Carbon supply and storage in tilled and non-tilled soils as influenced by cover crops and nitrogen fertilization.

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Introduction

Cover cropping can provide additional residues that not only reduce soil erosion but also improve soil quality and productivity by increasing soil organic C (SOC) (McVay et al., 1989; Kuo et al., 1997). Similarly, N fertilization can increase SOC by increasing crop biomass production and amount of residue returned to the soil (Gregorich et al., 1996; Omay et al., 1997). The increase in SOC due to these management practices can, however, be different in tilled and non-tilled soils due to difference in mineralization rates of plant residues (Cambardell and Eliott, 1993; Allmaras et al., 2000; Sainju et al., 2002). These practices can provide opportunities to increase SOC in the southeastern United States where SOC is usually lower than in northern regions because of rapid mineralization (Doran and Smith, 1987).

Objectives

Examine total C inputs returned to the soil from aboveground (stems and leaves) and belowground (root) biomass of cover crops, cotton, and sorghum from 2000 to 2002 as influenced by cover cropping and N fertilization.

Determine the effects of cover crops and N fertilization rates on SOC in tilled and non-tilled soils at the 0 to 120 cm depth.

Treatments

Cover crops (main plot):

Rye, hairy vetch, rye/hairy vetch biculture, and winter weeds (no cover crop).

N fertilization rates (split plot):

Cotton (2000 and 2002): 0, 60, and 120 kg N ha^{-1}

Sorghum (2001): 0, 65, and 130 kg N ha^{-1}

Design: Split plot arrangement in randomized complete block with three replications in no-tilled, strip-tilled, and chisel-tilled soils of the same series.

Discussion and Conclusions

Cover crops and N fertilization have potentials to increase SOC, regardless of tillage, in the southeastern United States. Because of higher C inputs from hairy vetch/rye biculture and associated cotton and sorghum residues, the biculture with 120 to 130 kg N ha^{-1} either increased SOC at the surface soil in no-tilled plots or reduced its rate of depletion at the surface and subsurface soils in tilled plots compared with other treatments. A mixture of legume and nonlegume cover crops can sequester C at a greater rate than either species alone, especially in no-tilled soil. This will not only improve soil organic matter and soil productivity but also help to reduce global warming by sequestering a greater level of atmospheric CO_2 in the soil.

Results

Although residue C returned to the soil was higher in cover crops than in winter weeds, total aboveground and belowground C inputs from cover crops and associated cotton and sorghum were greater in hairy vetch/rye biculture than in monocultures, regardless of tillage (*Table 1*).

Significant differences in SOC in tilled and non-tilled soils between treatments were observed mostly at the 0 to 30 cm depth (*Tables 2, 3, and 4*). The SOC was higher with cover crops than with winter weeds, regardless of tillage. Increases in SOC were greater in cover crops with 120 to 130 kg N ha^{-1} than with other treatments at 0 to 30 cm in strip-tilled soil and at 10 to 60 cm in chisel-tilled soil.

The SOC level varied with cover crops and time of sampling at 0 to 10 cm in no-tilled soil (*Fig. 1*). Levels of SOC were higher in vetch/rye than in winter weeds at 10 to 30 cm in no-tilled and at 0 to 60 cm in chisel-tilled soil (*Figs. 1 and 2*).

Only rye and vetch/rye sequestered C in no-tilled soil (*Table 5*). The sequestration rate was 267 and 33 kg C ha^{-1} yr^{-1} for vetch/rye and rye, respectively.

After 3 yr, SOC at 0 to 30 cm, averaged across cover crops and N rates, was higher in no-tilled and strip-tilled than in chisel-tilled soil (*Fig. 3*).

Rye

Hairy vetch

Hairy vetch and rye biculture

Winter weeds

Tables 1-5.

