No-till on Cecil Soil: Hydrologic and Water Quality Impacts

DM Endale[1], HH Schomberg[1], ML Cabrera[2], DE Radcliffe[2], MB Jenkins[1]

[1]USDA-ARS, J. Phil Campbell, Sr., Natural Resource Conservation Center, 1420 Experiment Station Rd., Watkinsville, GA

[2]Crop and Soil Sciences Department, University of Georgia, Athens, GA

Background

Rationale

★ Needs for and development of conservation practices have evolved through time in line with the problems, innovations in agricultural machinery and chemicals, and management of cropping and grazing systems, and advances in knowledge base of fundamental landscape processes.

★ Cecil and closely related soils occupy more than 50% of soils mapped in the 16.7 million ha Southern Piedmont physiographic region in south eastern United States. This region is one of the most severely eroded part of the nation as a result of intense summer storms, inherently erodible soils, and generations of conventionally-tilled single crop agriculture. Several conservation practices have been implemented since the 1930s to reduce soil loss and environmental degradation such as terracing, vegetated waterways and buffers, etc.

★ Progress in equipment for residue management, weed control and management techniques for cover crops has allowed dramatic increase and adoption of no-till as conservation practice in recent decades throughout the U.S. However, variation in regional environmental and management variables can lead to variation in impact of no-till.

Objective

★ To compare hydrologic and water quality impacts of conventionally-tilled and no-tilled cropping systems on Cecil soil in Southern Piedmont.

Methodology

★ Research was conducted on twelve plots, each 10 by 30 m on Cecil sandy loam soil, near Watkinsville GA, 8-miles south of Athens Georgia. Plots were instrumented to measure runoff and drainage and collect water samples for nutrient analysis (Endale et al., 2002a, 2002b)

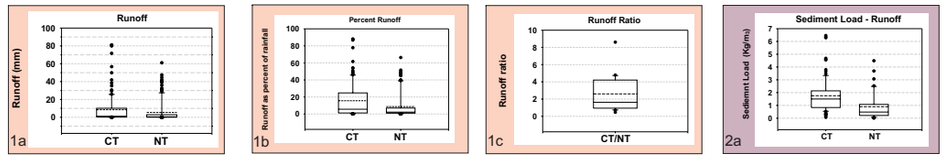
★ Cropping system was spring/summer cotton followed by fall/winter rye in 1997

★ A factorial combination of two tillage conventional tillage (CT) vs no-till (NT) and two fertilizer ammonium nitrate vs poultry litter treatments, with three replication of each treatment arranged a randomized complete block design over the 12 plots. Fertilizer rates provided equivalent of 60 kg N ha-1 in one application at planting of cotton. Rye cover crop received equivalent of 50 kg N ha-1 as ammonium nitrate.

★ Samples were collected from up to 29 runoff or drainage events. Runoff and drainage samples were analyzed for NH4-N, NO3-N and PO4-P. Some runoff samples were also analyzed for sediment load.

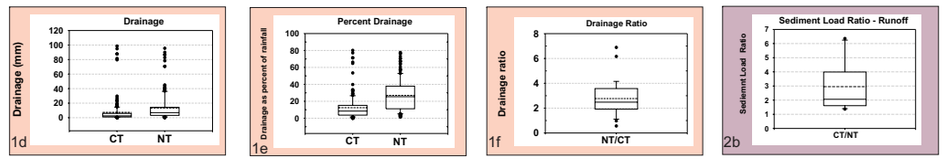
★ Data were pooled across fertilizers within the two tillage treatments for analysis in this presentation.

