

UTILIZATION OF POLYMER-COATED UREA FERTILIZER AND MANAGED SUBSURFACE DRAINAGE SYSTEMS TO IMPROVE N MANAGEMENT AND CORN YIELDS

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Agronomic production on poorly drained soils in humid regions, such as the Central Claypan Region (MLRA), can exhibit low crop production in moderate to wet growing seasons. Extended periods of saturated soil conditions during a growing season may severely lower crop production by inhibiting plant growth, increasing the chance of disease, and providing conditions ideal for nutrient loss. Trafficability issues are often overlooked but can have a significant impact on crop production due to potential delays in fertilizer, herbicide, and pesticide applications, planting, and harvesting. Installation of a subsurface tile drainage system can effectively minimize issues with saturated soil conditions near the soil surface and the plant root zone. In NE Missouri, subsurface tile drainage has been found to improve corn and soybean yields by 20% compared to non-tile drained soil (Nelson et al., 2010). However, since nitrate-N is soluble and has little affinity for adsorption onto soil particles there is a considerable amount of fertilizer N that can be lost in subsurface drainage water from agricultural soils (Cambardella et al., 1999).

Recent advances in subsurface drainage technology now allow for the management of the tile outlet height with the addition of a water level control structure, thereby effectively regulating the water table height and drainage outflow (Brown et al., 1997). Corn production in dry growing seasons may improve with managed subsurface drainage systems (MD) compared to conventional subsurface drainage systems (CD) due to the ability to increase retention of crop-available water and nutrients in the root zone. Although little agronomic research has been conducted on managed drainage, a recent two year research study evaluating corn and soybean yield production differences between managed and conventional subsurface drainage systems reported significantly higher yields in both seasons with managed drainage systems (Drury et al., 2009). Additionally, reducing tile drain outflow during the non-cropping season can significantly reduce the annual N loss in water draining out of tile drains. A study by Drury (1996) reported 88 to 95% of the total nitrate-N transported through the tile drains occurred during the non-cropping period (i.e., fall, winter, spring). Research evaluating managed subsurface drainage has reported up to a 75% reduction in annual nitrate-N loss compared to conventional subsurface drainage systems (Fausey et al., 1995; Drury et al., 1996; Frankenberger et al., 2006; Drury et al., 2009).

Polymer-coated urea (PCU) is designed to have a slower release rate than traditional dry urea fertilizers (NCU) (Wilson et al., 2009), which in wet growing conditions can potentially reduce N loss, resulting in increased corn production. Evidence for this decreased N loss using PCU compared to NCU can be found in a recent corn study conducted in this region which found that in low-lying areas, PCU increased N recovery efficiency (NRE) by 116 and 17% compared to NCU in 2005 and 2006, respectively (Noellsch, 2009). Surface applications of PCU also have been found to reduce ammonia volatilization loss by 60% compared with NCU (Rochette et al.,

2009). A study conducted in a claypan soil found reduced nitrate-N concentration in water located in the soil profile early in the growing season with PCU compared to NCU fertilizer (Nelson et al., 2009), which indicates PCU's potential to minimize nitrate-N leaching. In regards to corn grain yield, pre-plant application of PCU has been reported to increase yields by 6.4 to 11.2 bu/acre compared to NCU (Blaylock et al., 2004, 2005; Nelson et al., 2008). These results are presumably a function of a slower release of urea throughout the growing season resulting in greater plant uptake of N and reduced N loss.

Based on past studies, literature, and conditions in NE Missouri in which a majority of rainfall typically occurs in the first two months of the growing season, combining PCU with MD could create a synergistic relationship that would further maximize crop production, as well as possibly reduce nitrate loss in tile drains. However, no studies at this time have evaluated the impact of combining both of these best management practices. Therefore, the objective of this study is to determine the effects of MD and PCU fertilizer on corn grain yields and the fate of applied N.

