XXXV Congresso Brasileiro de Ciência do Solo
CENTRO DE CONVENÇÕES - NATAL / RN
O SOLO E SUAS MÚLTIPLAS FUNÇÕES
02 a 07 DE AGOSTO DE 2015

Soil Structure in Different Management Systems[1]

Adriana Pereira da Silva [2]; Letícia Carlos Babujia [3]; Julio Cezar Franchini [4]; Ricardo Ralisch [5]; Mariangela Hungria [6]; Maria de Fátima Guimarães [7]

[1] Trabalho executado com recursos do PROBIO II–Embrapa e Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq
[2] Professor; Universidade Paranaense - UNIPAR; Umuarama, PR; E-mail: adrianapsilva@unipar.br; [3] Estudante de Pós-doutorado (bolsista CNPq); Embrapa – CNPSo; E-mail: leticiacb_@hotmail.com; [4] Pesquisador; Embrapa – CNPSo; E-mail: julio.franchini@embrapa.br; [5] Professor; Universidade Estadual de Londrina – UEL; E-mail: ralisch@uel.br; [6] Pesquisador; Embrapa – CNPSo; E-mail: mariangela.hungria@embrapa.br; [7] Professor; Universidade Estadual de Londrina; E-mail: mfatima@uel.br.

SUMMARY: Soil and crop management have a fundamental role in the maintenance and improvement of soil quality. The aim of this study was to qualify and quantify homogeneous morphological units (HMUs) in a dystroferric Red Latosol, in a 22-year experiment with treatments consisting of a no-tillage planting system (NT), no-tillage with chiseling every three years (NTC) and conventional tillage (CT), using crop rotation (CR) [with five different crop species in three years] and succession systems (CS) [only two crop species]. The cultural profile method was used as described by Tavares Filho et al. (1999). The determining factor in the morphological changes to the soil was the degree of mechanical intervention it was subjected to during preparation and planting. Higher volumes of compact soil were found in the profiles taken from treatments with a higher degree of tillage. The NT and NTC treatments presented HMUs with a continuous and cohesive structure and increased visible porosity at the surface, and continuous and cohesive units with lower porosity below this layer. The surface layer of the NT treatment presented free units made up of small and medium sized clods, and below this layer, compact, continuous units with little porosity. The soil management systems with crop rotation presented less compact units and roots with fewer morphological deformities than in the treatments with succession systems.

Index terms: cultural profile, soil tillage; no-tillage.

INTRODUCTION

The biggest challenge within modern agriculture is to find soil management systems that contribute to the economic and environmental sustainability of production systems. The no-tillage planting system (NT), in which the soil is not disturbed through tillage, reduces impacts on soil structure and has been indicated as an alternative means of sustainable soil management. Soil preparation is the activity with the most influence on the physical properties of the soil, as it has a direct impact on its structure (Ralisch et al., 2010). On the other hand, cropping systems that involve crop rotation or succession have a fundamental role in the formation and stability of aggregates (Munkholm et al., 2013).

Performing qualitative and quantitative evaluation on soil structure in the field in order to verify the effect of soil use and management on the morphology of the soil is challenging. The French cultural profile methodology (Gautronneau & Manichon, 1987), modified by Tavares Filho et al. (1999) for tropical conditions, has proved to be promising in this area. This methodology identifies soil volumes that are affected by the intervention of agricultural tools, root systems and natural factors, providing a differentiated picture of the effects of agriculture on the conservation and quality of the soil. Tamia et al. (1999) use the term Homogeneous Morphological Units (HMUs) to describe the soil volumes in the cultural profile affected by soil use and management activities.

The aim of this study was to qualify and quantify homogeneous morphological units (HMUs) in a dystroferric Red Latosol, in a 22-year experiment with treatments consisting of a no-tillage planting system (NT), no-tillage with chiseling every three years (NTC) and conventional tillage (CT), using crop rotation (CR) [with five different crop species in three years] and succession systems (CS) [only two crop species].

MATERIAL AND METHODS

Characterization of the experimental area

According to the Brazilian classification system, the soil is a very clayey dystroferric Red Latosol, and according to the American classification system it is a Rhodic Eutrudox with 710 g clay, 82 g silt and 208 g sand per kg^{-1} of soil.

