EFFECT OF TILLAGE PRACTICES ON AGGREGATE SIZE DISTRIBUTION IN A LATOSSOLO VERMELHO (OXISOL) OF SP-BRAZIL

M.M. Taboada-Castro[A], *M.C. Alves*[B] *and J. Whalen*[C]
[A] Universidad de A Coruña. Facultad de Ciencias. Campus de A Zapateira, 15071. A Coruña, Spain.
[B] Universidade Estadual Paulista. Facultade de Engenharia. Campus de Ilha Solteira, São Paulo-Brazil.
[C] McGill University. Faculty of Agricultural and Environmental Sciences. Montreal. Canada.

Abstract
The size and aggregation state of soil aggregates can be influenced by different soil management processes. The objective of this work was to determine the influence on water stable aggregate size distribution of two different tillage options, conventional tillage and no-tillage with cover plants in spring in a succession of beans (*Phaseolus vulgaris*) in winter and maize (*Zea mays*) in summer (*Zea mays*). Soil samples were collected at two depths (0-5 cm and 5-15 cm) before management of the cover plants in 2002. The water stable aggregates were determined by wet sieving, and six diameter classes were differentiated. Independently of the crop system, succession of crops and depth, the most abundant aggregate size class was that >4 mm in diameter. For the 0-5 cm depth, a higher percentage of water stable aggregates with a diameter >4 mm (56.8-67.9%) were found in the conventional system compared with the no-tillage treatment (48.2-53.4%). This fact is associated with the higher organic material content found with conventional tillage at the time of evaluation. In the conventional system, at a depth of 0-5 cm, over 60% of the macroaggregates were water stable in guandú, mucuna and fallow. However, in the no-tillage case, mucuna had a negative effect on stability in the uppermost surface horizon.

Additional Keywords: soil structure, distribution of aggregate sizes, no-tillage, conventional tillage, crop systems.

Introduction

The size of aggregates and aggregation state can be influenced by different cropping processes and agricultural activities that alter the content of organic matter and the biological activity of the soil. Over short periods of time, the stability of soil aggregates is modified under the influence of different cropping treatments, probably being more related to changes in the organic constituents than to the actual total organic matter content (Haynes *et al*., 1991). This aspect was shown by Baldock *et al*. (1987) and Haynes and Swift (1990). However, over long periods of time, the stability of the aggregates diminishes as the organic matter content declines as a result of it being used as an energy source by the microorganisms of the soil.

Crop systems present a differentiated behavior on soil aggregation. Grasses, due to their extensive root system, are the plants that present the greatest effect on the aggregation and the highest aggregate stability (Harris *et al*., 1996; Tisdall and Oades, 1979; Carpenedo and Mielniczuk, 1990; Paladini and Mielniczuck, 1991). On the other hand, the different crop systems exercise their effects on the formation and stabilization of the aggregates in a differentiated way and that depending on the type of cropping and soil use, their effects will be bigger or smaller in terms of degradation. Considering these aspects, the objective of this work was to evaluate the impact of crop rotation and soil management systems on its structural stability, measured from the distribution of the size of water stable aggregates

Materials and Methods

This study was carried out in an experimental area of UNESP, located at Selvíria (Mato Grosso do Sul, Brazil) with geographical coordinates of 51° 22' longitude, west of Greenwich, and 20° 22' latitude south, with altitude of 335 meters. The soil of the area is a Latossolo Vermelho Distrófico (Demattê, 1980; EMBRAPA, 1999) and according to *Soil Survey Staff* (1998) it is an Oxisol. The study was performed on an area with conventional tillage and on another with no-tilling. For a five year period the following rotation was carried out: beans (*Phaseolus vulgaris*) in the winter, cover plants in spring and maize cultivation in summer. The management of the cover plants was carried out before the end of the vegetative cycle and it consisted of drying the no-tillage area and of incorporation by harrowing in the conventional tillage area.

The experimental design used was that of random blocks in rows with ten different treatments and four repetitions. The treatments consisted of conventional tillage systems and no-tillage and of cover plants with guandú (*Cajanus cajan*), crotalária (*Crotalaria juncea*), mucuna (*Mucuna aterrima*) and milheto (*Pennisetum americanum*), apart from spontaneous vegetation in fallow areas. The sampling process was carried out on November 18, at the end of the vegetative cycle of the cover plants during the agricultural year of 2002. Soil samples were collected at two depths: 0-5 cm and 5-15 cm. Aggregate stability was determined by wet sieving, using the Angers and Mehuys (1993) method, initially using aggregates with a diameter between 4 and 6.35 mm. The classes of aggregate sizes considered were: >4 mm; 4-2 mm; 2-1 mm; 1-0.5 mm; 0.5-0.25 mm and <0.25 mm. The percentage of water stable aggregates (WSA) was determined for each of the six classes along with the mean weight diameter (MWD) for the four repetitions in each of the layers studied.