This is a four year study was initiated in 2010 at the University of Missouri's Greenley Memorial Research Center (40° 1' 17" N 92° 11' 24.9" W) near Novelty, MO (Figure 1) in a Putnam silt loam (fine, smectitic, mesic, Vertic Albaqualfs). Depth to the claypan at this research station ranges from 18 to 24-in (data not presented). Sub-surface tile drainage systems, including control structures were installed in Aug., 2009. The sub-surface tile drains run 200 to 300 ft long with 20-ft spacing, and at a depth of 2 ft.

The experiment field site was in continuous corn (*Zea mays L.*) production under conventional tillage. There were two replications of treatments consisting of the N fertilizer source [i.e., NCU and PCU (ESN, Agrium Advanced Technology, Denver, CO)] at 180 lbs-N/acre in combination with a sub-surface drainage system [i.e., CD, MD, and non-subsurface drained (ND)]. Each plot was 30 ft wide, 200 to 300 ft long, and separated by plastic lining in the soil (i.e., 2.3 ft depth) and berms on the surface to impede any potential movement of fertilizer N across treatments (Figure 1). Within each replication there was a 20 ft wide, non-drained, non-treated control.

Extremely wet conditions occurred in the spring of both the 2010 and 2011 growing seasons which likely impacted corn production and minimized the grain yield response to subsurface drainage. Because of the large amount of rainfall in the spring as well as , planting and N fertilizer application was delayed until July in 2010, while corn plant population was very low across the field trial, N deficiency was observed, and it was the second year of continuous corn in 2011 (Figure 1). Fall tillage will be utilized to help breakdown corn residue in the future. In 2010, the addition of a CD or MD in combination with N fertilizer sources had no significant ($P < 0.10$) increase in grain yield over the ND treatment (Figure 2). In 2011, minimal yield benefits with CD or MD compared to ND was also observed, however; on average yield with PCU fertilizer increased by 37 bu/acre ($P < 0.10$) compared to NCU when there was no subsurface drainage system. These results mirror a previous study conducted at the University of Missouri, Greenley Research Center which found PCU increased corn yield over NCU in poorly drained areas (Noellsch et al., 2009).

Field measurements of plant N content and ammonia volatilization loss taken during the 2010 and 2011 growing season provide additional information on how subsurface drainage systems and N fertilizer source impacted the fate of applied N. In 2010, ear leaf N content was significantly ($P < 0.10$) greater with NCU (0.97 %) compared to PCU (0.87%) when averaged over the subsurface drainage treatments (Figure 3). Polymer-coated urea had a 70% reduction in ammonia volatilization lost compared to NCU which lost 18.5 lbs-N/acre (Figure 4). In 2011, plant uptake of N was approximately 84 lbs-N/acre, but no impact on N uptake was found due to subsurface drainage or N fertilizer source (Figure 4). Ammonia volatilization loss with PCU (4.2 lbs-N/acre) was similar to that lost in 2010, while loss with NCU (4.9 lbs-N/acre) was 73% less. Differences in ammonia volatilization loss with NCU among the growing seasons may be due to the later application date and the timing of rainfall after N application in 2010.

The largest amount of annual N loss typically occurred through the water that drained out of the subsurface drainage systems. Conventional subsurface drainage on average drained approximately 50% of the rainfall received, which was approximately 200% greater ($P < 0.05$) than the amount of water drained with MD in 2010 (7-6-10 to 12-31-10) and 2011 (Figure 5). With CD there was 24 and 32 lbs nitrate-N lost per acre in 2010 and 2011, respectively (Figure 6). Managed subsurface drainage significantly ($P < 0.05$) reduced nitrate-N/loss by 51 and 68% compared to CD in 2010 and 2011, respectively.

