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Land Management Effects on Nitrogen and Carbon Cycling in an Ultisol

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ABSTRACT

Soil carbon (C) content in agro-ecosystems is important in a global context because of the potential for soil to act as a sink for atmospheric CO_2. However, soil C storage in agro-ecosystems can be sensitive to land management practices. The objective of this study was to examine the impact of land management systems on C and nitrogen (N) cycling in an Ultisol in Alabama. Soil samples (0-10, 10-20, and 20-30 cm depths) were collected from a Marvyn sandy loam soil (fine-loamy, siliceous, thermic Typic Hapludults) under five different farm scale management systems for at least 5 years. The five systems were cotton (*Gossypium hirsutum* L.) production managed with 1) conventional tillage only, 2) conventional tillage with a grazed winter cover crop (wheat, *Triticum aestivum* L.), 3) conservation tillage with a winter cover crop grown for cover only with strip tillage; or taken out of cotton production with either 4) long-term fallow (mowed), or 5) Conservation Reserve Program

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with loblolly pine (*Pinus taeda* L.) (CRP-pine). Total N, total organic C (TOC), total P, and soil C:N ratios were determined. Potential C mineralization, N mineralization, C turnover and C:N mineralization ratios were determined on samples during a 30-day laboratory incubation study. The fallow system had significantly higher TOC concentration (7.7 g kg^{-1} C) while the CRP-pine system had lower TOC concentration (3.1 g kg^{-1} C) compared with the farmed management systems (≈4.7 g kg^{-1} C). The fallow system had a significantly lower C turnover at all three soil depths compared with the other management systems. At the 0-10 cm depth, the highest C:N mineralization ratio levels were observed in management systems receiving the most tillage. Our results indicate that for Ultisols in the Southeast the use of surface tillage in land management systems is a controlling factor which may limit soil C sequestration.

INTRODUCTION

The combined impact of population increases, industrial expansion, and deforestation has resulted in increased atmospheric CO_2 concentration (Holland, 1978; Smil, 1985; Warneck, 1988), which is projected to double in the next century (Bolin, 1986). The implications of these changes, while highly debated, are for global warming and local climate shifts. Soils play a major role in the global C budget not only because of the large amount of C stored in soil, with estimates ranging from 1,395 to 1,636x10^{15} g (Ajtay et al., 1979; Post et al., 1992; Schlesinger, 1984), but also because the soil contribution to the annual flux of CO_2 to the atmosphere is 10 times that contributed by fossil fuel usage (Post et al., 1990). Jackson (1992) estimated that 1.3x10^{15} g of gross CO_2 is removed from the atmosphere by crops each year. Agro-ecosystems are important in the global context not only because of CO_2 flux to the atmosphere, but also because C storage in agro-ecosystems can be sensitive to management practices such as tillage and cropping systems (Kern and Johnson, 1993). Lal (1997) estimated that if 15% of the world production of residue could be converted to a passive soil organic C pool it could lead to a C sequestration rate of 0.2x10^{15} g CO_2 yr^{-1}. Therefore, an essential question is how residue management impacts the sequestration of C in soil.

Conservation tillage leads to increases in TOC concentration near the soil surface (Franzluebbers et al., 1995; Torbert et al., 1997; Potter et al., 1997; Reeves, 1997), but the ability of the soil to sequester C may be dependent not only on residue management, but also on the amount of plant residues added to the soil (Wood et al., 1990, 1991), crop sequence (Potter et al., 1997), and climate (Reeves, 1997; Potter et al., 1998).