Table 1. Total cover crop, cotton, and sorghum C inputs from 2000 to 2002

Cover crop	N rate	No-till	Strip till	Chisel till
	kg N ha^{-1}	----Mg residue C ha^{-1}----		
Weeds	0	6.8	11.0	12.0
	60-65	7.8	14.2	9.8
	120-130	10.0	14.0	13.8
Rye	0	12.2	13.9	11.6
	60-65	13.7	16.6	14.8
	120-130	14.8	17.5	16.1
Vetch	0	16.4	15.8	18.4
	60-65	16.2	17.0	11.3
	120-130	15.8	17.6	17.5
Vetch/ rye	0	17.7	20.2	18.9
	60-65	16.5	23.6	22.0
	120-130	18.9	22.4	20.6
LSD (0.05)		6.3	6.5	6.5

Table 2. Organic C in no-tilled soil

Cover crop	N rate	Soil depth (cm)				
		0-10	10-30	30-60	60-90	90-120
	kg N ha^{-1}	---------------Mg soil C ha^{-1}-------------				
Weeds	0	10.6	14.0	10.1	8.4	7.0
	60-65	10.6	13.8	11.7	9.4	6.4
	120-130	10.9	13.3	10.5	7.0	5.6
Rye	0	11.1	14.1	10.3	7.9	5.3
	60-65	11.1	15.6	10.3	8.1	5.8
	120-130	11.5	17.1	11.3	6.6	6.8
Vetch	0	11.8	14.4	11.7	9.3	6.0
	60-65	11.2	16.1	12.9	8.1	6.3
	120-130	11.5	14.0	11.9	8.8	6.2
Vetch/ rye	0	10.6	15.5	11.5	9.0	6.7
	60-65	10.9	16.0	10.7	7.3	5.7
	120-130	11.6	16.5	11.0	6.7	5.7
LSD (0.05)		1.0	2.3	3.4	3.4	2.2

Table 3. Organic C in strip-tilled soil

Cover crop	N rate	Soil depth (cm)				
		0-10	10-30	30-60	60-90	90-120
	kg N ha^{-1}	-------------Mg soil C ha^{-1}--------------				
Weeds	0	9.7	13.7	9.9	6.9	6.1
	60-65	8.8	14.0	10.1	8.0	5.6
	120-130	10.2	15.5	9.4	8.3	5.6
Rye	0	9.4	14.3	8.8	6.7	5.2
	60-65	9.7	15.3	10.8	7.9	5.8
	120-130	11.0	16.7	10.3	6.4	5.4
Vetch	0	10.0	14.3	9.7	6.5	5.8
	60-65	9.9	14.5	9.2	6.5	5.7
	120-130	10.3	15.9	9.0	6.4	5.5
Vetch/ rye	0	9.0	14.7	10.1	8.4	4.9
	60-65	9.1	14.9	10.6	7.3	5.4
	120-130	10.8	15.1	10.3	7.9	6.6
LSD (0.05)		1.0	2.8	3.0	3.3	2.1

Table 4. Organic C in chisel-tilled soil

Cover crop	N rate	Soil depth (cm)				
		0-10	10-30	30-60	60-90	90-120
	kg N ha^{-1}	-------------Mg soil C ha^{-1}---------------				
Weeds	0	8.0	12.4	9.2	7.1	5.5
	60-65	9.2	13.1	9.8	6.7	4.5
	120-130	9.4	13.1	9.4	7.9	6.2
Rye	0	8.9	12.9	8.8	7.6	6.0
	60-65	9.0	13.7	9.1	7.1	5.8
	120-130	9.1	14.0	12.1	8.1	5.9
Vetch	0	9.1	13.9	10.9	6.4	6.0
	60-65	9.1	13.6	10.3	7.0	6.0
	120-130	9.5	14.6	12.1	8.0	6.6
Vetch/ rye	0	9.5	14.3	10.4	8.1	6.4
	60-65	10.1	14.2	11.0	8.3	5.0
	120-130	9.5	14.6	11.6	7.8	6.0
LSD (0.05)		0.9	2.2	2.9	3.4	2.3

Table 5. Soil C sequestration rate at 0-30 cm depth

Cover crop	No-till	Strip till	Chisel till
	---------kg C ha^{-1} yr^{-1}---------		
Weeds	-967	-1233	-1066
Rye	33	-733	-667
Vetch	-133	-900	-500
Vetch/rye	267	-467	-233

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Figure 1.

