UTILIZATION OF POLYMER-COATED UREA FERTILIZER AND MANAGED SUBSURFACE DRAINAGE SYSTEMS TO IMPROVE CORN YIELDS IN A WABASH SOIL

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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 (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). This is a major concern in the Mississippi-Atchafalaya River basin, where there is a high density of agricultural practices which has lead to high levels of nitrate in surface waters and growing health concerns over the drinking water and the hypoxia zone in the Northern Gulf of Mexico. As these issues have grown increasingly larger, it is becoming more apparent that a balance between high crop production and environmental protection will be needed in order to maintain a high quality of life in this region for years to come.

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 ability to increase the retention of crop-available water and nutrients in the root zone (Wesström and Messing, 2007). A two year research study evaluating corn and soybean yield production differences between managed and conventional subsurface drainage systems reported significantly greater 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 the 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) was 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^{-1} compared to NCU (Blaylock et al., 2004, 2005; Nelson et al., 2008). These results are presumably a function of a slower release of microbial available urea throughout the growing season resulting 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 a MD could create a synergistic relationship that would further maximize crop production, as well as 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 objectives of this study are to determine the effects of MD and PCU fertilizer on the fate of applied N and subsequent corn grain yield.

Experiment Information

This is a four year study that was initiated in 2010 at an off-field site near Novelty, MO (Figure 1) in a Wabash silty-clay soil. Due to the low topographic position, this field typically has a shallow water table throughout most of the year. Sub-surface tile drainage systems, including control structures were installed in spring 2010. The sub-surface tile drains run 1200 ft long with 20-ft spacing, and at a depth of 3 ft. The experiment field site is in continuous corn (*Zea mays L.*) production under conventional tillage. There are 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^{-1} in combination with a sub-surface drainage system [i.e., CSD, MSD, and non-subsurface drained (NSD)].

2010-2012 Preliminary Results

As of the first three years of this study, yield response to the addition of CSD or MSD has been limited. In 2010, a severe flood event in July resulted in the loss of the entire corn crop (Figure 1 and Table 1). In 2011, a severe flood event occured in June that did not result in crop failure but presumably impacted yield production. Grain yields ranged from 192 to 205 bu acre^{-1}. There were no significant ($P \leq 0.10$) difference in yields due to subsurface drainage (CSD, MSD, and NSD) and N source (NCU and PCU). In 2012, wet field conditions in the spring were followed by severe drought conditions throughout the summer. Although not statistically significant, the addition of a subsurface tile drainage system (CSD or MSD) increased grain yields by 8-13%. With a naturally high water table, artificially lowering the water table with subsurface drainage may have promoted greater root development and improved the ability to cope with the summer drought conditions as compared to plants in areas without subsurface drainage.

Nitrate-N loss in the subsurface tile drainage water was affected by the subsurface drainage systems (CSD and MSD) and N source (NCU and PCU) at times throughout July 6, 2010 to Oct. 15, 2012. In 2010, total nitrate-N loss in the tile drainage water was minimal for all treatments (Table 1), which was likely due to high amounts of the N fertilizer applied being transported off the field due the severe flooding event. In 2011, annual nitrate-N loss in the tile drainage water with CSD/NCU was 51 lbs-N acre^{-1}, which was significantly ($P \leq 0.10$) greater than the CSD/PCU and MSD/NCU treatments. Managed subsurface drainage in combination with NCU had 35 lbs-N acre^{-1} lost annually in the tile drainage water, which was significantly lower than all other treatments. In 2012, although not statistically significant, MSD reduced total nitrate-N loss by 71% compared to CSD regardless of N source as of Oct. 2012.

Conclusions

The potential for improved drainage, growing conditions, and corn grain yields in a poorly-drained Wabash soil by the addition of subsurface tile drainage was most likely masked by severe flooding events which occurred in 2010 and 2011. In soils with naturally high water tables, the addition of subsurface tile drainage may improve root system development and subsequent yield production, especially when drought conditions occur in the summer. Lastly, MSD in most instances was able to successfully reduce annual nitrate-N loss by minimizing flow during the non-cropping season. However, the type of N fertilizer source in combination with weather may impact the percent MSD can reduce annual N loss in tile drainage water compared to CSD.

