Microbiological Characterization of Eroded Soils in Conservation Tillage Systems in the Georgia Piedmont

D. Jordan, R. R. Bruce and G. W. Langdale[1]

Introduction

Soil microorganisms play an important role in the retention and release of nutrients and energy. Any attempts to assess nutrient and energy flow in the soil system must take the soil microbial biomass into account (Parkinson and Paul, 1982). In agricultural soils, the microbial biomass acts as a source-sink for labile nutrients. Cropping practices which alter the size of the microbial biomass or its rate of turnover can affect crop growth (Granatstein et al., 1987). Microbial biomass responds more quickly to management changes than does organic C or N (Nannipieri, 1984) and has an important role in residue decomposition (Adams and Laughlin, 1981). In conservation tillage systems where plant biomass inputs are diverse with varying C to N ratios, understanding how these materials are decomposed and recycled by the biological community is necessary to assess nutrient availability to subsequent crops. The decomposition process is influenced by a variety of environmental, climatic and soil conditions. The Georgia Piedmont soils are historically recognized as some of the most eroded areas of the United States and significant areas of shallow, clayey, surface soil layers are common (Bruce et al. 1987; White, 1985). These finer textured surfaces can absorb, retain and slowly release nut-

[1]Microbiologist and Soil Scientists, Southern Piedmont Conservation Research Center, USDA-ARS, Watkinsville, GA 30677.

rients. Our objective was to characterize microbial and chemical changes on the range of soil textures associated with different conservation treatments over the growing season.

Materials and Methods

We measured the microbial. chemical and physical changes associated with conservation tillage procedures (no-tillage and paratillage) during the 1988 growing season. Measurements were intended to characterize the range of conditions that are encountered in a representative portion of the landscape near Watkinsville. GA. In this preliminary report, we will focus on the microbial and chemical changes associated with conservation tillage practices.

General Soil Characteristics

A Cecil/Pacolet (clayey, kaolinitic, thermic Typic Hapludult) sandy loam and sandy clay loam was measured for chemical and biological changes across the landscape. The total N content for sandy loam and sandy clay loam was 0.05% and 0.11%, respectively. The pH was 6.0 for 0-10 cm across the landscape

Previous and Present Cropping Practices

The field had been previously no-till planted to soybeans for three years following long-term cropping using conventional tillage methods. One year prior to beginning the present experiment. the field had been left fallow with no-tillage and contained diverse weeds.

Prior to beginning this study in the fall of 1987. the whole experimental area was limed at two tons/acre of dolomite. Fertilizer was added at 50, 215, and 150 lbs of N, P_20_5 and K_20, respectively. The experimental layout included three winter cover crops (including a fallow treatment) and three conservation tillage treatments replicated five times in 500-ft long strips. Stacy wheat and Tibbe crimson clover were no-till planted as winter cover crops at a rate of 1.5 bushels/acre and 25 lbs seed/acre. respectively. Ammonium nitrate was applied in February and July 1988 at a rate of 50 lbs N/acre to all wheat transects.

After the winter cover crops were killed with paraquat. grain sorghum (Sorghum bicolor L. Moench) was no-till planted across the entire field.

Preparation of Plant and Soil Samples for Analyses

The amount of plant biomass produced was determined by taking a fresh weight sample of each cover crop every 25 ft before complete kill. Subsamples were taken. washed. dried at 65°C for 2 days, weighed. then ground in a Wiley Mill 2 mm sieve screen and stored for further analyses.

Immediately after harvesting, each plant part was dried at 65°C for 2 days, weighed, then ground in a Wiley Mill 2 mm sieve screened for chemical analyses.

Soil samples were air-dried and subsampled for sieving on a 2 mm sieve.

Analytical Procedures

Total N analysis was determined on soil and plant samples by salicylate method using a flow-injector analyzer (Lachat) after a standard Kjeldahl digestion (Bremner, 1965).

Microbiological Procedures

Microbial biomass C was determined by measuring the CO_2-C evolved from a chloroform fumigated sample minus a unfumigated sample after a 10-day incubation period in a mason jar kept at a constant temp (Parkinson and Paul, 1982). The mason jar contained a base trap (2N NaOH) which was removed at the end of the 10-day incubation and titrated with 0.1 N HCI.

The number of bacteria produced at different depths across the landscape under varying soil textures and erosion levels were determined using a spiroplater and laser counter.

Results and Discussion

Clay content influenced the total nitrogen and C/N ratio of plant biomass inputs. A higher total nitrogen wasobserved in the lower clay content with an inverse relationship seen in the C/N ratio (Table 1). The total carbon remained constant across varying clay content (Table 1).

Table 1. Description of Crop Biomass Inputs and Erosion in Relation to Clay Content of Surface Soil and Percentage Total N, Total C, and CIN in Dawson Field in 1988.