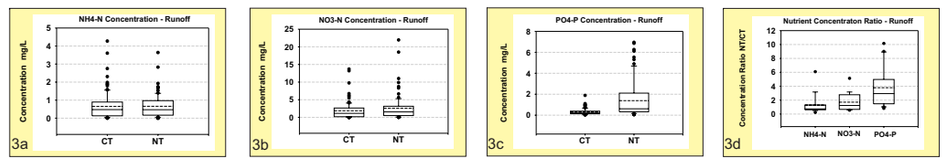
Result Figures



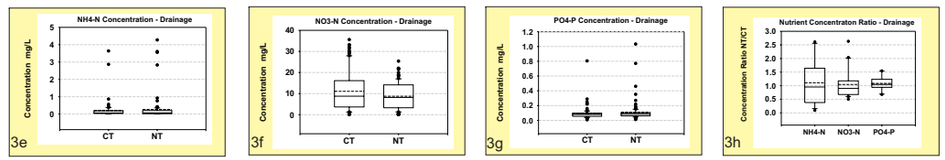
Figures 1a-1f: Runoff & drainage volume

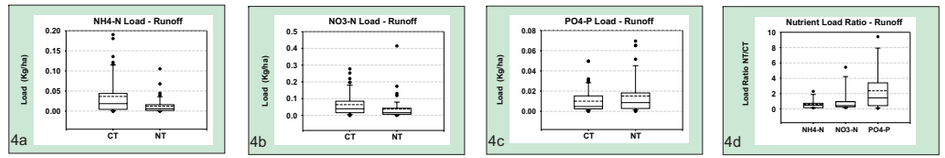
Figures 2a & 2b: Runoff sediment



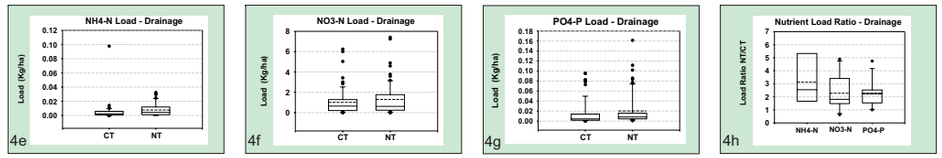


Figures 3a-3h: Nutrient concentration





Figures 4a-4h: Nutrient load



Box plots showing comparison between conventional tillage CT and no-till NT for runoff and drainage volume, nutrient concentration and load in runoff and drainage. The whiskers show the 10th and 90th percentiles. The boxes bound the 25th and 75th percentiles. Dashed lines inside boxes show means while solid lines show medians. Values outside this range are shown as dots

Result Summary

RUNOFF - mm; Fig. 1a - 1c (in parenthesis are mean, median and number of samples)

- CT produced more runoff than NT: (CT- 8.5, 1.2, 120), (NT- 5.4, 0.5,120).
- The CT/NT ratio, based on averages of runoff events, had mean of 2.6 and median of 1.6 (n=20).
- Percent runoff (rainfall partitioned to runoff) was higher in CT than NT: (CT- 15.6, 5.6, 120), (NT- 8.7, 2.2, 120).

DRAINAGE - mm; Fig. 1d - 1f (in parenthesis are mean, median and number of samples)

- There was more drainage from NT than CT: (CT- 7.3, 2.5 mm, 174), (NT- 13.5, 7.0, 174).
- The NT/CT ratio, based on averages of drainage events, had mean of 2.8 and median of 2.5 (n=29).
- Percent drainage was also higher in NT than CT: (CT- 12.5, 8.4, 174), (NT- 27.0, 25.4, 174)

NUTRIENT CONCENTRATION - mg/L, Fig. 3a-3h, (mean, median and number of samples in parenthesis)

Runoff

- NH4-N: Similar between CT & NT. (CT- 0.65, 0.48, 103), (NT- 0.66, 0.47, 86), (NT/CT- 1.29, 0.74, 19)
- NO3-N: More from NT but overall means were low: (CT- 1.86, 1.14, 110), (NT- 2.18, 1.54, 85), (NT/CT- 1.71, 1.24, 19).
- PO4-P: NT had higher concentration than CT, but both had elevated values: (CT- 0.31, 0.21, 95), (NT- 1.39, 0.61, 78), (NT/CT- 3.79, 2.84, 20).

