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WATER QUALITY CONCERNS UNDER CONTRASTING TILLAGE AND NUTRIENT MANAGEMENT OF CROPPING SYSTEMS IN A CECIL SOIL OF THE SOUTHERN PIEDMONT

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Summary

This research compared nitrate-nitrogen (NO_3-N) losses through drainage from cotton managed under no-tillage and fertilized with poultry litter versus that from conventionally-tilled cotton fertilized with ammonium nitrate. The study was conducted at the USDA-ARS facility near Watkinsville, GA in 1997 and 1998. The site consisted of 12 instrumented tile-drained plots each 10 m x 30 m on nearly level (0-2% slope) Cecil sandy loam. Cotton was grown in summer followed by rye as cover crop in winter. A factorial combination of two tillage (no-tillage and conventional-till) and two nutrient sources (poultry litter and ammonium nitrate) generated four treatments which were replicated three times. No-till did not increase NO_3-N leaching when compared to conventional-till in 1997. Although poultry litter lead to larger NO_3-N loss than ammonium nitrate in 1997, the difference was relatively small and considered to be unimportant biologically. There was no drainage in 1998 due to limited rainfall. With respect to water quality concerns, these are encouraging results to those engaged in cotton production under no-till with poultry litter.

Keyword: nitrate, conservation tillage, no-till, drainage, water quality, Cecil

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ABSTRACT

Concern about nitrate-nitrogen (NO_3-N) contamination of water resources from non-point sources is high worldwide. The objective of this study was to quantify NO_3-N losses by drainage from a cotton/rye cropping system on a Cecil soil of the Southern Piedmont managed under different tillage and nutrient sources. The experiment was conducted near Watkinsville, GA, on twelve 10 m x 30 m instrumented and tile-drained plots as a randomized complete block design in a 2 x 2 factorial arrangement of no-till (NT) and conventional-till (CT) with poultry litter (PL) and ammonium nitrate as conventional fertilizer (CF). Drainage was measured by tipping buckets and recorded digitally with data loggers. About 275 ml for every 600 liters of drainage was automatically collected for NO_3-N analysis.

There was no difference in total NO_3-N loss between CT and NT (mean 8.9 and 8.2 kg/ha, respectively; $P>0.73$) from planting to harvest of cotton in 1997. Total NO_3-N loss from PL and CF plots was 10.3 and 6.5 kg/ha ($P=0.007$), respectively. This difference in NO_3-N loss between nutrient sources is relatively small and biologically is considered to be unimportant and may have been due, in part, to a larger than expected N mineralization from poultry litter. Peak concentrations reached to 20 to 30 mg/L from CT and 10 to 15 mg/L from NT plots during the first two months after N application, and then fell to below 5 mg/L late in the season. In both PL and CF plots, peak concentrations were between 10 and 20 mg/L with that from PL being higher by up to 5 mg/L. There was no drainage in the 1998 cotton season due limited rainfall. With respect to water quality concerns, these are encouraging results for producers engaged in cotton production under no-till with poultry litter.

INTRODUCTION

There is a prevalence of elevated NO_3-N concentration in surface and ground waters of watersheds with intensive agricultural use (Heathwaite, 1995; Mueller et al., 1995; NRC, 1993). The type of tillage, as well as N source and rate of fertilizer may influence the quantity of NO_3-N moving through the soil profile. Water infiltration and preferential flow typically increase when tillage is reduced or eliminated (Adreini and Steenhuis, 1990) increasing the potential contamination of ground water with soluble nutrients. Field studies, however, often provide wide-ranging estimates of the relative effect of contrasting tillage practices on nutrient leaching losses.

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Economic, environmental and legislative issues facing farmers are changing traditional agriculture. Conservation tillage (CTIC, 1998) and use of animal waste as an alternative nutrient source are getting increased attention nationwide as avenues towards sustainable agriculture. The Southeast is experiencing rapid growth in cotton acreage (Rodekhor and Rahn, 1997), continuing expansion of use of poultry litter as an alternative nutrient source, and growth in alternative tillage methods in recent years. However, only limited data are currently available for the Southeast concerning the fate of nutrients under contrasting tillage treatments. Further, little is known about the possible interactions between tillage and poultry litter on nutrient movement to ground and surface water.