The ability of residue management to impact soil C sequestration is unclear and is dependent on climate and soil type (Reeves, 1997; Lal, 1997). Dick (1996), using the Erosion Productivity Impact Calculator (EPIC) model, examined the

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impact of widespread conversion to no-till production in the Corn Belt of the United States. He estimated that $3.3x10^{12}$ g of C could be conserved and sequestered each year for the next 100 years. Likewise, Mitchell et al. (1996) used EPIC with the National Resources Inventory (NRI) database to examine the impact of the CRP (a USDA government program aimed at long-term conversion of marginal farm land out of crop production) and conservation tillage on C sequestration and found that agricultural soils would be a sink for C in the central United States. Converting crop production land to perennial grass cover associated with CRP in Texas, Kansas, and Nebraska would result in an estimated increase in TOC of 1.1 x 10^6 g of C ha^{-1} yr^{-1} (Gebhart et al., 1994). However, Huggins et al. (1996) reported that land converted from cropland to CRP seldom expressed an increase in TOC when measured in fields in the Corn Belt, Northern Great Plains, and the Columbia Plateau of the United States. Likewise, Allan et al. (1996) reported that while conversion of cropland to CRP resulted in changes in soil physical and chemical properties of soil, no change in TOC was found in 6-7 years of CRP in Minnesota.

Much less research has been conducted on the impact of conservation tillage and CRP conversion in the humid Southeast, United States. In the Southeast, CRP conversion has been largely in the form of planting loblolly pine (*Pinus taeda* L.). The objective of this study was to examine the impact of residue management systems on C and N cycling in an Ultisol in central Alabama, including the impact of CRP-pine production compared to cotton production, a major crop of the region.

MATERIALS AND METHODS

A study area was identified in central Alabama where continuous cotton had been produced for at least 50 years on a Marvyn sandy loam soil with a 6% slope. Sites were identified where the land use had been maintained under five different management systems: 1) conventional tilled winter fallowed cotton (20 y), 2) winter grazed cover crop with conventional tilled cotton (5 y), 3) strip-tilled cotton (5 y), 4) fallow (10 y), and 5) CRP-pine (5 y). At the time of sampling, in May 1993, the conventional tillage system consisted of fall disking after harvest (i.e., boll weevil (*Anthonomus grandis* Boh.) eradication program requirement), and in spring, disking, chisel plowing (20-cm depth), and field cultivation. The strip-tilled cotton consisted of disking and planting wheat (*Triticum aestivum* L.) as winter cover after cotton harvest and planting cotton into herbicide-terminated wheat cover with an in-row subsoiler (40-cm depth) planter. The winter grazed cover crop system consisted of disking and planting wheat after cotton harvest and grazing cattle until time for land preparation for cotton planting in spring. In spring, the wheat was disked followed by chisel plowing (20-cm depth), disking, and field cultivation. Other cultural practices for production of cotton and wheat cover crops followed guidelines recommended by Auburn University. The fallow

TABLE 1. Effect of land management system on soil pH and soil extractable[a] levels of P, K, and Mg in the soil surface (0-10 cm).[b]

Tillage	pH	P	K	Mg
		(Kg ha^{-1})		
Conventional	5.7	31 (M)	141 (H)	104 (H)
Strip-till	6.1	56 (M)	119 (M)	138 (H)
Grazed	6.2	57 (H)	175 (H)	184 (H)
Fallow	6.4	43 (M)	87 (M)	149 (H)
CRP-Pine[c]	6.3	37 (M)	66 (L)	64 (H)

[a]Soil samples extracted with Mehlich 1 solution.

[b]Letters in parentheses indicate relative soil fertility level for that nutrient: H=high, M=medium, and L=low according to Hue and Evans (1979).

[c]CRP-Pine=Conservation Reserve Program with loblolly pine.

system consisted of no tillage or weed control. This site was part of government "set aside" program where a certain portion of farmers' land was taken out of cotton production in order to qualify for government price support programs. The site was dominated by grassy weed species and was occasionally mowed to prevent intrusion of woody plant species. The CRP-pine system (for last 5 y) was planted to loblolly pine according to CRP regulations.