The study compared the effects of three soil preparation systems: no-tillage planting (NT), where sowing is carried out on the residues of the previous crop and mechanical intervention is restricted to the digging of a narrow planting row (~4 cm deep); no-tillage with chiseling every three years (NTC), with the objective of breaking up the compact surface layer (~25 cm deep) but without the use of soil leveling operations; and conventional tillage (CT), where the soil is prepared every year with a disc plow (~20 to 25 cm deep), followed by a leveling harrow (~15 cm deep) before the planting of the summer crop, and a heavy harrow (~15 cm deep) followed by a light harrow (~15 cm deep) in the winter. The chisel plow used in the NTC treatment was last used three years before the soil evaluation took place.

In addition, each soil preparation system was submitted to the effects of crop rotation and succession. The crop rotation (CR) consisted of five different crop species: white lupine (*Lupinus albus*)-maize (*Zea mays*), black oat (*Avena strigosa*)-soybean (*Glycine max*), wheat (*Triticum aestivum*)-soybean, every three years; and crop succession (CS) with soybean in the summer and wheat in the winter.

Cultural Profile

The cultural profile method was used for the evaluations, as described by Tavares Filho et al. (1999). Cultural profile methodology classifies HMUs into two levels: (1) organization of clods in the soil profile (C- continuous; F- cracked; L- free and Z-laminar), and (2) internal state of the clods (μ- not compact; Δ- compact and μΔ/Δμ- ± compact).

Statistical analysis

Three charts were prepared for each profile: the first shows the HMUs of the profile, the second the layers in 10 cm intervals and a third the profile perimeter only. The last chart was used as a template for trimming the first two to exactly the same size. Next, the HMU chart was intersected with the depth chart, to obtain a fourth chart with the areas of each HMU per profile depth. The polygon areas were calculated for each scheme (in cm^2) as described in Pereira Neto et al. (2007).

RESULTS AND DISCUSSION

The profiles for the NT treatments under crop rotation **(Figure 1)** presented continuous units in the surface layer, which were homogeneous, cohesive and porous, corresponding to a CμΔ structure. The roots were branched without much twisting and were positioned vertically in the profile. Below this layer, the units presented medium porosity, corresponding to a CμΔ/Δμ structure, with highly branched roots that were slightly flattened and also situated vertically in the profile.

The other NT profiles with crop succession presented units at the surface corresponding to a CμΔ structure **(Figure 1)**, with root morphology similar to that described for the NT treatment with crop rotation. The CμΔ structures with higher visible porosity found in the surface layer of the NT treatments (Fig. 1) can be attributed to higher TOC levels, which were higher at the surface due to the presence of crop residues and the higher concentration of roots at this depth (Morris, et al., 2010; Giarola et al., 2013).

According to Franchini et al. (2012), considering that the NT system involves the least tillage, the permanent presence of soil coverage and crop diversification through rotation, chiseling of the soil is not required to break up the compacted layers as was observed in this study. This practice increases production costs through fuel consumption and labor, and the disruption of the structure of the soil can lead to loss of soil, water and nutrients through erosion.

The NTC profile under crop rotation presented cracked units at the surface. This unit was characterized by the presence of small and medium clods, which were porous but with indications of compression and presented visible medium roughness, corresponding to a FμΔptmt structure **(Figure 1)**. This profile presented rectilinear, branched roots growing mainly between the cracks and vertically through the clods. For the NTC treatment with crop succession, the surface predominantly contained units corresponding to a CμΔ structure **(Figure 1)**, with root morphology similar to that described for the NT treatments with crop rotation and succession. According to Tavares Filho et al. (2001), if structures that allow the diffusion of oxygen and ideal conditions of humidity and nutrients are present, the roots grow towards the points of lowest resistance, although they may suffer morphological deformations. Ralisch et al. (2010) observed that mechanical disruption without root complementation promoted short-lived effects on the physical recuperation of the soil, making continuous addition of organic residue through cover crops or green manure necessary in order to produce longer-lasting effects.

The CT treatment under crop rotation and succession presented a unit corresponding to LμΔptmt structure **(Figure 1)**. Below this structure there were continuous and compact units with some visible porosity, with flattened and twisted branched roots positioned vertically and horizontally in the profile, corresponding to a CΔμ structure.