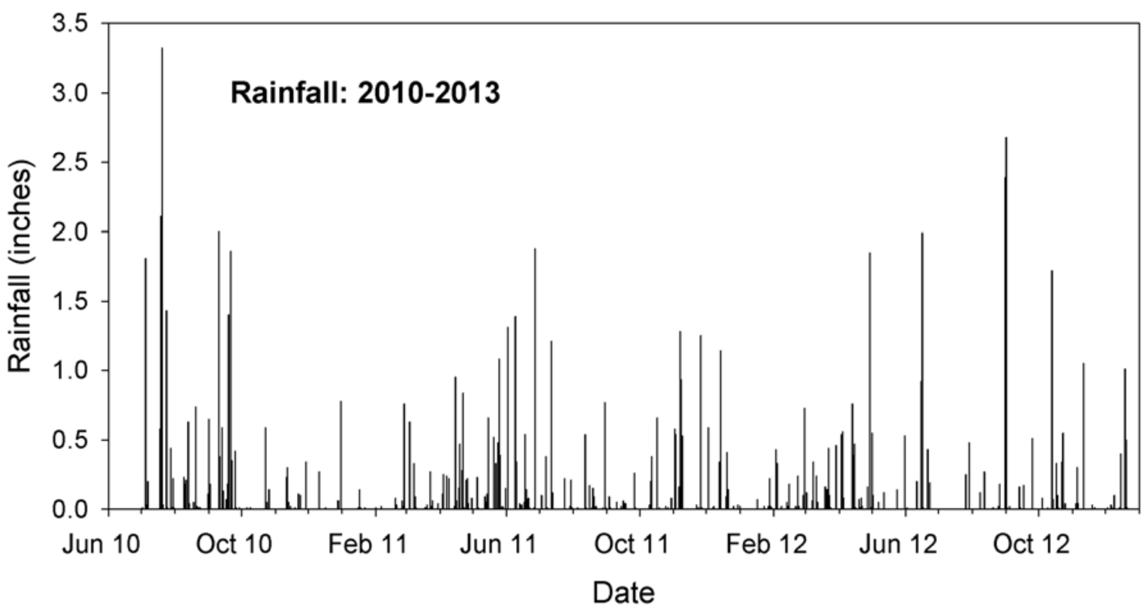

Figure 1. Daily rainfall that occurred on-site over the period of June 2010 through 2012.

Table 1. Yield and nitrate loss via tile drainage from 2010-12 on a Wabash silty-clay soil in continuous corn production.

				Subsurface drainage
Year(s)‡	Drainage	N fertilizer	Yield¶ (Bu/acre)	Nitrate loss (Lbs-N/acre)
2010§	NSD†	NCU	0	--------
2010	NSD	PCU	0	--------
2010	CSD	NCU	0	8.1a
2010	CSD	PCU	0	7.1a
2010	MSD	NCU	0	13.3a
2010	MSD	PCU	0	9.5a
2011	NSD	NCU	204.6a	--------
2011	NSD	PCU	198.5a	--------
2011	CSD	NCU	192.0a	51.2a
2011	CSD	PCU	200.7a	46.1b
2011	MSD	NCU	194.2a	35.2c
2011	MSD	PCU	193.6a	49.7ab
2012	NSD	NCU	92.2a	--------
2012	NSD	PCU	90.5a	--------
2012	CSD	NCU	102.5a	20.9a
2012	CSD	PCU	100.0a	12.8a
2012	MSD	NCU	101.4a	4.3a
2012	MSD	PCU	100.1a	5.4a
			Average	Total
2010-12	NSD	NCU	148.4a	--------
2010-12	NSD	PCU	144.5a	--------
2010-12	CSD	NCU	147.3a	80.2a
2010-12	CSD	PCU	150.3a	66.0a
2010-12	MSD	NCU	147.8a	64.6a
2010-12	MSD	PCU	146.8a	52.8a

† Abbreviations: CSD = conventional subsurface drainage; MSD = managed subsurface drainage; NCU = non-coated urea; NSD = non-subsurface drainage; PCU = polymer-coated urea.
‡ Annual values were calculated over the period of July 6 through Dec. 31 in 2010 and Jan. 1 through Oct. 15 in 2012.
§ Corn crop in 2010 was lost due to severe flooding event.
¶ Letters following yields and nitrate-N loss denote Fisher's Least Significant Difference (P = 0.1) by year.

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