Soil samples were collected in May 1993 at 0-10, 10-20, and 20-30-cm depth increments to investigate management system effects on soil nutrient status and soil C and N cycling. The management systems were blocked into three slope zones consisting of summit, backslope, and footslope to block any effect of slope position of an erosional continuum (Woods and Schuman, 1988). Composite soil samples were collected from 10 random soil cores from each block in each management system. Soil samples were stored at 5°C until processing for laboratory and incubation analyses. Subsamples of the soils were dried (60°C), ground to pass a 0.15-mm sieve, and analyzed for total N on a FISON NA1500 nitrogen and carbon determinator (Fison Instruments, Inc., Dearborn, MI). Soil TOC was determined with a LECO CR12 Carbon Determinator (LECO Corp., St. Joseph, MI; Chichester and Chaison, 1992). Particle size analysis was determined by the hydrometer method (Gee and Bauder, 1986). Characterization of soil fertility for each site was conducted by analyzing a subsample from the 0-10 cm depth. The procedures of Auburn University (Hue and Evans, 1979) were used to determine pH and phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), boron (B), and molybdenum (Mo) levels (Table 1).

Methods used by Wood et al. (1990) were utilized for triplicate determinations of potential C and N mineralization. Soil inorganic N (NO_2-N+NO_3-N and NH_4-N)

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P	K	Mg
------------ (Kg ha^{-1}) ------------		
31 (M)	141 (H)	104 (H)
56 (M)	119 (M)	138 (H)
57 (H)	175 (H)	184 (H)
43 (M)	87 (M)	149 (H)
37 (M)	66 (L)	64 (H)

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was extracted with 2 *M* KCl and measured (before and after incubation) by standard colorimetric procedures using a Technicon Autoanalyzer (Technicon Industrial Systems, 1973a, 1973b). Sieved soil samples (2-mm sieve) were weighed (25-g dry weight basis) and placed in plastic containers. Deionized water was added to adjust soil water content equivalent to -20 kPa at a bulk density of 1.3 Mg m^{-3}. The containers were placed in sealed glass jars with 20 ml of water for humidity control, and a 20 ml vial of 1 *M* NaOH as a CO_2 trap. The jars were incubated in the dark at 25°C and removed after 30 days. Carbon dioxide in the NaOH traps was determined by titrating the excess base with 1 *M* HCl in the presence of $BaCl_2$. Potential C mineralization was the difference between CO_2-C captured in sample traps and in blanks. Potential N mineralization was the difference between final and initial inorganic N contents for the incubation. The C mineralization divided by TOC was used to calculate C turnover. A ratio of C mineralized to N mineralized during the incubation was also calculated.

The statistical analyses was a block design of 5 management system treatments with three replications. The triplicate samples in the laboratory incubation were treated as subsamples in the analysis. Statistical analyses were performed using GLM procedure of SAS (SAS Institute, 1985), and means were separated using least significant difference (LSD) at an *a priori* 0.10 probability level.

RESULTS AND DISCUSSION

The five different land management systems examined in this study are of the same soil type and are in very close proximity to each other, but all were managed by different land owners. Some inherent or management-induced difference in soil fertility between sites were noted (Tables 1 and 2). Except for K under the CRP-pine system, soil fertility rankings for the five management systems were in the medium to high soil fertility range for P, K, and Mg.

The Marvyn soil is a very deep loamy soil commonly found in the Coastal Plain region of the southeastern United States. Soil particle size data for each soil depth measured, averaged over management and slope positions, are presented in Table 3. Particle size analysis indicated no significant difference between land management systems or slope positions for the soil depths measured.

Soil Analysis

The results of chemical analysis for TOC, total N, total P, and C:N ratio indicated that changes had occurred due to land management system. However, in many cases, large differences between means were nonsignificant, indicating large within-site variability in these measured parameters.