In the CT profiles under crop succession, below the LμΔptmt structure there was a cracked unit with large clods corresponding to a FΔgt structure, which was compact with low porosity and with flattened and twisted roots with some branching that were positioned vertically between the cracks **(Figure 1)**. Next to this structure in one of the profiles was a more compact unit with no visible porosity and few very flattened roots positioned horizontally, corresponding to a CΔ structure.

Despite being more evident in the NT and NTC areas, crop rotation had a small effect in the CT area, which presented roots that were less flattened and twisted, as was also observed by Munkholm et al. (2013). According to their study, these differences can be observed as the visual evaluation of the soil in the field allows for analysis of the growth and behavior of the roots.

Various studies demonstrate that soil preparation involving aeration and harrowing reduces organic matter content, especially in the tropics (Balota & Auler, 2011). For this reason, the intense tillage of the soil in CT systems disaggregates the macroaggregates that are important for the protection and preservation of organic matter, resulting in its rapid oxidation and a reduction in the quality of the soil (López-Guarrido et al., 2012).

CONCLUSIONS

The superior soil quality found in NT and NTC planting systems, which contain HMUs that are predominantly less compact and present a higher porosity than those observed in CT systems.

Crop rotation contributed to the conservation of the structure of the soil by reducing the effects of soil management.

The profiles under crop rotation systems presented less compact soil volumes than those under crop succession systems and with less morphologically deformed roots.

ACKNOWLEDGMENTS

The project was partially financed by PROBIO II-Embrapa and CNPq-Universal (470515/2012-0). We would like to thank Jose´ Francirlei de Oliveira, Giovani de Oliveira Arieira and Edinei de Almeida for their assistance in the analysis of the cultural profiles. A.P. Silva, M. Hungria and M.F. Guimara˜es would also like to thank the National Council for Scientific and Technological Development (CNPq) for granting their PhD and Research fellowships.

REFERENCES

BABUJIA, L.C., HUNGRIA, M., FRANCHINI, J.C., BROOKES, P.C. Microbial biomass and activity at various soil depths in a Brazilian oxisol after two decades of no-tillage and conventional tillage. Soil Biology & Biochemistry, 42:2174–2181, 2010.

BALOTA, E.L., AULER, P.A.M. Soil microbial biomass under different management and tillage systems of permanent intercropped cover species in an orange orchard. Revista Brasileira de Ciência do Solo, 35:1873-1883, 2011.

FRANCHINI, J.C., DEBIASI, H., BALBINOT JUNIOR, A.A., TONON, B.C., FARIAS, J.R.B., OLIVEIRA, M.C.N, TORRES, E. Evolution of crop yields in different tillage and cropping systems over two decades in southern Brazil. Field Crops Research, v: 137:178–185, 2012.

GAUTRONNEAU, Y., MANICHON, H. Guide méthodique du profil cultural, Lyon: CEREF-GEARA, 1987.71p.

LÓPEZ-GUARRIDO, R., DEURER, M., MADEJÓN, E., MURILLO, J.M., MORENO, F. Tillage influence on biophysical soil properties: The example of a long-term tillage experiment under Mediterranean rainfed conditions in South Spain. Soil & Tillage Research, 118:52–60, 2012.

MUNKHOLM, L.J., HECK, R.J., DEEN, B. Long-term rotation and tillage effects on soil structure and crop yield. Soil & Tillage Research, 127:85–91, 2013.

PEREIRA NETO, O.C., GUIMARÃES, M.F., RALISCH, R. FONSECA, I.C.B. Análise do tempo de consolidação do sistema de plantio direto. Revista Brasileira de Engenharia Agrícola e Ambiental, 11:489-496, 2007.

RALISCH, R., ALMEIDA, E., SILVA, A.P., PEREIRA NETO, O.C., GUIMARÃES, M.F. Morphostructural characterization of soil conventionally tilled with mechanized and animal traction with and without cover crop. Revista Brasileira de Ciência do Solo, 34:1795–1802, 2010.

TAMIA, A., MOREAU, R., FORTIER, M., YORO, G., 1999. Influence du travail du sol sur l'évolution physique d'un sol forestier ferrallitique après défrichement motorisé. Étude et Gestion des Soils, 6:27–29, 1999.

