EARLY INDICATORS OF SOIL QUALITY CHANGE FOR NO-TILLAGE SYSTEMS IN THE BRAZILIAN CERRADOS

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Introduction

The Brazilian Cerrado region is the leading grain producing area of Brazil. Farmers in this region have been converting their conventional agricultural systems, characterized by ploughing followed by the use of light harrows, to the no-tillage system, whereby seeds are inserted into the soil through plant residues from previous crops, with no primary nor secondary tillage. This system is significantly beneficial to the environment due to a remarkable diminution of soil water erosion, increase in soil organic matter content and greater economic stability of rural communities. The pedo-climatic conditions of the Cerrado leads to rapid plant residue decomposition over the soil surface. This has demanded the development of research devoted to the selection of plant species to be used as cover crops in order to optimize biomass production necessary to protect soil surface from the impacts of rainfall and solar exposure, and to significantly augment, in shorter periods of time, soil organic carbon contents. These research initiatives would greatly benefit from using soil quality indicators sensitive enough to enable early predictions of sustainable increases in soil quality as a result of different crop rotations or soil management schemes.

Objectives

1) Analyze the bacterial diversity in soils under different crop rotations and soil management schemes using molecular techniques;

2) Evaluate aggregation indices and organic carbon contents of different aggregate size classes in soils under no-tillage and conventional tillage systems;

3) Search for early indicators of soil quality change in different tillage and crop rotation schemes.

Material and Methods

Soil sampling for bacterial diversity analyzes

We will present results from soils sampled in June 1999 (dry season), and in January 2000 (wet season). Three replicate composite samples were taken from each treatment from the depths of 0-5 and 5-10 cm, and kept at -20ϒC prior to the molecular analyses.

Soil sampling for aggregation stability and organic carbon studies

Three replicates samples were collected at field capacity in March 2001 at 0 - 5, 5 - 10, 10 - 20 and 20 - 30 cm depths. Each soil sample was passed through a 19-mm sieve by gently breaking apart the soil. Clods and aggregates larger than 19 mm diameter were discarded. The air dried soil samples were stored at ambient temperature until analysis.

Soil DNA extraction and amplification

DNA was extracted from soil using the protocol of van Elsas et al. (1997). Fragments of rRNA genes were amplified using primers described elsewhere (Nübel et al., 1996). All PCR amplifications were performed according to Peixoto et al. (2002).

Bacterial diversity analyzes

Soil extracted and amplified DNA was analyzed by denaturing gradient gel electrophoresis (DGGE) Unweighted pair group with mathematical averages analysis (UPGMA; Dice coefficient of similarity) using the NT-SYS software package (Exceter Software, USA) was used to compare the banding patterns seen on the gels according to Gelsomino et al. (1999).

Fractionation of aggregate size classes

Aggregate size classes were separated by wet sieving (Castro Filho et al., 2002) through a series of eight sieves (8, 4, 2, 1, 0.5, 0.250, 0.125 and 0.053 mm). Aggregates were oven dried (105°C), weight and stored in plastic flasks at room temperature for carbon analysis.

Determination of parameters expressing the size distribution of aggregates

The *Meanweight Diameter (MWD)* of aggregates:

$$MWD = \sum_{i=1}^{n} (xi.wi)$$ where,

wi = proportion of each aggregate class in relation to the whole,
xi = mean diameter of the classes (mm);
The *Mean Geometric Diameter (MGD)* of aggregates:

$$MGD = EXP \frac{\sum_{I=1}^{N} wp.\log xi}{\sum_{I=1}^{N} wi}$$ where,

wp = weight of each aggregate class (g);
The *Aggregate Stability Index (AS)* of soils:

$$AS = \frac{\text{Weight of the dry sample - wp25 - sand}}{\text{Weight of dry sample - sand}} .100$$ where,

wp25 = weight of aggregates >0.25 mm

Organic carbon analysis

The total organic carbon content of whole soils and aggregate size classes were determined by dry combustion with a Perkin Elmer CHNS/O Analyser 2400. Coefficient of variation of the method was 3%.

Characterization of Studied Site

The soil studied was a clayey Haplic Ferralsol (Latossolo Vermelho Amarelo distrófico, Brazilian Soil Classification). Samples were taken from an area under Cerrado Forest and from an adjacent field

experiment at Embrapa Rice and Beans. Before establishing the experiment in 1995, the soil had been cultivated conventionally (disc-ploughed) since 1989 with a maize-common bean succession. Tillage treatments were: no-tillage (no soil disturbance other than sowing operation; NT) and conventional tillage (mouldboard plough followed by two light disc harrowings; CT).

Results

Due to the short duration of the experiment (5 years at the time of sampling) the tillage systems did not show significant effects on the total soil carbon content, Aggregate Stability Index (AS), and Mean Geometric Diameter (MGD). The Meanweight Diameter (MWD) however, was significantly higher under NT than under CT in the 0-5 cm soil layer. This means that NT promotes the formation of larger aggregates in a greater mass than CT (Table 1).

Table 1. Effect of tillage and plant rotation on the aggregation indices NT: no-tillage; CT: conventional tillage.