At the 0-10 cm depth, significant differences were observed for TOC (Table 4). At this depth, the fallow system had significantly higher TOC compared to the systems farmed to cotton (conventional, strip-till, and grazed). Similarly, at the

TABLE 2. Effect of land management system on soil extractable[a] levels of Ca, Cu, Fe, Mn, Zn, and B in the soil surface.[b]

Tillage	Ca	Cu	Fe	Mn	Zn	B
	(mg kg^{-1})					
Conventional	205	0.2	645	24	1.2	4.1
Strip-tillage	204	0.2	701	33	1.2	4.4
Grazed	427	0.3	692	66	1.6	5.6
Fallow	323	0.3	832	60	1.2	4.9
CRP-Pine[c]	160	0.2	938	75	1.2	4.8

[a]Soil samples extracted with Mehlich 1 solution.

[b]Letters in parentheses indicate relative soil fertility level for that nutrient: H=high, M=medium, and L=low according to Hue and Evans (1979).

[c]CRP-Pine=Conservation Reserve Program with loblolly pine.

20-30 cm depth, the fallow system was significantly higher than the cotton systems while the CRP-pine was significantly lower in TOC compared to all other management systems. No significant differences were observed between the management systems for TOC at the 10-20 cm depth.

No significant differences were observed between the five management systems for total N concentration at the 0-10 cm or the 20-30 cm depth (Table 4). At the 10-20 cm depth, an increase in total N concentration was observed for the grazed system compared to the other management systems. The concentration of total P in the soil was higher for the grazed system at all three depths compared to the other management systems (Table 4).

TABLE 3. Percent sand, silt, and clay at 0-10, 10-20, and 20-30 cm depth averaged over land management systems and soil slope position.[a]

Depth	Sand	Silt	Clay
	(%)		
0-10 cm	66.0 (0.9)	10.3 (0.2)	23.7 (0.9)
10-20 cm	65.4 (0.9)	10.6 (0.2)	24.0 (0.9)
20-30 cm	65.4 (0.7)	10.4 (0.1)	24.2 (0.7)

[a]Soil particle analysis determined by hydrometer method. Values represent means of 15 replicates. Numbers in parenthesis are standard deviations.

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Cu	Fe	Mn	Zn	B
(mg kg^{-1})				
0.2	645	24	1.2	4.1
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0.3	692	66	1.6	5.6
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management systems and soil slope position.[a]

	Silt	Clay
	(%)	
.9)	10.3 (0.2)	23.7 (0.9)
.9)	10.6 (0.2)	24.0 (0.9)
.7)	10.4 (0.1)	24.2 (0.7)

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plicates. Numbers in parenthesis are standard

TABLE 4. Effect of land management system on total organic C, total N, total P, and C:N ratio at 0-10, 10-20, and 20-30 cm depth.[a]

Tillage	Total organic C	Total N	Total P	C:N
	(g kg^{-1})			(g g^{-1})
0-10cm				
Conventional	4.5 bc	0.33 a	0.18 b	14.0 a
Strip-tillage	5.1 b	0.35 a	0.21 ab	14.4 a
Grazed	4.6 bc	0.47 a	0.27 a	10.4 a
Fallow	7.7 a	0.51 a	0.21 ab	15.7 a
CRP-Pine[b]	3.1 c	0.36 a	0.21 ab	12.2 a
10-20cm				
Conventional	3.8 a	0.26 b	0.17 b	14.8 bc
Strip-tillage	3.6 a	0.23 b	0.19 b	17.0 ab
Grazed	3.2 a	0.42 a	0.27 a	9.0 c
Fallow	5.2 a	0.22 b	0.19 b	23.1 a
CRP-Pine[b]	4.2 a	0.20 b	0.15 b	19.9 ab
20-30cm				
Conventional	3.6 ab	0.22 a	0.18 ab	17.0 ab
Strip-tillage	3.1 b	0.18 a	0.17 b	18.6 ab
Grazed	3.8 ab	0.27 a	0.21 a	13.8 b
Fallow	5.0 a	0.20 a	0.17 b	25.8 a
CRP-Pine[b]	2.7 b	0.22 a	0.16 b	14.8 ab

[a]Values represent means of 3 replicates. Means within a column followed by the same letter do not differ significantly (0.1 level) as determined by LSD.
[b]CRP-Pine=Conservation Reserve Program with loblolly pine.