TAVARES FILHO, J., RALISCH, R., GUIMARÃES, M.F., MEDINA, C.C., BALBINO, L.C., NEVES, C.S.V.J. Método do perfil cultural para avaliações do estado físico de solos em condições tropicais. Revista Brasileira de Ciência do Solo, 23:393–399, 1999.

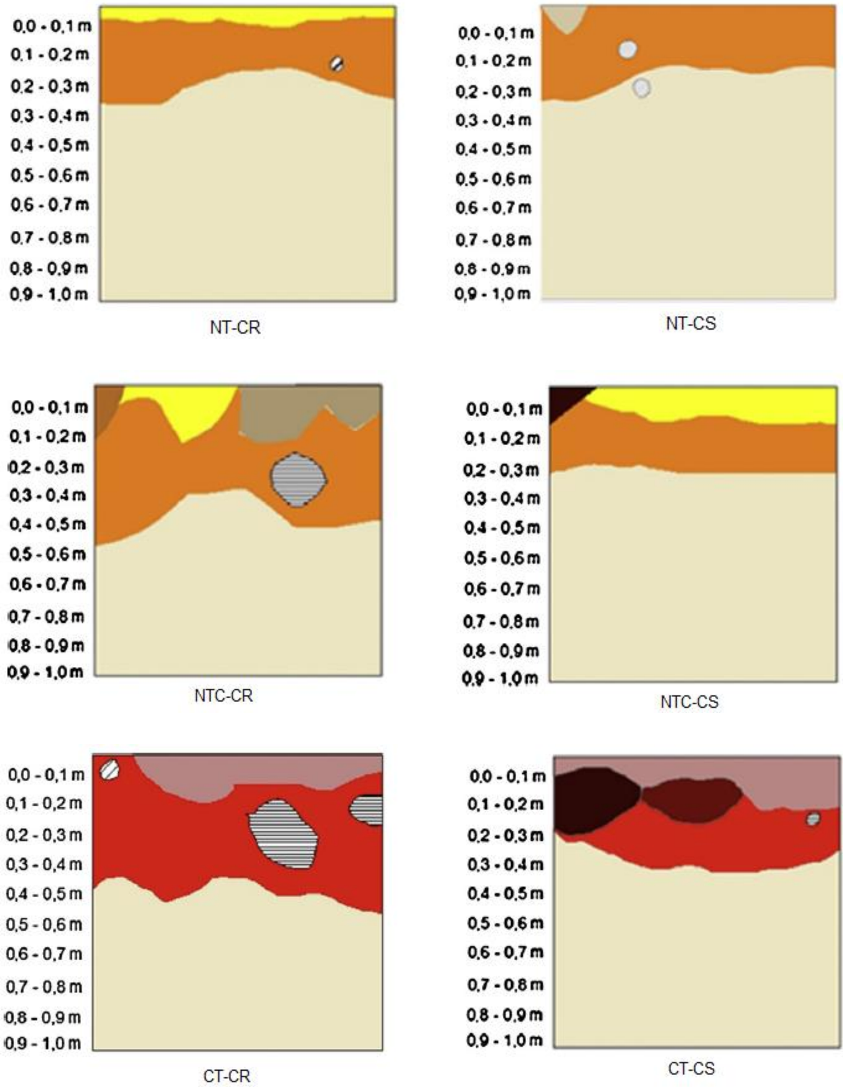

Figura 1 – Cultural profiles of a dystroferric Red Latosol under no-tillage system (NT); no-tillage planting system with chiseling every three years (NTC) and conventional tillage system (CT) with crop rotation (CR) and crop succession (CS).

Organization of clods (HMUs): C, continuous soil volume; F, cracked soil volume; L, free soil volume. Internal state of clods: μ, porous; μΔ, porous with indications of compression; μΔ/Δμ, medium porosity; Δμ, compact with some porosity; Δ, compact with no visible porosity. Size of clods: pt, small clods; mt, medium clods; gt, large clods. Structure resulting from macrofauna activity: G, gallery (3 to 10 cm Ø); C, chamber (> 10 cm Ø). Crop rotation (CR): lupine/maize/black oats/soybean/wheat/soybean. Crop succession (CS): soybean/wheat.