Fig. 1. Organic C in no-tilled soil

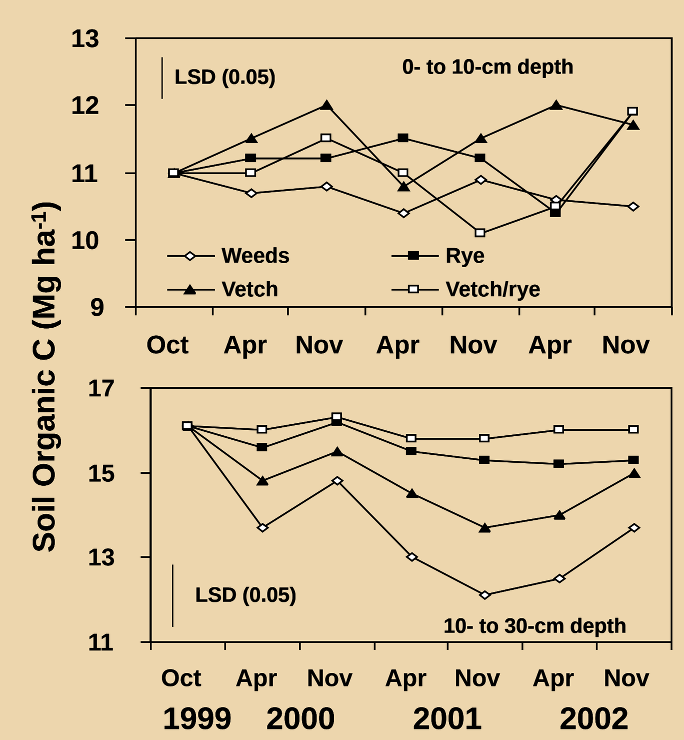

Figure 2.

Fig. 2. Organic C in chisel-tilled soil

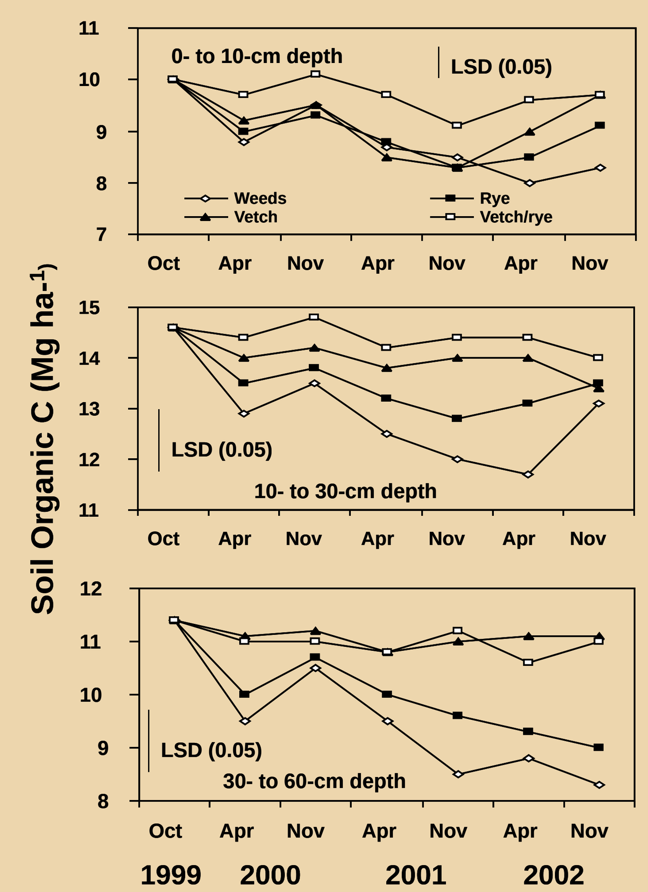

Figure 3.

Fig. 3. Effect of tillage on soil organic C