At the 0-10 cm depth, no significant differences were observed between management systems for soil C:N ratio (Table 4). However, significant differences were observed between management systems for soil C:N ratio at the 10-20 and 20-30 cm depths (Table 4), with the highest C:N ratio observed in the fallow system and the lowest in the grazed system. This change in C:N ratio was due to the observed increase in total N with the grazed treatment and the increased C levels in the fallow treatment.

Soil Incubation

No significant differences were observed for C mineralization at any soil depth. Significant differences were observed between land management systems for C turnover (C mineralized/TOC) during the 30-day incubation at all depths (Table

TABLE 5. Effect of land management system on C mineralization, C turnover, N mineralization, and C:N mineralization ratio at 0-10, 10-20, and 20-30 cm depth during 30-day incubation.[a]

Tillage	C Mineralization	C Turnover	N Mineralization	C:N Mineralization
	(mg kg^{-1})			(g g^{-1})
0-10 cm				
Conventional	806 a	18.0 a	8.89 a	156 a
Strip-tillage	833 a	17.9 a	11.60 b	80 ab
Grazed	837 a	18.5 a	9.97 ab	149 ab
Fallow	845 a	10.9 b	13.61 c	70 b
CRP-Pine[b]	776 a	25.1 c	8.44 a	99 ab
10-20 cm				
Conventional	870 a	23.3 a	2.40 a	687 a
Strip-tillage	842 a	24.5 b	2.76 a	365 b
Grazed	855 a	25.8 c	4.14 b	336 b
Fallow	845 a	17.0 d	3.73 b	242 b
CRP-Pine[b]	864 a	25.0 bc	3.93 b	231 b
20-30 cm				
Conventional	851 a	24.3 a	2.06 ab	1466 a
Strip-tillage	843 a	30.4 b	1.32 a	1155 a
Grazed	853 a	27.4 c	1.74 a	880 a
Fallow	848 a	17.1 d	1.80 a	610 a
CRP-Pine[b]	837 a	31.4 b	3.21 b	371 a

[a]Soil incubated at 25°C for 30 days. Values represent means of 9 samples, 3 subsamples of each 3 replications. Means within a column followed by the same letter do not differ significantly (0.1 level) as determined by LSD.

[b]CRP-Pine=Conservation Reserve Program with loblolly pine.

5). At each depth, the lowest C turnover was observed under the fallow system. At the surface (0-10 cm) the highest C turnover was observed with CRP-pine, but there were no significant differences between the three cropping systems. Likewise, at the 10-20 and 20-30 cm depth, the highest C turnover was observed with the CRP-pine, but some differences were observed between the farmed systems (Table 5).

At the 0-10 cm depth, the amount of N mineralized was much higher compared to the 10-20 cm depth (Table 5); levels ranged from 2.4 to 4.1 mg kg^{-1} at 10-20 cm, compared with a range of 8.4 to 13.6 mg kg^{-1} in the surface layer (0-10 cm). Likewise, the 20-30 cm depth had lower N mineralization levels relative to the other depths, with N mineralization ranging from 1.3 to 3.2 mg kg^{-1}.

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...on	C Turnover	N Mineralization	C:N Mineralization
	(mg kg^{-1})		(g g^{-1})
	18.0 a	8.89 a	156 a
	17.9 a	11.60 b	80 ab
	18.5 a	9.97 ab	149 ab
	10.9 b	13.61 c	70 b
	25.1 c	8.44 a	99 ab
	23.3 a	2.40 a	687 a
	24.5 b	2.76 a	365 b
	25.8 c	4.14 b	336 b
	17.0 d	3.73 b	242 b
	25.0 bc	3.93 b	231 b
	24.3 a	2.06 ab	1466 a
	30.4 b	1.32 a	1155 a
	27.4 c	1.74 a	880 a
	17.1 d	1.80 a	610 a
	31.4 b	3.21 b	371 a

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Significant differences were observed for N mineralization between land management treatments, but differences were not consistent with soil depth (Table 5). At the 0-10 cm depth, the fallow and strip-till systems had higher levels of N mineralization compared with the conventional, grazed, and CRP-pine management systems. At the 10-20 cm depth, the conventional and strip-tilled treatment had the lowest N mineralization, while at the 20-30 cm depth, the highest N mineralization was observed with the conventional and CRP-pine treatments (Table 5).