The objective of this study was to quantify NO_3-N losses by drainage from a cotton/rye cropping system on a Cecil soil of the Southern Piedmont under contrasting tillage and nutrient source management.

METHODS AND MATERIALS

The experiment was conducted in 1997 and 1998 at the USDA-ARS, J. Phil Campbell Sr. Natural Resource Conservation Center, Watkinsville, GA. The site consisted of 12 instrumented and tile-drained 10 m x 30 m plots, located on nearly level (0-2%) slope Cecil sandy loam (clayey, kaolinitic, thermic Typic Kanhapludults). Five 30 m long drain lines were installed in each plot spaced 2.5 m and on a 1% grade, 0.75 m at the shallow end. The lines were made of flexible, slotted 102 mm (4") diameter PVC. Plots were isolated from lateral flow by polyethylene sheeting installed around each plot to the depth of the drain lines. The volume of water drained from a plot was measured by tipping buckets, and recorded digitally with Campbell CR10X data loggers. About 275 ml of the drainage was automatically collected for every 600 liters of flow and stored under refrigeration ($4^{O}C$) in the field by ISCO model 3700 FR sequential water samplers until taken to the laboratory for filtration and NO_3-N analysis.

The experimental design was a complete randomized block with a factorial combination of tillage (no-till, conventional-till) and fertility source (ammonium nitrate, poultry litter) treatments with each treatment replicated three times. The conventional-till treatment consisted of chisel plowing and disking, while no-till consisted of coulter planter use only. Tillage treatment started on the 12 plots in April 1991 in connection with another study (McCracken et al. 1993). Fertilizer rates were: poultry litter - 4.5 Mg/ha (2 tons/acre 30% moisture basis; equivalent to about 60 kg available N/ha), and ammonium nitrate, applied as CF, 60 kg available N/ha. Pesticides and fertilizers were applied before planting and were incorporated into the soil by light disking immediately afterwards in conventional-till plots. There was no soil incorporation of pesticides and fertilizer in no-till plots. Stonville 474 variety cotton was planted on May 14, 1997 and May 14, 1998. Harvest dates were November 4, 1997 and November 12, 1998. Rye was used as cover crop each winter and received about 50 kg available N /ha as ammonium nitrate in all plots just before planting. Rye was chemically killed about two weeks before planting of cotton. Data were analyzed with the General Linear Models Procedure of SAS (SAS Inst., 1989).

RESULTS AND DISCUSSION

Mean NO_3-N losses during the 1997 cotton season are presented in Figures 1 and 2. There was no difference in NO_3-N loss between no-till and conventional-till treatments (CT vs NT, P=0.741; CTCF vs NTCF, P=0.935; CTPL vs NTPL, P=0.699). Poultry litter increased NO_3-N loss compared to conventional fertilizer (CF vs PL, P=0.01; CTCF Vs CTPL, P=0.03; NTCF vs NTPL, P=0.05; CTCF vs NTPL, P=0.06). The difference in NO_3-N loss between fertilizer sources was, however, relatively small (CF vs PL, 3.7 kg/ha; CTCF Vs CTPL, 4.0 kg/ha; NTCF vs NTPL, 3.5 kg/ha; CTCF vs NTPL, 3.4 kg/ha) and biologically is considered to be not significant, and may have been due to, in part, a larger than expected N mineralization from poultry litter. In our calculation, we had assumed that 50% of the organic N in poultry litter would be mineralized in a year.

Nitrate-nitrogen concentrations of the draining water during and just after the 1997 cotton season are shown in Figures 3 and 4. Before the application of N on May 14, 1997, NO_3-N concentrations in draining water were below 3 mg/L in all treatments. During the first two months after N application, concentrations increased to 20 to 30 mg/L from CT and 10 to 15 mg/L from NT plots with the PL treatments in each group showing up to 5 mg/L higher NO_3-N concentrations than the CF treatments. By late September, concentration had decreased to about 5mg/L or below in all treatments. The N application to the cover crop increased NO_3-N concentration to about 10 mg/L during December 1997 and January 1998, which then fell below 5 mg/L in early February 1998.