Modest yield production and limited yield benefit with subsurface drainage over non-subsurface drained treatments observed in 2010 was presumably due to a delay in planting and N fertilizer application until July. In 2011, a combination of reduced plant populations across the field trial, N deficiency (visual observation), and the second year of continuous corn with spring tillage for residue management likely resulted in low yield production which minimized any potential yield benefits of subsurface drainage. During wet growing seasons, application of PCU instead of NCU for corn production on poorly drained soils without subsurface drainage may produce significantly greater grain yields due to a slower release of plant available N over time. Lastly, since both 2010 and 2011 were wet growing seasons we would not expect to find yield benefits with MD compared to CD systems, but MD was able to reduce nitrate-N loss entering surface waters by at least 50% without lowering grain yields production.

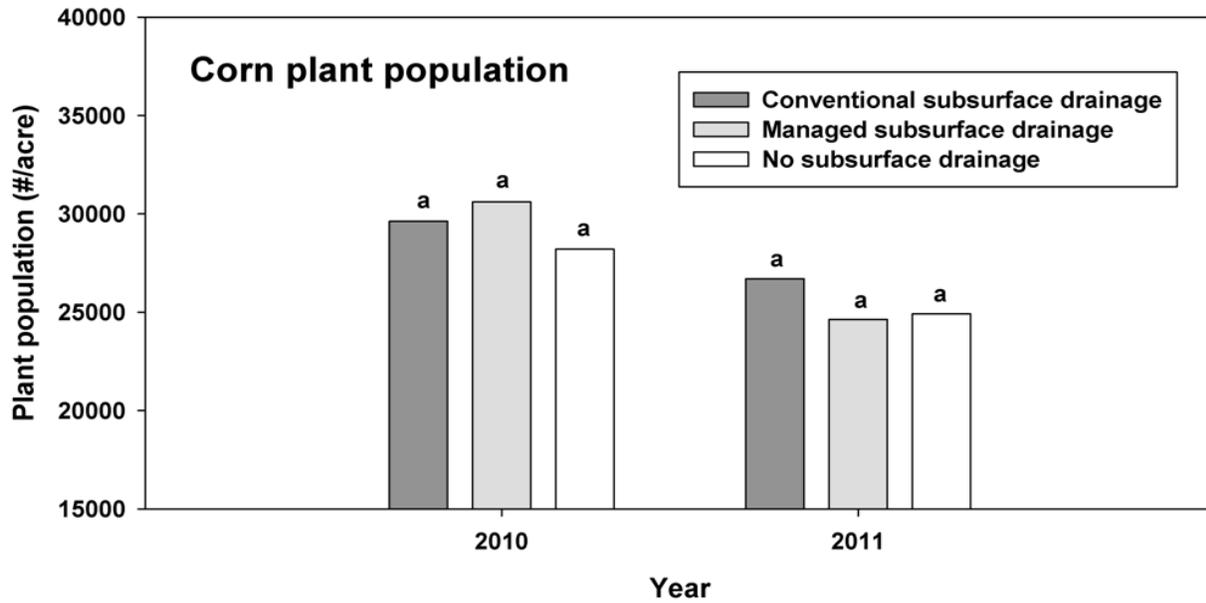


Figure 1. Corn plant population as affected by subsurface drainage systems in the 2010 and 2011 growing seasons. Letters over bars indicate differences among treatments within a given year using Fisher’s Protected LSD ($P < 0.10$).