The ratio between C to N mineralization during the 30-day incubation was significantly different at the 0-10 cm depth (Table 5). At this depth, the C:N mineralization ratio was highest for conventionally tilled and grazed systems and lowest for the fallow land management system. At the 10-20 cm depth, the highest C:N mineralization ratio was observed with the conventional land management system (Table 5). At the 20-30 cm depth, no significant differences between land management systems for the C:N mineralization ratio were observed.

Land Management

The land management systems examined in this study reflect changes in quality and quantity of C inputs in addition to changes in tillage intensity. Within the farmed systems, conventional tilled and grazed systems received the same amount of tillage, but the level of C inputs (i.e., manure and winter cover) were presumably higher in the grazed system due to the wheat cover crop for winter grazing. The strip tillage system represented an increase in C inputs since none of the wheat cover crop biomass was removed through grazing. In addition, this system is expected to have a reduction in C oxidation as a result of reduced tillage compared to the other cotton-farmed systems. The fallow system represented both a complete elimination of tillage and an increase in C inputs (i.e., weeds) since none of the biomass produced was removed. While this area was not planted to grass (as required in the CRP program), it closely represents the effects expected with CRP-grass management. The CRP-pine system represents a complete departure from production-agriculture-based land management systems. If this area had not been planted to pines, it would have become dominated by woody species. Although the pines were present for a relatively short time span, this system was drastically different compared to the other land management systems. The CRP-pine system represents a complete removal of soil tillage and C inputs into soil were reduced since a large portion of the biomass allocation was to trunk and limbs and only a relatively small amount of C was returned to the soil through leaf litter and root turnover (Davis, 1966; Tissue et al., 1996).

As has been commonly observed, the highest TOC levels were in the 0-10 cm soil depth (Table 4). The fallow treatment had a significantly higher TOC level compared with the other land management systems, with an increase in mean TOC concentration of 3.2 g kg^{-1} for the fallow system compared to the conventionally tilled system and 4.6 g kg^{-1} compared to the CRP-pine system.

While mean differences in TOC were observed, there was no significant difference between any of the cotton-farmed management systems (conventional, grazed, or strip-tilled) (Table 4). While these results do not agree with estimates of the impact of conservation tillage systems in the Midwest reported by Dick (1996), they are consistent with findings for the humid, temperate region (Bruce et al., 1990; Staley, 1988). Bruce et al. (1990) reported that for sandy soils in the humid Southeast no significant difference in TOC was found in the surface soil between conventional tillage, in-row subsoiling tillage, and no-tillage systems following winter wheat. In that case, as in this study, all of the tillage treatments involved fall disking to establish the winter wheat crop. These results are consistent with results reported by Reicosky et al. (1997), which indicated that large losses of C are associated with tillage operations. Other reports for the Southeast have shown that soil TOC can be increased if no tillage is combined with increased C inputs from winter cover crops (Reeves and Wood, 1994). Since both the strip-till and the grazed tillage systems examined in this study included an increase in C inputs compared to the conventional tillage system, the results indicate that tillage is the most important controlling factor for soil C sequestration and that C sequestration will be very slow as long as surface tillage is a part of the management system.

While there were no differences observed in TOC at the 10-20 cm depth, a significant increase in TOC was observed in the fallow system at the 20-30 cm depth (Table 4). This was most likely due to the increased soil C input from perennial grass species, which have been found to allocate a larger portion of their C to roots compared to annuals (Richter et al., 1990).