There was no significant drainage in 1998 and thus we collected little effluent. Rainfall was about 140 mm below normal for May through November, with a deficit in each month. Most rainfall events were below 25 mm, the approximate threshold above which drainage was observed in 1997.

SUMMARY AND CONCLUSIONS

This research was conducted to quantify and compare NO_3-N loss through drainage from cotton managed under no-till and fertilized with poultry litter versus that from conventionally-tilled cotton fertilized with conventional fertilizer. From our observation thus far, no-till did not increase NO_3-N loss when compared to conventional-till. Although poultry litter led to a larger NO_3-N loss than conventional fertilizer, the difference was relatively small and considered to be biologically unimportant. The study has one more year to run. Endale et al. (1999) reported that lint yield over three years from no-till and no-till-poultry-litter plots in this research was 30 and 50 percent more compared to conventional-till and conventional-till-conventional-fertilizer plots, respectively. Managing cotton under no-till with poultry litter did not appear to have adverse NO_3-N impacts in a Cecil soil of the Southern Piedmont and yet produced up to 50 percent more yield compared to cotton management under conventional-till with conventional fertilizer. These results are encouraging to those producers managing cotton under no-till with poultry litter in the Southeast.

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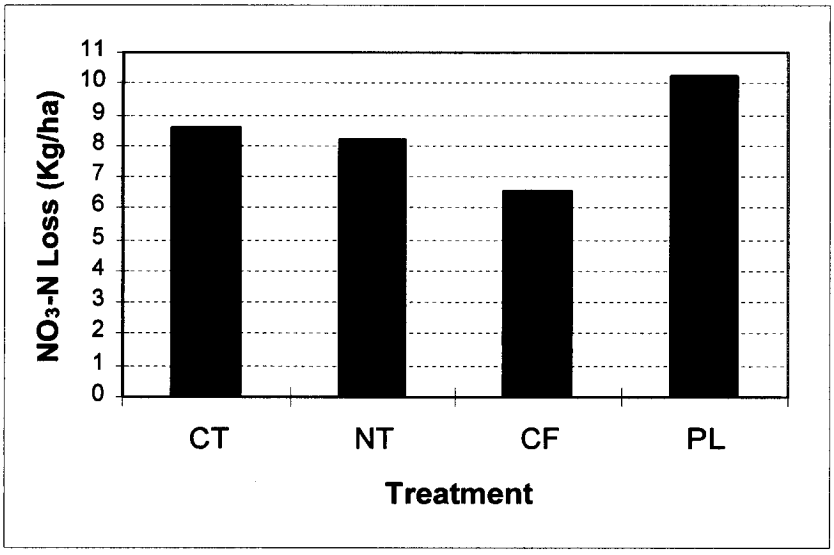

Figure 1- Mean nitrate-nitrogen loss from Conventional-till (CT), no-till (NT), conventional fertilizer (CF) and poultry litter (PL) treatments during the 1997 cotton crop.

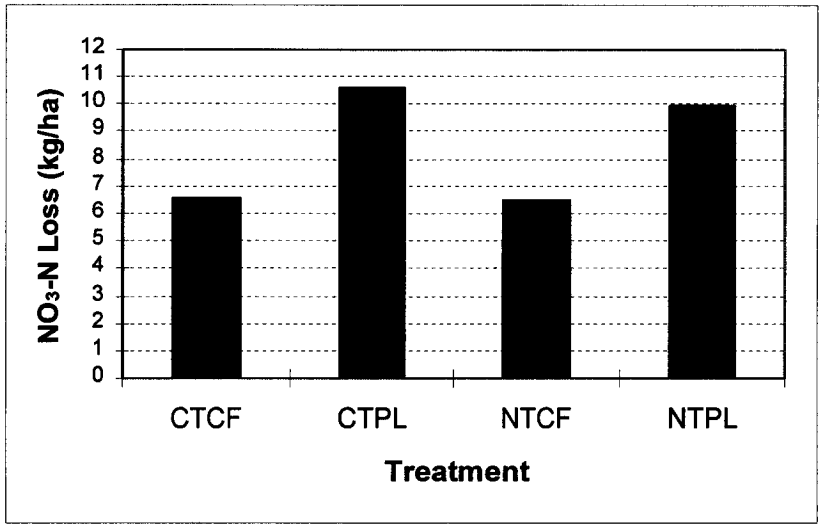

Figure 2- Mean nitrate-nitrogen loss from Conventional-till and conventional-fertilizer (CTCF), conventional-till and poultry litter (CTPL), no-till and conventional-fertilizer (NTCF), and no-till and poultry litter (NTPL) treatments during the 1997 cotton crop.

