Soil Properties and Microbial Activity as Affected by Tillage and Cover Crops in Soybeans

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INTRODUCTION

Management techniques such as no-tillage (NT) and cover crops can aid in conserving and protecting soil and water resources (Locke et al., 2002). The widespread acceptance of glyphosate-resistant soybean has promoted the flexibility for adoption of NT over conventional tillage (CT). The climatic conditions of the Mississippi Delta is conducive for the use of fall-seeded cover crops. Use of cover crops under a NT system can provide additional weed suppression, in addition to reducing erosion and runoff. Improved soil conditions and carbon sequestration are additional benefits of a NT cover crop system as are reduced equipment traffic conserving energy costs.

MATERIALS & METHODS

Experimental plots were established in 1997 on a Dundee silt loam soil. Plots were maintained in either NT or CT systems with rye or legume cover crop or no-cover (Reddy et al., 2003). Crimson clover was initially used as the legume cover crop but was changed to hairy vetch in 2002. The experiment was conducted in a split-split-plot arrangement of treatments in a RCB with tillage as main plots, cover crop as sub-plots and herbicide (glyphosate alone versus conventional) as sub-subplots with four replicates. All plots received paraquat in April, and all CT plots were tilled with a disk harrow following desiccation, prior to planting (late April).

Soil samples were collected from the upper 0-5 cm at four times (prior to planting, 14, 28 and 42-54 DAP). Aqueous soil suspensions (2:1) were assessed for electrical conductivity. Nitrate was analyzed by ion chromatography. Total organic carbon content was determined using a C.E. Elantec C-N analyzer. Microbial activity was assessed using the fluorescein diacetate hydrolysis assay (Schnürer and Rosswall, 1982). Soil microbial community structure was assessed using total Fatty Acid Methyl Ester (FAME) extracted according to (Shutter & Dick, 2002), and analyzed using MIDI (eukaryotic method). FAME profiles were assessed using SAS canonical analysis. Soils data were analyzed by SAS Proc GLM, data presented as mean of four yearly samples.

Figure 1. Experimental plots 14 days after desiccation, before planting (April 2003)

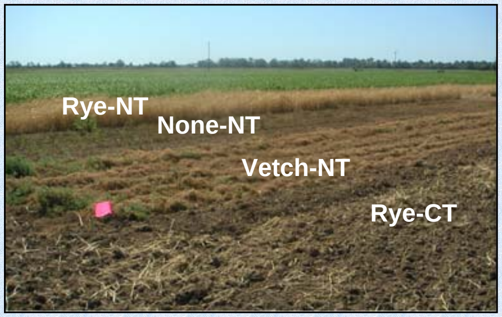

Table 1. Total soil organic carbon content

Treatment	2002	2003	2004
	(g total carbon kg^{-1} soil)		
CT-none	9.2 d	9.1 d	8.8 d
CT-rye	10.8 c	11.7 c	11.1 c
CT-H. Vetch	11.2 c	10.6 c	10.9 c
NT-none	13.6 b	14.1 b	15.8 b
NT-rye	17.0 a	17.7 a	19.6 a
NT-H. Vetch	18.3 a	18.3 a	20.0 a

Table 2. Water extractable soil nitrate

Treatment	2002	2003	2004
	(mg NO_3 kg^{-1} soil)		
CT-none	16.8 cd	15.9 c	14.5 d
CT-rye	14.0 d	15.9 c	14.6 d
CT-H. vetch	57.6 a	37.4 a	35.8 b
NT-none	18.2 cd	15.9 c	30.4 bc
NT-rye	22.1 c	16.8 c	28.4 c
NT-H. vetch	35.5 b	30.6 b	56.0 a

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Table 3. Soil electrical conductivity

Treatment	2002	2003	2004
	(μS cm^{-1})		
CT-none	58 c	55 c	62 c
CT-rye	67 c	67 c	74 c
CT-H.vetch	148 a	102 b	109 b
NT-none	74 c	80 bc	85 bc
NT-rye	105 b	103 b	110 b
NT-H.vetch	140 a	140 a	143 a

Table 4. Average soil moisture content

Treatment	2002	2003	2004
	(g H_2O kg^{-1} soil)		
CT-none	93 c	124 d	184 c
CT-rye	108 c	127 d	170 c
CT-H. vetch	101 c	142 c	176 c
NT-none	128 b	174 b	176 c
NT-rye	178 a	204 a	281 a
NT-H. vetch	173 a	178 b	261 b

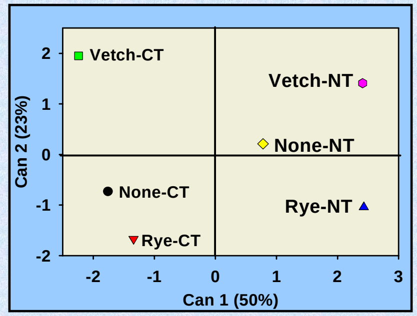
Table 5. Soil fluorescein diacetate hydrolytic activity

Treatment	2002	2003	2004
	(mmole fluorescein kg^{-1} soil h^{-1})		
CT-none	91 d	81 e	94 c
CT-rye	144 c	126 c	145 b
CT-H. vetch	115 cd	103 d	146 b
NT-none	195 b	152 b	145 b
NT-rye	253 a	176 a	221 a
NT-H. vetch	255 a	176 a	230 a

Table 6. Soybean yield

Treatment	2002	2003	2004
	(Mg grain ha^{-1})		
CT-none	2.81 a	3.65 a	2.52 ab
CT-rye	2.00 bcd	2.94 e	2.15 bcde
CT-H. vetch	2.81 a	3.59 ab	2.57 a
NT-none	2.44 abc	3.34 abcd	2.21 abcd
NT-rye	1.55 d	3.02 de	1.82 e
NT-H. vetch	2.73 ab	3.56 abc	2.41 abc

Figure 2. Canonical analysis of total soil FAME profiles at planting 2002



RESULTS

- Soils under long-term NT (5 to 7 yr) without cover crops had ~20% greater total organic carbon (TOC) compared to CT soils, with TOC increasing yearly. NT soils under cover crops had ~60 to 80% greater TOC than respective CT soils with less yearly TOC accumulation (Table 1).
- Soils under long-term legume cover crop had ~ two- to four-fold greater NO_3 than no cover CT soils (Table 2). Tillage effects on soil NO_3 in hairy vetch soils varied over the three years.
- The highest electrical conductivity was also associated with soils maintained under long-term legume cover crop (Table 3) reflecting greater available soil N (Eigenberg et al., 2002).
- NT soils especially under cover crops maintained the highest water content (Table 4). Residue cover reduced evaporation losses.
- The highest microbial activity (FDA hydrolysis) was associated with NT soils under cover crop management.
- Canonical analysis of total FAME profiles indicated microbial communities were unique among tillage / cover crop regimes (Figure 2).
- NT or a hairy vetch cover crop had no significant effect on soybean yield compared to CT no cover crop. In all years the rye cover crop significantly reduced soybean yield under NT conditions, and rye under CT reduced yield in 2001 and 2002.

SUMMARY

- Adopting a NT-hairy vetch cover crop system can improve soil biological activity, promote soil carbon sequesteration, and maintain sustainable soybean yield under Mississippi Delta conditions.