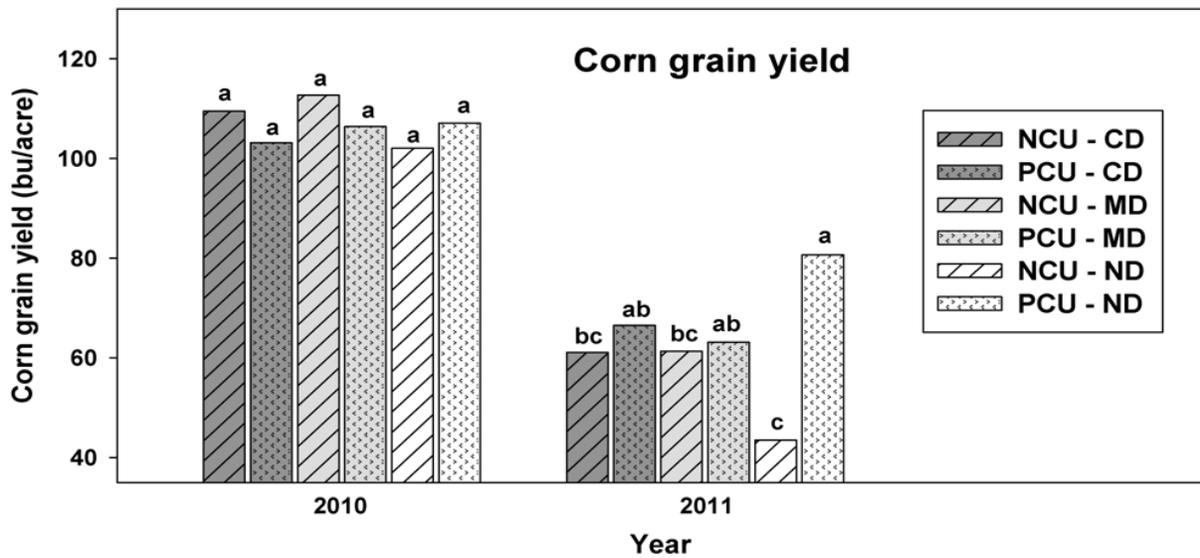


Figure 2. The interaction of N fertilizer source [non-coated urea (NCU), polymer-coated urea (PCU) and a subsurface drainage system [conventional (CD), managed (MD), non-subsurface drained (ND)] on corn grain yield in the 2010 and 2011 growing seasons. Letters over bars indicate differences among treatments within a given year using Fisher’s Protected LSD ($P < 0.10$).

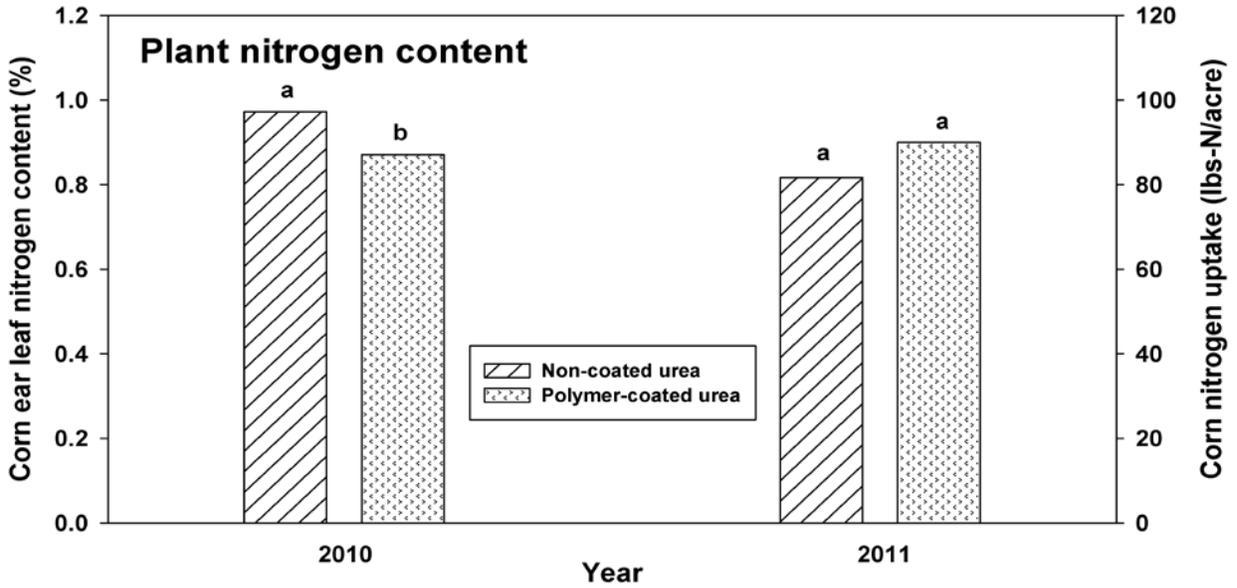


Figure 3. Corn ear leaf N content and uptake due to N fertilizer source in the 2010 and 2011 growing seasons, respectively. Letters over bars indicate differences among treatments within a given year using Fisher's Protected LSD ($P < 0.10$).