Results and Discussion

Figures 1 and 2 show histograms of the particle size distribution obtained after wet sieving. The results show that the fragment size distribution, in terms of percentage, behave differently between the treatments but that in both cases the >4mm fraction is highly stable. The other size classes did not surpass 20% in any case.

To compare the effects of tillage on the formation and stability of aggregates, structural stability was determined in land adjacent to the experimental area with natural vegetation ("*cerrado*") representing the original aggregation conditions of the soil before subjecting it to agricultural activities. In this reference soil, 89.6% of the water stable aggregates of the uppermost surface layer correspond to the >4 mm class.

Of the two tillage systems, better aggregate stability of the soil was observed in conventional tillage, as seen by the high percentage of aggregates of diameter >4 mm at a depth of 0 to 5 cm (range from a minimum of 56.8% to a maximum of 67.9%) with respect to that calculated in no-tillage (48.2% to 53.4%) (Figure 1). The better structure in conventional tillage could be attributed to the effect of different agents that intervene in the aggregate stability. On the one hand, this could be due to a higher organic matter content as a consequence of the incorporation to the soil of residues coming from winter cropping (*beans*) and on the other hand, to that during the tillage operations, by the effect of soil turning, compacted horizons would be taken to the surface, forming stable aggregates that would arise from the compression (Carpenedo and MielniczuK, 1990) and not from the biological action of roots or microorganisms. The lower proportion of macroaggregates in no-tilling would be a consequence of the decrease in the organic matter content of the soil at the time of sampling because the residues of the cover plants had not been managed. Furthermore, for the >4 mm class the histograms show a considerable reduction in the percentage of water stable aggregates in no-tilling at a depth of 5-15 cm (Figure 2), with values that do not surpass 40%.

The second most abundant fraction was represented by macroaggregates of the diameter class 2-4 mm, reaching percentages above 10% and below 20%. In accordance with Tisdall and Oades (1982) the water stable aggregates of > 2 mm diameter remain aggregated mainly because of the action of the roots and hyphae in the case of soils with high carbon contents, and in soils of low organic carbon content (<10 g kg^{-1}) they would only remain together by the action of transitory cementing agents.

It is necessary to consider that the quantities of microaggregates are of the same order of magnitude, representing less than 10% of the fragmented aggregates, except in no-tilling in the deepest horizon. In guandú, mucuna and fallow more than 60% of the macroaggregates were water stable, not breaking up after the experiment, in the conventional system at a depth of 0-5 cm. The response to the deaggregation of these treatments was modified in no-tilling, as seen in the reduction in the percentage of particles in this same class. This effect is much greater at a depth of 5-15 cm, where the percentages of particles with > 4 mm diameter varied from 30 to 40%.

Conclusions

After five years of crop rotation, the soil presented a lower capacity to aggregate compared with natural soil. Independently of the tillage system, crop successions and depth, the most abundant class of aggregate sizes was that at >4 mm. The conventional system presented a higher percentage of water stable aggregates with diameter >4 mm than in no-tilling and for both depths. This finding is related to the higher content of organic matter found in the conventional tillage treatment during the analysis period.

Acknowledgements

This work was funded by XUNTA de GALICIA (Spain) through a grant awarded to the senior author. The authors thank the Faculty of Engenharia, Campus de Ilha Solteira, Brazil, for allowing the use of Fazenda de Ensino e Pesquisa and the Laboratory of Física do Solo to perform experiments.

