Aggregation of an Oxisol under management systems for 14 years in the Midwest of Brazil

Júlio Cesar Salton[A], Alex Ramos Costa[B] and Josileia Acordi Zanata[C]

[A]Embrapa Western Region Agriculture, Dourados,MS,Brazil, Email salton@cpao.embrapa.br
[B]University Center of Grande Dourados, Unigran, Dourados, MS, Brazil, Email alex_gardi@hotmail.com
[C]Embrapa Western Region Agriculture, Dourados,MS,Brazil, Email josileia@cpao.embrapa.br

Abstract
The adoption of a production system after long time results in changes in soil properties that can influence the soil quality and the productivity of crops. In order to evaluate the effect of soil management systems including crop-livestock was evaluated the soil aggregation in a long-term experiment located in Dourados, MS in the Midwest region of Brazil. Four management systems were implemented and conducted since 1995 in a clayey Oxisol with soybean cultivation in conventional tillage and no-tillage, permanent pasture and soybean in rotation with pasture on no-tillage. The largest average aggregate size was found in systems with the greatest time with the presence of grazing. This trend was also found to separate the aggregate size classes and these systems with the presence of as much pasture was observed in the class greater than 2 mm. The largest amount of aggregates class lower than 0.25 mm was found in the conventional system.

Key Words
Soil quality, no-tillage, crop-livestock, Savannas, tropical agriculture.

Introduction
Crop-livestock integration system together with no-tillage can be a solution to a serious and old problem of soil conservation and seasonal forage production in Brazil. This new production system based on the integration of crops and pasture has advantages for both activities. There are many combinations of this system that can be used for different soil and climate conditions. Usually, this system has shown to be able to cause breaks in diseases and pest cycles, to increase the efficiency of fertilizer and lime, to intensify crop production and nutrient recycling and also to maintain soil cover using plants and/or straw. Together, all these benefits can improve soil and environment quality (Salton *et al.* 2001). Crop-livestock integration system must include pasture in rotation or in consortium whit crops, which usually are directly grazed. This production system can promote significantly change in chemical, physical and biological soil attributes. Moreover, this system contributes to improvement of soil quality, especially when compared to systems with only crop. One approach way of assess modifications in soil due to the use of different production systems is the use of measurements that integrate several attributes, such as macro-aggregates formation. This work had the aim to compare the use forms and soil management systems after 14 year use by evaluating the soil aggregation.

Methods
Experimental area
The experiment has been carried out since1995 in an area of 28 ha located at Embrapa Western Region Agriculture in Dourados, Mato Grosso do Sul state, Brazil (22º14'S - 54º49'W and altitude of 430 m). The experimental area had been used for grain crops between 1970 and 1994 on conventional tillage. The soil is an Oxisol (kaolinitic with 630, 215 and 155 g/kg of soil for clay, silt and sand respectively). Regional climate is classified as Cwa - mesothermal humid climate with hot summers and dry winters. The experimental area was divided into seven plots, contend the following management systems: (a) soybean monoculture in summer and oat in winter with previous tillage using disc harrows (CS), (b) crop rotation, with soybean and corn in the summer, wheat and oats for the grain production, turnip for straw in the autumn-winter, keeping the sequence: .../turnip/corn/oats/soybean /wheat/soybean/... in no-tillage (NTS), (c) alternation of crops (soybean /oats) with pasture (*Brachiaria decumbens*) in no-tillage with cycles of two years and allowing to grazing pasture (CPR) and (d) one area of *Brachiaria decumbens* implemented in November/95 for permanent pasture (PP). The pasture in PP and CPR did not receive fertilizers or lime and the intensity grazing is adjusted to maintain a constant supply of forage, around 7%. The sequence of management systems is shown in Figure 1.

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Systems	1995	1995/96	1996	1996/97	1997	1997/98	1998	1998/99	1999	1999/00	2000	2000/01	2001	2001/02	2002	2002/03	2003	2003/04	2004	2004/05	2005	2005/06	2006	2006/07	2007	2007/08	2008	2008/09	2009
CS	C	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O
NTS a	C	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T
NTS b	C	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W
NTS c	C	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O	S	W	S	T	C	O
CPR a	C	S	O	S	O	*B. decumbens*				S	O	S	O	*B. decumbens*				S	O	S	O	*B. decumbens*				S	O	S	O
CPR b	C	*B. decumbens*				S	O	S	O	*B. decumbens*				S	O	S	O	*B. decumbens*				S	O	S	O	*B. decumbens*			
PP	*Brachiaria decumbens*																												

Figure 1. Sequence of crops in soil management systems on long-term experiment in Dourados, Brazil. C: corn, S: soybean, O: oat, T: turnip, W: wheat, CS: conventional system, NTS: No-till system, CPR: Crop-pasture rotation, PP: permanent pasture.