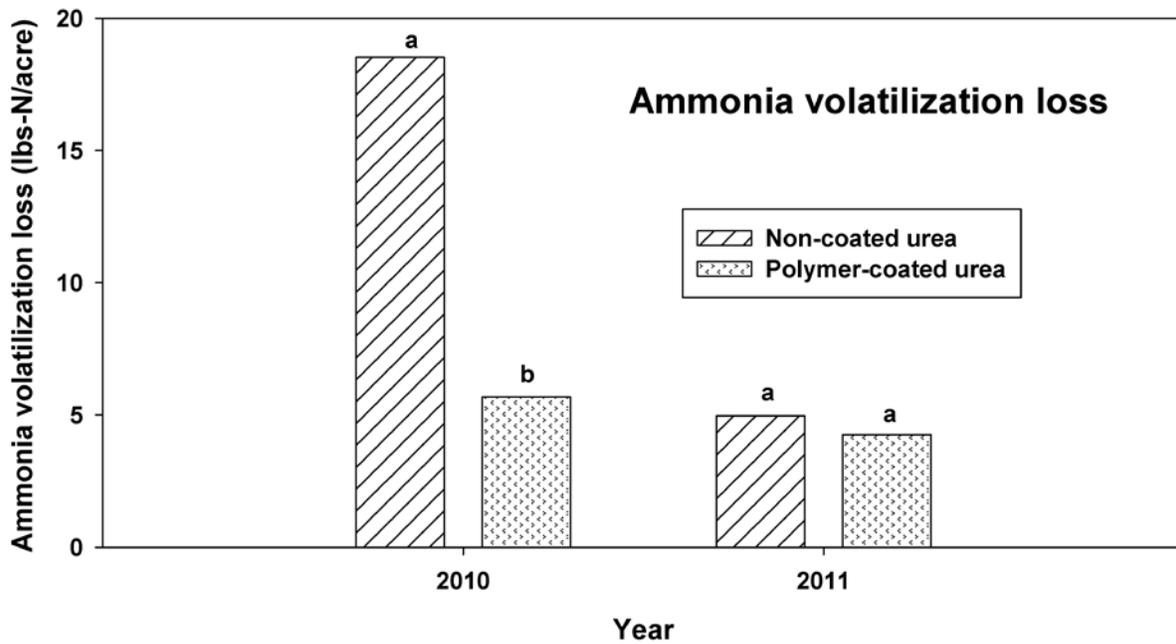


Figure 4. Ammonia volatilization loss in the 2010 and 2011 growing seasons due to N fertilizer source. Letters over bars indicate differences among treatments within a given year using Fisher's Protected LSD ($P < 0.05$).