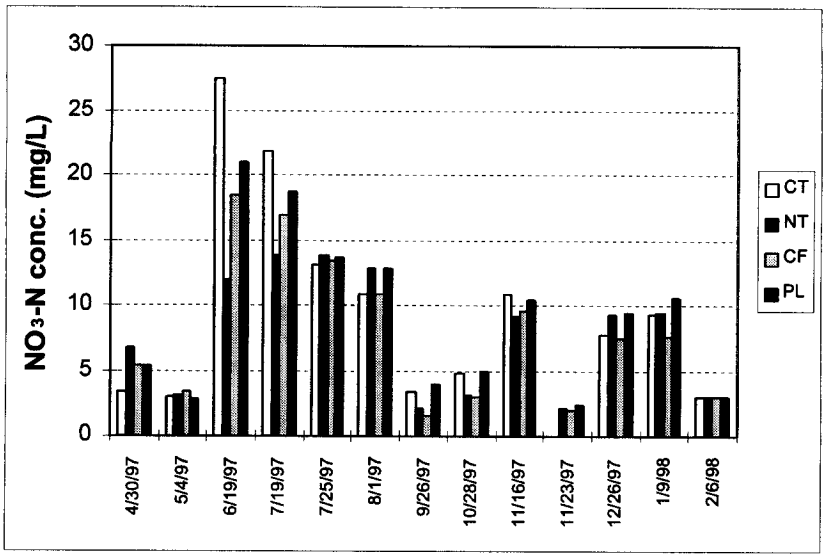

Figure 3-Mean nitrate-nitrogen concentrations of drainage water from Conventional-till (CT), no-till (NT), conventional fertilizer (CF) and poultry litter (PL) treatments during the 1997/1998 cotton and rye season. Fertilizer application dates were 5/12/97 for cotton and 11/14/97 for rye.

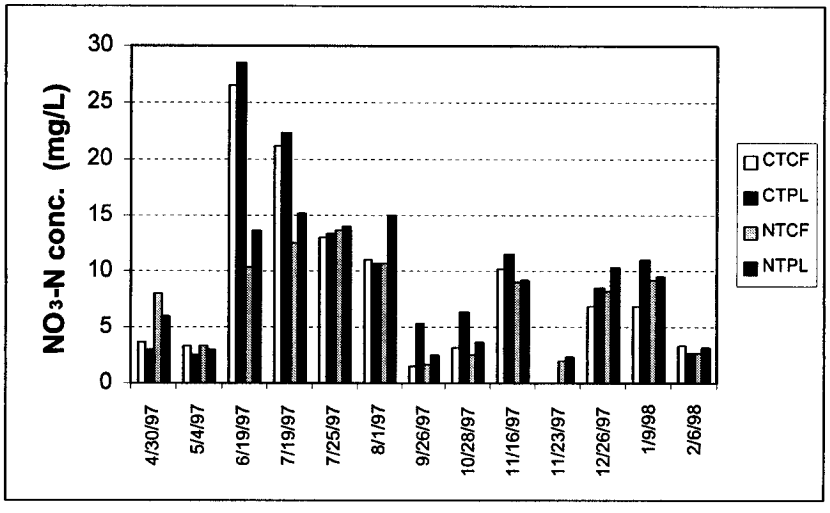

Figure 4-Mean nitrate-nitrogen concentration of drainage water from Conventional-till and conventional-fertilizer (CTCF), conventional-till and poultry litter (CTPL), no-till and conventional-fertilizer (NTCF), and no-till and poultry litter (NTPL) treatments during the 1997/1998 cotton and rye crop season. Fertilizer application dates were 5/12/97 for cotton and 11/14/97 for rye.