split into N fertilizer treatments of broadcast pre-plant-applied urea or polymer-coated-urea at rates of 0, 125, and 250 lbs N/acre. Each treatment combination had 4 replications.

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.

Soil sampling was periodic (every week from late April to late June and every other week until late September) to monitor the fate of applied fertilizer by changes in soil ammonium-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 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. Crop N recovery of applied fertilizer N due to the treatments was determined by measurement of total aboveground biomass at two different times during the season and at physiological maturity and by total N tissue analysis.

The results show that in the 2004 growing season when cumulative rainfall was 21 in., grain yields averaged approximately 94 bu/acre higher than the check plots receiving no N fertilizer across all drainage and irrigation treatments (Fig. 1A). 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 significant (Fig. 1A). In 2005, some yield advantage was observed with drainage, but, in general the largest response occurred when irrigation was applied (Fig. 1B). The importance of irrigation in 2005 was due to lower rainfall (10.4 in.) experienced during the growing season. No significant yield differences were observed between polymer-coated and conventional urea (Fig. 1B).

In 2004, drainage significantly reduced gravimetric soil water content compared to non-drained plots only at the beginning of the growing season (Fig 3A). Overhead irrigation increased soil water content at the end of the 2004 season and after 67 days after N application in the 2005 season (Fig 3A&B). Only 5.6 in. of irrigation was applied near the end of the 2004 season because it was a relatively wet year (Fig 3A). In contrast, overhead irrigation had a large impact on gravimetric soil water content in 2005 (11.9 in. was applied for the growing season).

Nitrate-N levels contained in suction lysimeter water samples at depths of 6 and 18 inches in 2004 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. 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). In 2005, sufficient water was found only two sampling dates (55 and 67 DAN). Higher nitrate-N levels were found in the urea-treated plots 67 days after application of N sources.

Soil N_2O flux was significantly lower in 2004 in the polymer coated urea-treated plots at the beginning of the season in the overhead irrigated, non-drained plots (Fig. 2A). Only plots with overhead irrigation and no drainage were graphed as they were assumed to have had better conditions for release of N_2O than the other drainage/irrigation treatments. In 2005, the only significant difference between fertilizers was observed at 41 days after N application when urea-treated plots released less N_2O than plots receiving polymer coated urea and after 125 days when both urea and polymer coated urea-treated plots had higher N_2O flux than the control (Fig. 2B). In general, polymer-coated urea had lower surface soil N_2O efflux compared to urea in the early part of the growing season during a relatively wet year. These results suggest polymer-coated urea may reduce N_2O losses under relatively wet conditions.