Drainage

- NH4-N: Similar between CT & NT. (CT- 0.21, 0.06, 73), (NT- 0.26, 0.07, 93), (NT/CT- 1.10, 095, 15)
- NO3-N: Similar but CT mean a little higher: (CT- 11.10, 8.79, 104), (NT- 8.77, 8.20, 121), (NT/CT- 1.04, 0.9, 20).
- PO4-P: Similar between CT & NT: (CT- 0.09, 0.08, 92), (NT- 0.11, 0.08, 103), (NT/CT- 1.08, 1.04, 19).

NUTRIENT LOAD - Kg/ha, Fig. 4a-4h, (mean, median and number of samples in parenthesis)

Runoff

- NH4-N: Reduced in NT: (CT- 0.037, 0.019, 56), (NT- 0.012, 0.006, 47), (NT/CT- 0.6, 0.48, 12).
- NO3-N: Reduced in NT: (CT- 0.064, 0.039, 58), (NT- 0.038, 0.016, 48), (NT/CT- 0.98, 0.43, 12).
- PO4-P: Somewhat elevated for N: (CT- 0.01, 0.005, 57), (NT- 0.015, 0.009, 47), (NT/CT- 2.36,1.44,12).

Drainage

- NH4-N: Somewhat elevated for N: (CT- 0.006, 0.002, 44), (NT- 0.008, 0.004, 51), (NT/CT- 3.1, 2.6, 8).
- NO3-N: Somewhat elevated for N: (CT- 1.011, 0.642, 68), (NT- 1.294, 0.614, 71), (NT/CT- 2.3, 1.8, 12).
- PO4-P: Somewhat elevated for N: (CT- 0.014, 0.004, 0.024, 67), (NT-0.02, 0.008, 71), (NT/CT- 2.2, 2.3,12).

SEDIMENT LOAD - RUNOFF -g/L (Kg/cubic meter), Fig. 2a-2b, (mean, median and n in parenthesis)

- Higher sediment loss in CT than NT: (CT-1.93, 1.55, 95), (NT-0.92, 0.51, 39), (NT/CT- 2.95, 2.1, 11).

Concluding Remarks & Observations

- No-till reduced runoff and increased drainage (infiltration) in cotton/rye cropping on Cecil soil. Endale et al (2002a, 2002b) showed soil water and crop yield enhancement as a result.
- No-till reduced off-site sediment loss, and by implication (no data available) adsorbed chemicals
- Concentration of NH4-N in runoff was similar between CT & NT but load was reduced in NT. In drainage, concentration was similar but NH4-N load was elevated in NT as a ratio, but actual mean values were small (<0.008 Kg/ha)
- Concentration of NO3-N in runoff, while slightly more in NT, nevertheless had mean below 3 mg/L. Nitrate load in runoff was slightly less in NT. Mean nitrate concentrations in drainage were close to 10 mg/L with that from CT slightly higher. Although nitrate load in drainage was slightly higher in NT, mean value was less than 1.3 kg/ha.
- Mean concentrations and loads of PO4-P were slightly higher in NT in both runoff and drainage, but mean loads were below 0.03 Kg/ha. Mean NO3-N concentration of 1.4 mg/L in runoff in NT was about 4 times that of CT.
- The data partially demonstrate the potential of no-till for combating environmental degradation in the Southeast arising out of cropping based on conventional tillage. Drought limited the data set from this experiment. More data are needed to make more definitive statements.

References

Endale, DM, ML Cabrera, JL Steiner, DE Radcliffe, WK Vencil, HH Schomberg, L Lohr. 2002a. Impact of conservation tillage and nutrient management on soil water and yield of cotton fertilized with poultry litter or ammonium nitrate in the Georgia Piedmont. *Soil & Tillage Research* 66:55-68

Endale DM, DE Radcliffe, JL Steiner, ML Cabrera. 2002b. Drainage characteristics of a Southern Piedmont soil following six years of conventionally tilled or no-till cropping systems. *Transactions of the ASAE* 45(5):1423-1432

Acknowledgments

The research was supported in part by a USDA-NRI grant. We appreciate the dedicated contribution of several technicians from USDA-ARS, Watkinsville, and students from UGA to the research.