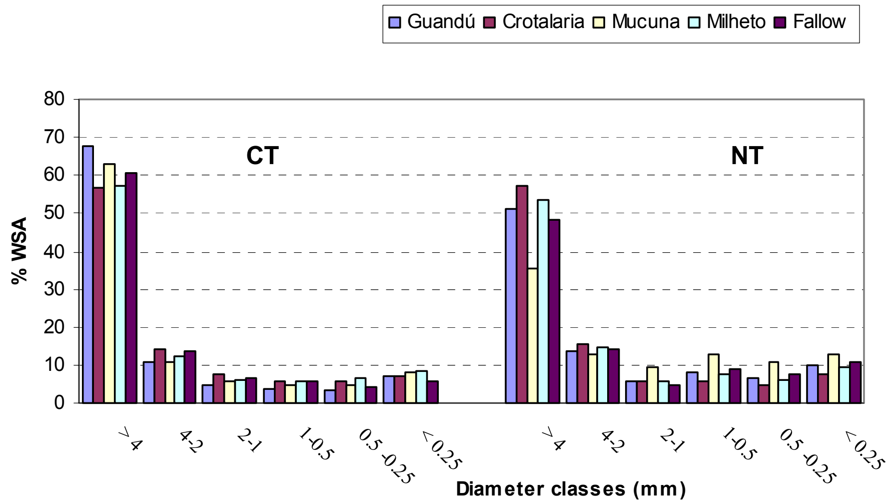

Figure 1. Aggregate size distribution in conventional tillage and no-tillage at a depth of 0-5 cm.
CT: conventional tillage; NT: no-tillage.

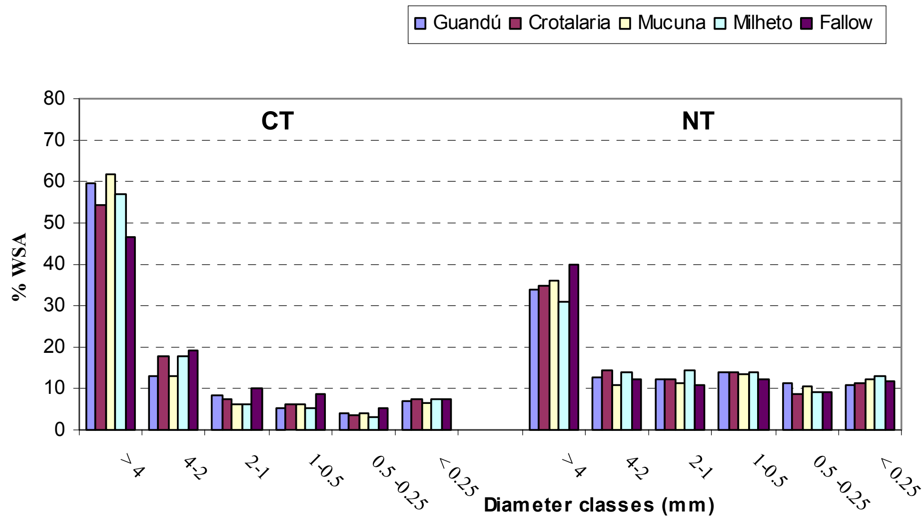

Figure 2. Aggregate size distribution in conventional tillage and no-tillage at a depth of 5-15 cm.
CT: conventional tillage; NT: no-tillage.

References

Angers, D.A. and Mehuys, G. (1993). Aggregate stability to water. *In:* Carter, M.R. (ed). *Soil sampling and methods of analysis*. Canadian Society of Soil Science, Lewis Publisher, Boca Raton, FL. pp.651-657.
Baldock, J.A., Kay, B.D. and Schnitzer, M. (1987). Influence of cropping treatments on the monosaccharide content of the hidrolisater of a soil and its aggregate fractions. *Can. J. Soil Sci*., Ottawa. 67, 489-499.
Carpenedo, V. and Mielniczuk, J. (1990). Estado de agregação e qualidade de agregados de latossolos roxos, submetidos a difentes sistemas de manejo. *R. Bras. Ci. Solo*. Campinas. 14, 99-105.
Harris, R.F., Chesters, G. and Allen, O.N. (1966). Dinamics of soil aggregation. *Adv. Agrom.*, New York. 18, 107-169.
Haynes, R.J. and Swift, R.S. (1990). Stability of soil aggregates in relation to organic constituents and soil water content. *J.Soil. Sci*., London. 41:73-83.
Haynes, R.J; Swift, R.S. and Stephen, R.C. (1991). Influence of mixed cropping rotations (pasture arable) on organic matter content, water stable aggregation and clod porosity in a group of soils. *Soil Til. Res*, Amsterdam. 19, 77-87.
Paladini, F.L. and Mielniczuk, J. (1991). Distribucão de tamanho de agregados de um solo Podzólico Vermelho-Escuro afetado por sistemas de culturas. *R. Bras. Ci. Solo*, Campinas. 15, 135-140.
SSS (Soil Survey Staff). (1998). Keys to soil Taxonomy. USDA. 326.pp. Washington, DC.
Tisdall, J.M and Oades, J.M. (1979). Stabilization of soil aggregates by the root systems of raygrass. *Austr. J. Soil Res., Victoria*. 17, 429-441.
Tisdall, J.M and Oades, J.M. (1982). Organic matter and water-stable aggregates in soils. *J. Soil Sci*., London. 33, 141-163.