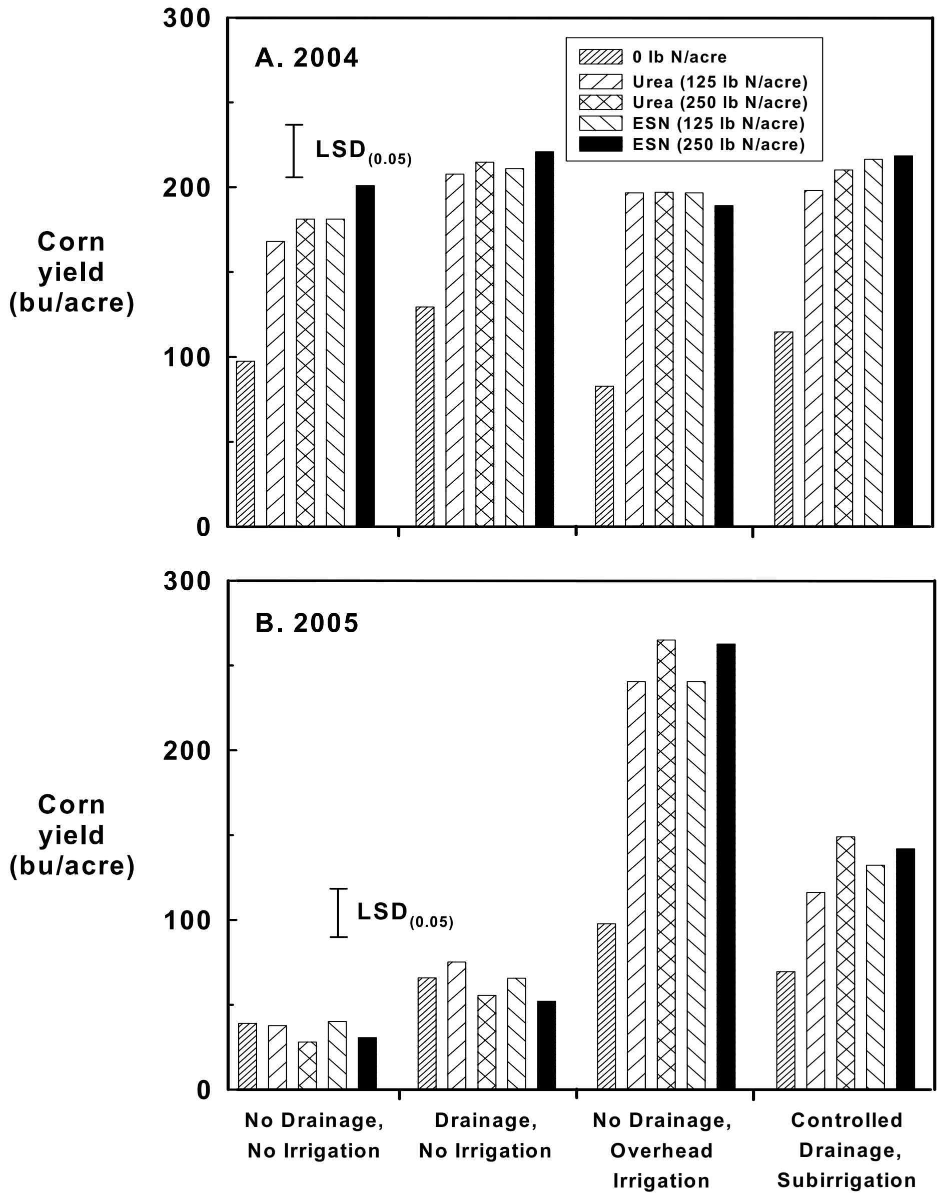

Figure 1A & B. Corn grain yield response in A) 2004 and B) 2005 to different application rates of conventional and polymer-coated urea (ESN) under different drainage and irrigation treatments. All sampling times without LSD bars were not significant.

$LSD_{(0.05)}$ = Least significant difference at 0.05 significance level.