Crop Inputs & Erosion	Range Clay Content (%)	Quant. of Biomass Added $g^{-1}ft^2$	Percentages Total C	Percentages Total N	C/N*
Wheat					
high clay (severe)	14-41	86	40.5	0.73	56
low clay (slight)	4-7	155	40.5	0.99	41
Clover					
high clay (severe)	14-41	49	39.9	1.85	22
low clay (slight)	4-7	50	40.6	2.00	20

*Total Carbon/Total Nitrogen = C/N

Microbial biomass measures the quantity of energy stored in a particular segment of the biological community. In general terms, it means "mass of living material" (Atlas and Bartha, 1987). In May, a high microbial activity was observed as freshly killed residues began to decompose and continued through June with slightly less activity probably due to less freshly decomposed material and onset of dry weather conditions. This is readily seen in July when severe drought occurred last summer and the residues had become more lignified, thus causing a slower decomposition rate (Table 2). Near the end of the growing season when weather conditions become more favorable (eg. more rain). the microbial activity increased.

Interestingly, we observed more microbial activity in the high clay sites than low clay sites in May. but slightly less than the low clay sites throughout the growing season. This suggests that microbial population may be somehow bound or protected in the high clay sites. Further studies will be done to confirm this hypothesis.

Generally, the number of bacteria decreased with depth as expected (Table 3). However, the overall population seemed

Table 2. Microbial Biomass Changes Associated with Varying Clay Content in Dawson Field in 1988 over the Growing Season.

Clay & Erosion		ugCO$_2$-C evolved g^{-1} soil			
		May	June	July	Oct.
			(0-2 in.)		
	range (%)				
High (severe)	14-41	740	487	263	520
Low (slight)	4-7	644	551	334	652

Table 3. Bacterial enumerations at various depths associated with clay content in Dawson Field in 1989.

Clay & Erosion		No. of ^{1}cfu ml^{-1}g $^{-1}$soil (10^7)		
		0-0.8	0.8-1.6	1.6-2.4
			(depth in.)	
	range (%)			
High clay (severe)	14-41	2.31	2.03	--
Low clay (slight)	4-7	2.56	1.21	I.06

^{1}cfu = colony-forming units of bacteria
-- = data incomplete

relatively low (10^7) which is consistent with low microbial biomass seen in a degraded site (Table 3). With a long-term practice of conservation tillage and winter cover crops, we expect that microbial number and activity will increase over time.

In the Georgia Piedmont, this microbial biomass carbon varies according to locale and cropping history, but has the same general trend of decreasing numbers for depth within the soil profile (Table 4). Most of the microbial activity will be observed in the surface soil where carbonaceous materials and nutrients (Rhizosphere effect) are present to stimulate greater microbial activity. Watkinsville site tends to have a lower biomass than Griffin or Horseshoe Bend because of degradation associated with erosion and continuous conventional tillage for many years (Table 4). The opposite effect is observed for Horseshoe Bend and Griffin where the soils have been in an aggradation phase for several years. The Griffin site has been in permanent sod for several years and the Horseshoe Bend site has had both conventional and no tillage treatments for 11 years.

Table 4. Microbial Biomass Carbon at Three Different Depths and Sites in the Georgia Piedmont.

Site	ug CO$_2$-C evolved g^{-1} soil		
	0-2	2-4	4-6
		(depth-in.)	
Watkinsville	418	236	I85
Horseshoe Bend (Athens)	763	214	212
Griffin	1110	529	423

Literature Cited

Adams, T.M. and R. J. Laughlin. 1981. The effects of agronomy on the C and N contained in the soil biomass. J. Agric. Sci. 97:319-327.

Atlas, R.M. and R. Bartha. 1981. Microbial Ecology: Fundamentals and Applications. The Benjamin iCummings Publishing Co.. lnc.. Menlo Park.

Bremner, J. M. 1965. Total nitrogen. *In* Methods of Soil Analysis, Part 2 eds. C. A. Black, D. D. Evans. J. L. White, L. E. Ensminger and F. E. Clark, Agronomy 9.1149-1178. American Society of Agronomy, Inc.. Madison. Wisconsin.

Bruce, R. R., S.R. Wilkinson, and G. W. Langdale, 1987. Legume effects on soil erosion and productivity. ed. I. F. Power. *In* The role of legumes in conservation tillage systems. Soil Cons. Soc. of Am. pp. 127-138.

Granatstein, D. M., D. F. Bezdicek, V. l. Cochran, L. F. Elliot and J. Hammel. 1987. Long-term tillage and rotation effects on soil microbial biomass, carbon. and nitrogen. Biol. and Fen. of Soils. 5:265-270.

Nannipieri, P. 1984. Microbial biomass and activity: ecological significance ed. M. J. Klug and C. A. Reddy. *In* Current Perspectives in Microbial Ecology. Washington. pp 512-521.

Perkinson, D. and E. Paul. 1982. Microbial Biomass. In Methods of Soil Analysis Part 2. Chemical and Microbiological Properties. Agronomy 9:821-830.

White. A. W.. Jr.. R. R. Bruce, A. W. Thomas, G. W. Langdale. and H. F. Perkins. 1985. Characterizing productivity of eroded soils in the Southern Piedmont. *In* Erosion and Soil Productivity. Pub. 8-85 Am. Soc. Agr. Eng., St. Joseph, Mich. pp. 83-95.