	Sampling depth, cm					
	AS (%)		**MWD (mm)**		**MGD (mm)**	
Treat- ment	***0-5***	***5-10***	***0-5***	***5-10***	***0-5***	***5-10***
Forest	87.99	93.89	5.63	8.46	1.12	1.20
NT	88,21a	80,86a	**6,60a**	3,50a	1,14a	1,05a
CT	82,79a	82,62a	**4,26b**	4,15a	1,03a	1,07a

The largest macroaggregate size class (19000-8000 μm) accumulated significantly more soil material (not shown) and total carbon in the NT 0-5 cm layer soil samples than those from CT plots (Table 2).

Table 2. The effect of tillage and plant rotation on the total organic carbon (TOC, $g.kg^{-1}$ whole-soil) in aggregate size classes (NT: no-tillage; CT: conventional tillage).

	Aggregate size classes, μm							
Treatment	**19-8000**	**8-4000**	**4-2000**	**2-1000**	**1000-500**	**500-250**	**250-125**	**125-53**
					0-5 cm			
Forest	8.72	2.96	2.47	1.95	3.75	3.19	1.50	0.60
NT	**7,96a**	1,22a	1,08a	1,17a	**1,54b***	1,68a	0,82a	0,33a
CT	**4,86b**	1,38a	1,25a	1,48a	**2,44a***	2,25a	1,13a	0,48a

The bacterial diversity was also significantly affected by NT in both 0-5 cm and 5-10 cm layers. The DNA fingerprints of NT soils were more similar to those from the original Cerrado forest soil, when compared to those from CT soils.

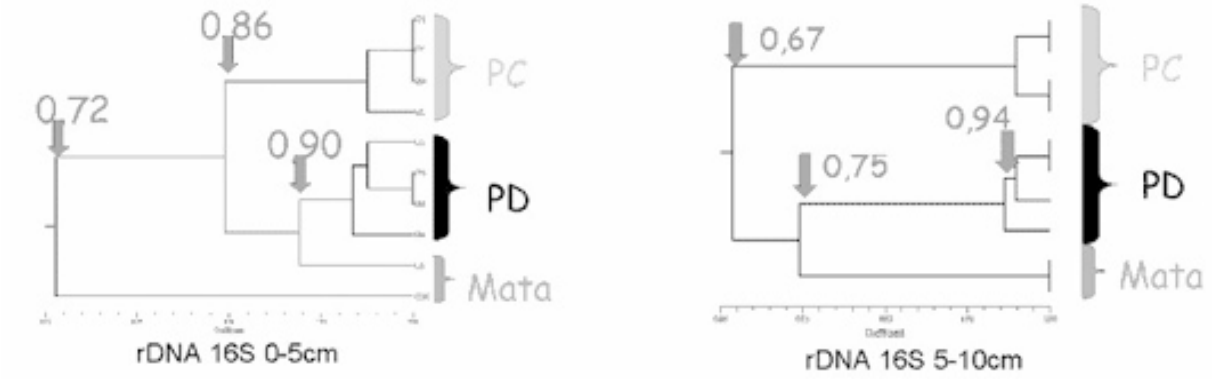

Figure 1. Dendrograms representing the similarity between DGGE profiles produced by 16S rDNA fragments amplified from soil extracted DNA. Numbers near arrows represent similarity values (PC: conventional tillage; PD: no tillage; Mata: Cerrado forest soil)

Conclusions

Soil structure and bacterial diversity were better early indicators of alterations in soil quality conditions induced by tillage, when compared to total soil carbon and other soil physical attributes. We hypothesize that soil structural improvement resulting from the conversion to no tillage systems creates the environmental conditions needed for the re-establishment of part of the native microbial genotypes repressed by the soil physical degradation caused by conventional agricultural systems.

References

Castro Filho, C.; Lourenço, A.; Guimarães, M. De F.; Fonseca, I. C. B. (2002) Aggregate stability under different management systems in a red Latosol in the State of Paraná, Brasil. *Soil Tillage Research 65*: 45-51.

Gelsomino, A.; Keijzer-Wolters, A. C.; Cacco, G. and Van Elsas, J. D. (1999) Assessment of bacterial community structure in soil by polymerase chain reaction and denaturing gradient gel electrophoresis. *Journal of Microbiological Methods 38*: 1-15.

Nübel, U.; Engelen, B.; Felske, A.; Snaidr, J.; Wieshuber, A.; Amamm, R. I.; Ludwig, W. and Backhaus, H. (1996) Sequence heterogeneities of genes encoding 16 rRNAs in *Paenibacillus polymyxa* detected by temperature gradient gel electrophoresis. *Journal of Bacteriology*. *178*: 5636-5643.

Peixoto, R. S.; Coutinho, H. L. C.; Rumjanek, N. G.; Macrae, A. and Rosado, A. S. 2002. Use of *rpo*B and 16S rRNA genes to analyse bacterial diversity of a tropical soil using PCR and DGGE. *Letters of Applied Microbiology 35(4):* 316–320.

Van Elsas, J. D.; Garbeva, P.; Salles, J. (2002) Effects of agronomical measures on the microbial diversity of soils as related to the suppresion of soil-borne plant pathogens. *Biodegradation 13*: 29-40.