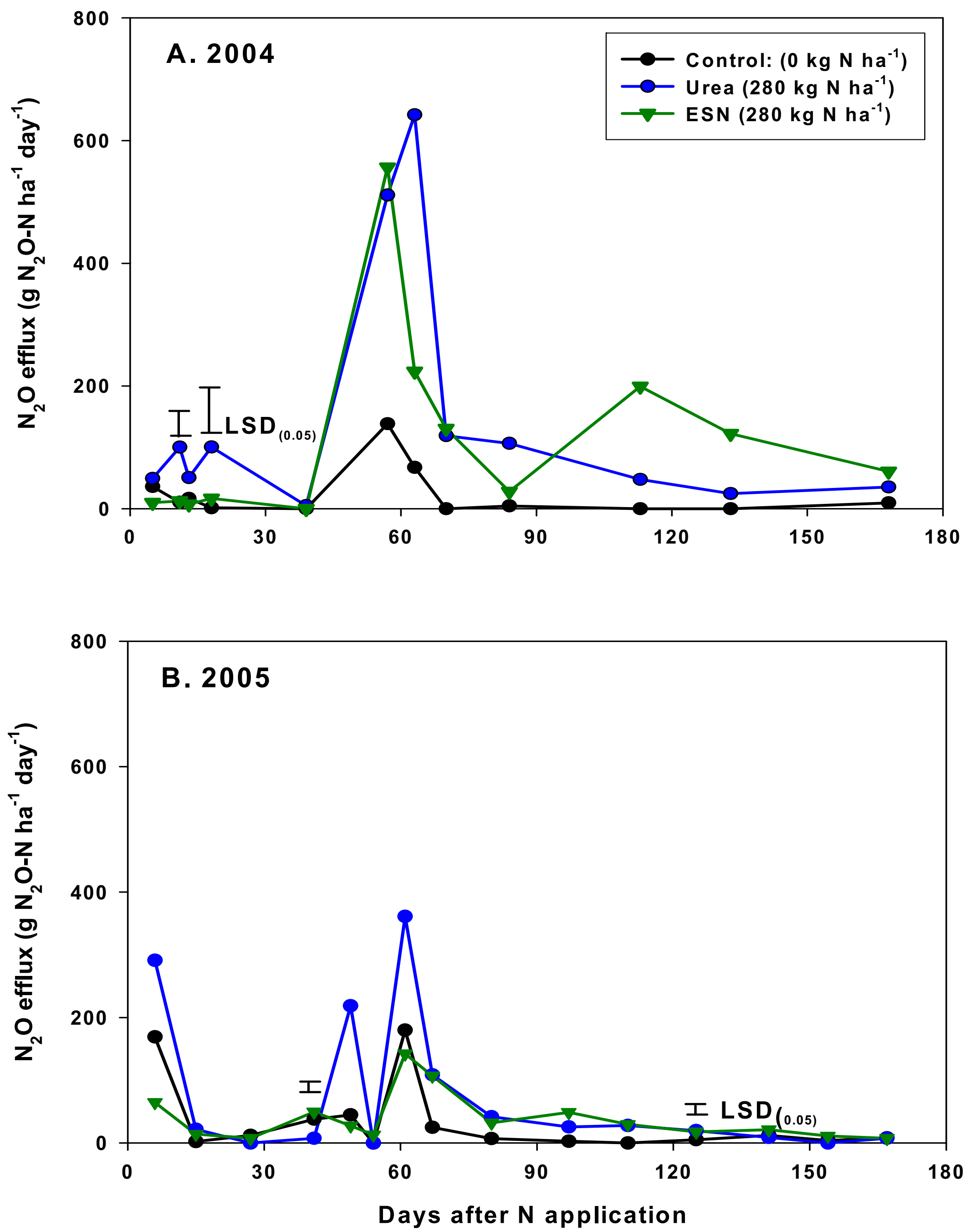

Figure 2 A&B. N_2O efflux under each fertilizer treatment in the overhead irrigated, non-drained plots over the growing season in (A) 2004 and (B) 2005. All sampling times without LSD bars were not significant.
$LSD_{(0.05)}$ = Least significant difference at 0.05 significance level.

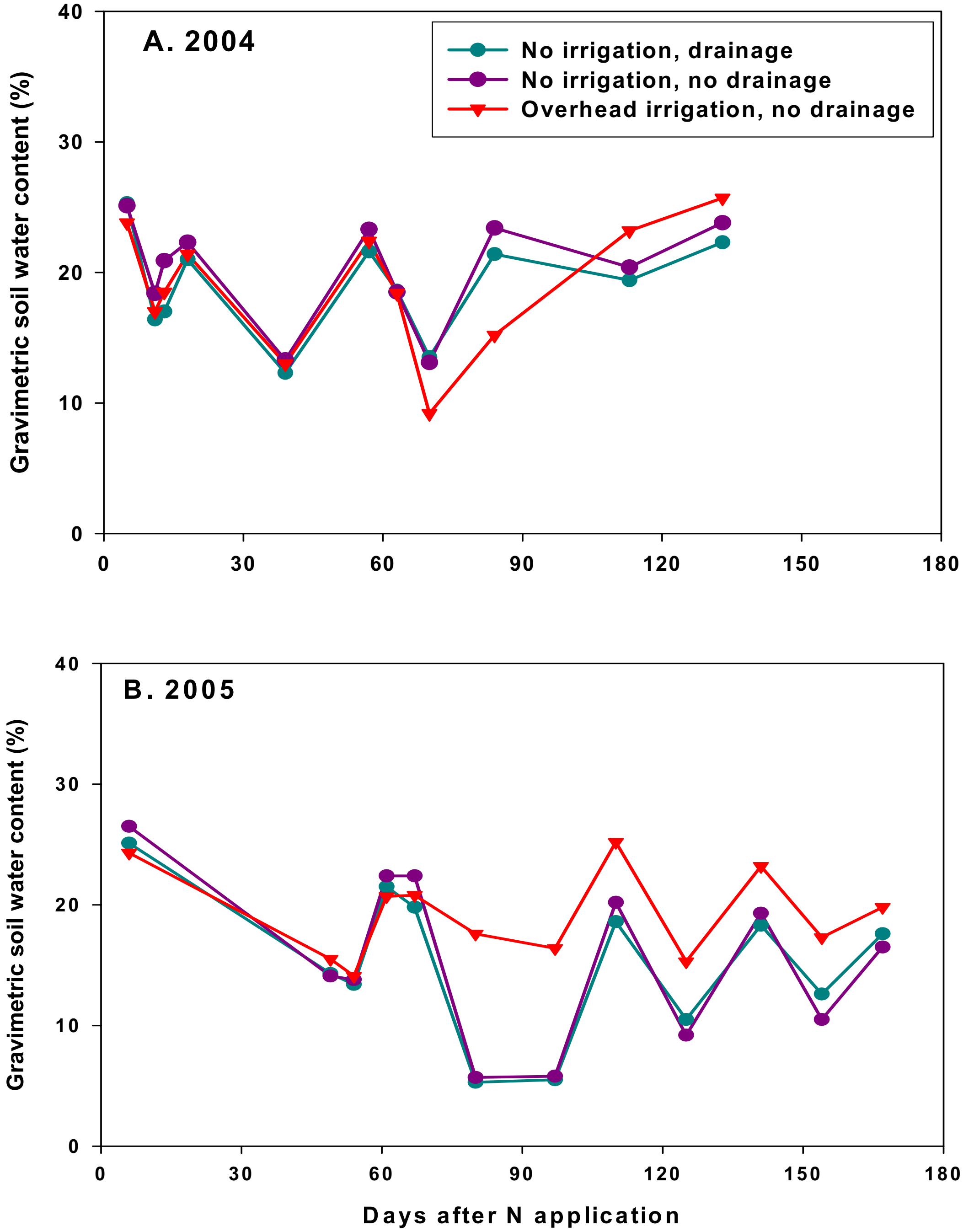

Figure 3 A&B. Gravimetric soil water content (A&B) at 5 cm depth under each drainage and irrigation treatment after application of 280 kg N ha^{-1} (as ESN) over the 2004 and 2005 growing seasons. All sampling times without LSD bars were not significant. $LSD_{(0.05)}$ = Least significant difference at 0.05 significance level.