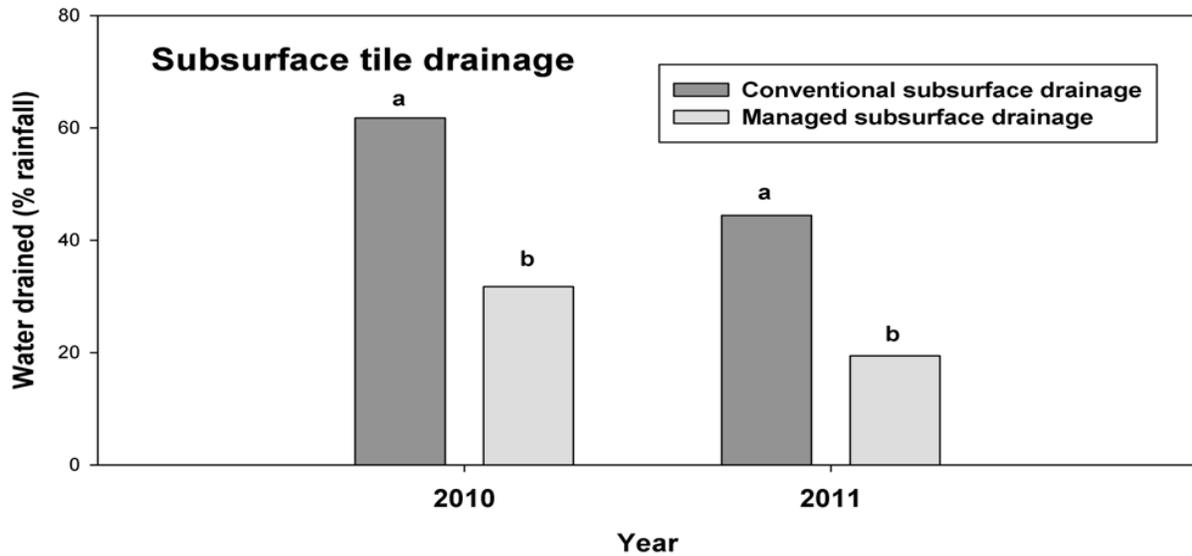


Figure 5. Total water drained with subsurface drainage due to the drainage system and expressed in the percent of rainfall received. Letters over bars indicate differences among treatments within a given year using Fisher's Protected LSD ($P < 0.05$).

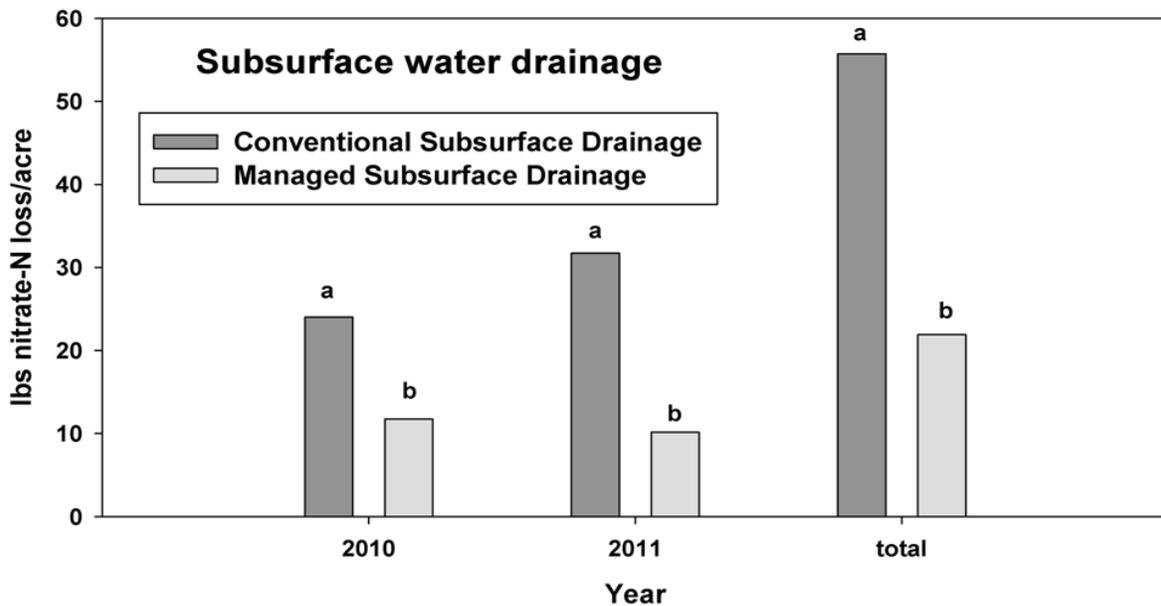


Figure 6. Annual nitrate-N loss in subsurface drainage water due to the drainage systems in 2010 (7-6-10 through 12-31-10) and 2011. Letters over bars indicate differences among treatments within a given year using Fisher's Protected LSD ($P < 0.05$).

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