With the CRP-pine system, the TOC concentration was significantly lower at the 0-10 cm and 20-30 cm soil depth compared to the other land management systems (Table 4). It appears that changing land management systems to pine tree production will drastically change C cycling in soil, with a large portion of the total C sequestered is in the trunk and branches and therefore will not be returned to soil (Davis, 1966; Tissue et al., 1996). Rollinger (1996) reported that following stand initiation, the greatest C sequestration of the total ecosystem carbon would be in the vegetative component of red pine (*Pinus resinosa* Ait.) during early establishment. Also, our soil sampling did not include the duff layer of pine needles which would also contain a large portion of the total C sequestered by the trees. In addition, Rollinger (1996) reported that most of the TOC in red pine would be in the top 0-4 cm and would decline exponentially at deeper soil depths. Since samples for this study were collected in 10-cm increments, much of the of TOC content in the near surface layer may have been diluted and therefore not detected.

Carbon and Nitrogen Cycling

Data from the laboratory incubation portion of this study (C turnover rate and the C:N mineralization ratio) indicated that as well as total soil C storage, soil C

TOC were observed, there was no significant
otton-farmed management systems (conventional,
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difference in TOC was found in the surface soil
n-row subsoiling tillage, and no-tillage systems
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and N cycling was changed by land management (Table 5). At the soil surface, the fallow system had the lowest C turnover, while the CRP-pine system had a significantly higher C turnover, compared to the farmed management systems. No significant differences were observed in the surface soil between the farmed management systems. These differences correspond to differences observed in TOC in the soil with these land management systems at this depth (Table 4). As in the surface, at depths below 20 cm the fallow system had a significantly lower C turnover, while the CRP-pine tended to have the highest C turnover. These data indicate that soil C cycling processes had been altered by the land management systems examined in this study.

The ratio between C mineralization to N mineralization is an index of the levels of recalcitrant C in soil; an increase in C:N mineralization ratio indicates a decrease in the recalcitrant C present (Nadelhoffer et al., 1991; Torbert et al., 1997). At the 0-10 cm depth, there was an increase in the C:N mineralization ratio in management systems receiving the most tillage (conventional and grazed). There tended to be a reduction in this ratio as tillage intensity was reduced (Table 5). Likewise, at the 10-20 cm depth, the C:N mineralization level tended to be lower with the non-farmed management systems (i.e., fallow and CRP-pine). These data indicate that the type of soil C present had been altered by the land management systems examined in this study. This agrees with Torbert et al. (1997) which found that an increase in the level of tillage intensity in a Vertisol decreased the level of recalcitrant C as reflected by C:N mineralization ratio.

In the surface 0-10 cm depth, the strip-till management system, with reduced levels of tillage compared with the conventional and grazed tillage system, had a reduction in the C:N mineralization ratio (Table 5). This corresponds to a trend for TOC to be increased in the 0-10 cm depth with the strip-till land management system compared to the other farmed land management systems (Table 4), which indicated changes in C and N cycling for the strip-till system could increase levels of C sequestration in the soil surface. However, this further indicates that while changes in C and N can be affected by a reduction in tillage, the process of C sequestration will be very slow as long as some level of tillage occurs in this soil.

CONCLUSIONS

A study was conducted to examine the impact of land management systems on soil C and N cycling in the humid southeastern United States. Soil samples were collected from an area with the same soil type (Marvyn sandy loam) that had been traditionally utilized for cotton production, but having 5 different land management systems in recent years. The land management systems within this study represented changes in both residue management and changes in the residue quantity. The lowest C turnover observed in this study was for the fallow land management system, indicating that soil C cycling processes had been altered by changes in land management systems examined. The highest C:N mineralization ratio levels were observed in management systems receiving the most tillage, indicating that the type of C present in soil had been altered by changes in the land management systems. The results from this study further indicate that tillage is the most important controlling factor for soil C sequestration and that C sequestration will be very slow as long as surface tillage is a part of the management system.

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