UNIVERSITY OF MINNESOTA

Southwest Research & Outreach Center

Soil Characteristics and Water Quality from Conventional and Alternative Cropping Systems

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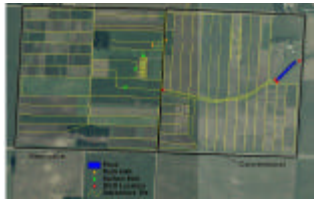
INTRODUCTION

Changes to current crop and livestock production systems will be necessary to meet emerging TMDLs. The research was conducted on adjacent fields containing non-replicated, long-term alternative and conventional management practices, each covering 65 ha (160 acres). Alternative cropping system species included corn, soybean, oat, alfalfa, buckwheat, hairy vetch, rye, native prairie grasses, and other perennial species, while the conventional system consisted mainly of corn and soybean. The objective of this study was to quantify differences between soil properties and nitrogen and phosphorus losses through subsurface drainage from alternative and conventional farming practices.

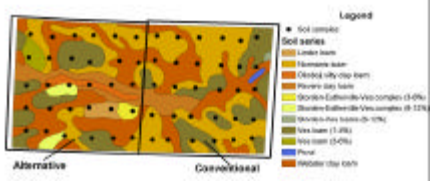
METHODS

This study was conducted at the University of Minnesota Southwest Research and Outreach Center near Lamberton, Minnesota. Soils at the site were formed in glacial till and focused primarily on poorly drained Webster (Typic Endoaquolls) clay loam soils located at bottom slope positions, moderately well drained Normania (Aquic Hapludolls) clay loam soils located on concave midslope areas, and well drained Ves (Calcic Hapludolls) loam soils located on convex upper slope areas. The experimental areas are drained by subsurface tile drains spaced approximately 55 m (180 feet) apart and 1.2 m (4 feet) below ground surface.



Soil Collection and Analysis

Soil sampling was conducted across the entire 130 ha (320 acre) site using a grid design with spacing of 133 m (436 feet) in the east/west direction and 159 m (521 feet) in the north/south direction (Figure 2). Soil analyses included: soil texture (sand, silt, and clay), organic carbon content, soil moisture retention, vertical saturated hydraulic conductivity (*Ks*), and bulk density. Results will be presented for *Ks* and bulk density.



Water Collection and Analysis

Subsurface drainage flow and quality was monitored from the alternative and conventional systems on a continuous basis during periods of flow: April - October 2002, April - July 2003 and April - November 2004. Surface water runoff was not monitored. Water samples were collected during storm events and weekly to quantify storm and base flow nutrient losses. All samples were analyzed for nitrate-nitrogen, dissolved reactive phosphorus, and total phosphorus.

RESULTS

Bulk density was significantly lower under alternative management (AL) practices for all horizons compared with conventional (CN) practices (Table1). Saturated conductivity in the A horizon was significantly higher under AL practices compared with CN practices (Table1). Higher Ks in the A horizon under AL management practices is consistent with the significantly lower soil bulk density. The AL system had significantly smaller Campbell *b* values the CN system. A smaller *b* value indicates that the soil releases more water than a soil with a larger *b* values, all other factors being equal. Campbell air entry values were significantly larger in the A and C horizons under AL practices (Table 1). Larger air entry values in the A horizon of the AL system are consistent with its smaller bulk density.

Table 1. Median values for selected soil properties from different soil horizons for alternative (AL) and conventional (CN) management practices.

	Soil Property							
Horizon	Bulk density		Saturated conductivity		Campbell *b* value		Campbell air entry value	
	AL	CN	AL	CN	AL	CN	AL	CN
	Mg m^{-3}		cm d^{-1}				kPa	
A	1.39**	1.43**	45.5**	18.1**	7.85**	9.98**	1.10*	0.79*
B	1.44**	1.48**	123.7	166.5	7.17**	8.73**	0.95	0.76
C	1.50**	1.57**	57.2	71.9	7.40**	9.24**	1.78**	0.65**

* Significance at the 0.05 probability level. ** Significance at the 0.01 probability level.

Alternative practices reduced subsurface drainage discharge by 41% compared with a CN system (Table 2). Nitrate-N losses in the subsurface drainage water from the AL system were 3.8 times lower than from the CN system (Table 2). Phosphorus losses from agriculture are primarily associated with surface runoff. In view of this, large losses in phosphorus through subsurface drainage were not expected in this study. Annual loss of DRP and TP were minimal and not considered a concern for surface water pollution.

Table 2. Mean annual drainage, NO_3-N, DRP, and TP loss from subsurface drainage from 2002-2004.

	Water Quality Parameter			
Management Practice	Drainage	NO_3-N	DRP	TP
	cm	kg ha^{-1}		
Alternative	6.9	5.8	0.03	0.04
Conventional	11.6	21.9	0.06	0.08

DISCUSSION

Diverse cropping systems, additions of animal manure, and differences in tillage on the AL system could all contribute to smaller bulk density, higher Ks, smaller Campbell *b* values and larger Campbell air entry values than in the CN system. In addition, higher surface soil Ks would be expected to lead to greater infiltration and less surface runoff for AL management practices compared with CN practices.

Differences in soil physical properties in part explain difference in drainage volume between the AL and CN systems. Greater crop diversity and weed pressure within the AL system also provide a greater range of evapotranspiration rates than the CN system, allowing for a wide range in rates of water removal upward through the plants. Reduced loss of nitrate-nitrogen under AL compared with CN practices could partially due to differences in fertilizer source, rate, and timing as well as increased nitrogen uptake due to earlier planting and a longer growing season for some AL crop species.

SUMMARY

Overall, AL management practices improved soil physical properties and should provide potential environmental benefits to improve water quality compared with CN management practices.

In 2002, there were 22.73 million acres of crop land in Minnesota. Corn and soybean were grown on 14.4 million acres while certified organic production occurred on 43,375 acres. Clearly alternative or organic production systems account for only a minute sector of current agricultural production in Minnesota. However, the benefits of adopting alternative production practices and/or increasing crop diversity on soil and water quality cannot be ignored.

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