Soil sampling and methodology

Soil samples were collected in 2008 to assess the effects of management systems in soil aggregation using a grid of equidistant points with an interval of 30 m resulting in 240 sampling points (Figure 2). Monoliths with 20 x10 x 10 cm were collected and placed in sealed plastic boxes and properly identified for the determination of soil aggregation. Samples were kept in the shade and the soil was manually disaggregated observing the weak points of the monolith. Thereafter all soil samples were air dried and sieved through a 9.52 mm mesh sieve. Sample fragments retained on sieves (i.e. plants, stones and gravel) were removed from the samples. The method used for soil aggregation determination is described by Kemper and Chepil (1965) with amendments proposed by Carpenedo and Mielniczuk (1990) and Silva and Mielniczuk (1997).This method consisted of aggregate size separation in different classes by dry sieving. Two sub-samples of 50 g were sieved in a set of sieves with openings of 4.76, 2.00, 1.00, 0.50, 0.25, 0.105 and 0.053 mm by horizontal agitated vibration Solotest® during one minute with power of 30%. The content of remaining aggregate in each sieve was weighed. The values obtained in the sieving were used to calculate the mean weight diameter (MWD) through the following equation: $MWD = \Sigma(xi.wi)$, where wi is the proportion (%) of each class in relation to the total and xi is mean diameter of the classes (mm).

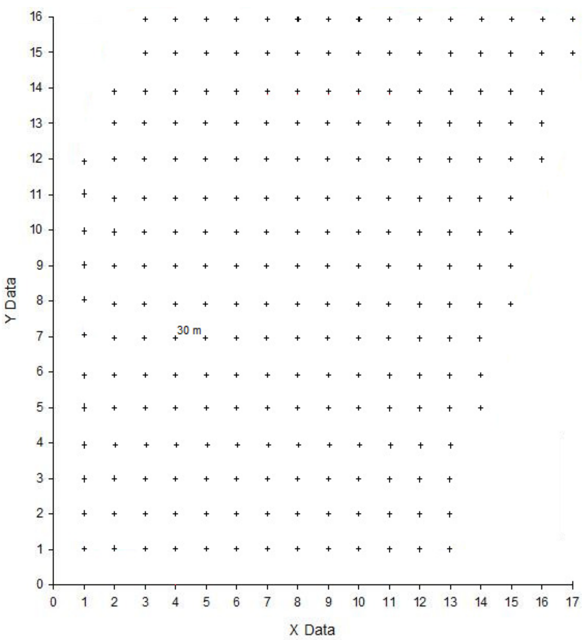

Figure 2. The grid with distribution of samples points on the long-term experiment in Dourados, Brazil.

Results

Considering only soil aggregate structures smaller than 0.25 mm, it was found predominant in conventional system (CS) with around 14% (Table 2). This lower degree of organization of soil in the CS is also evident in the analysis of the MWD (3 mm) compared to the others (Table 2). On the other hand, macro aggregates larger than 2 mm are present in systems with the presence of pasture (CPRa and PP) with values above 50%. It is evident the effect of pasture, especially root activity in the formation of macro aggregates as observed by Six *et al.* (1998), Six *et al.* (2004) and Salton *et al.* (2005).

Table 2. Relative distribution of the soil mass in class of size and mean weight diameter (MWD) of aggregates of an Oxisol submitted to management systems for 14 years in Dourados, Brazil.

Management system	Size class aggregate (mm)			MWD	n[1]
	<0.25	0.25 - 2.00	> 2.00		
	(%)			(mm)	
CS	14.1±0.72	12.0±0.31	30.4±1.31	3.03±0.09	26
NTS a	5.5±0.32	11.8±0.36	45.6±1.41	4.24±0.07	26
NTS b	5.4±0.41	12.2±0.34	45.7±1.62	4.18±0.11	26
NTS c	7.3±0.87	12.8±0.36	41.3±1.62	3.91±0.10	27
CPR a	2.7±0.17	12.2±0.31	51.0±1.06	4.67±0.06	42
CPR b	3.8±0.23	13.9±0.35	46.1±1.03	4.34±0.06	45
PP	2.2±0.12	10.6±0.29	56.2±0.98	4.93±0.06	48

[1]n: number of replications considered for calculating the mean and standard error for each system, CS: conventional system, NTSa: No-till system with sequence corn-oat- soybean -wheat- soybean -turnip, NTSb: No-till system with sequence soybean-turnip-corn-oat- soybean -wheat, NTSc: No-till system with sequence soybean-wheat- soybean -turnip-corn-oat, CPRa: Crop-pasture rotation with the sequence *B. decumbens*- soybean -oat, CPRb: Crop-pasture rotation with the sequence soybean -oat- soybean - *B. decumbens*, and PP: permanent pasture with *B. decumbens*.

The spatial distribution of MWD (Figure 3) coincides with the limits of management systems in the experimental area, i.e. is distinct the CS for systems with the presence of pasture, in the case of the integrated system (CPRb) possibly the effect of the recent presence of *B. decumbens* contribute to higher MWD than others. In no-tillage system (NTSb and NTSc) can be established that the presence of turnip, with a smaller volume and number of roots resulted in a lower value for the MWD. Aggregates formation in soil is the result of energy and matter flows that occur in the soil. It represents the degree of the soil organization, which is the initial phase of micro aggregates (<0.25 mm) formation is related to the interaction of mineral matter among themselves and with organic compounds (Tisdal and Oades 1982). Subsequently, the influence of the growth of roots, fungal hyphae, along with plant material

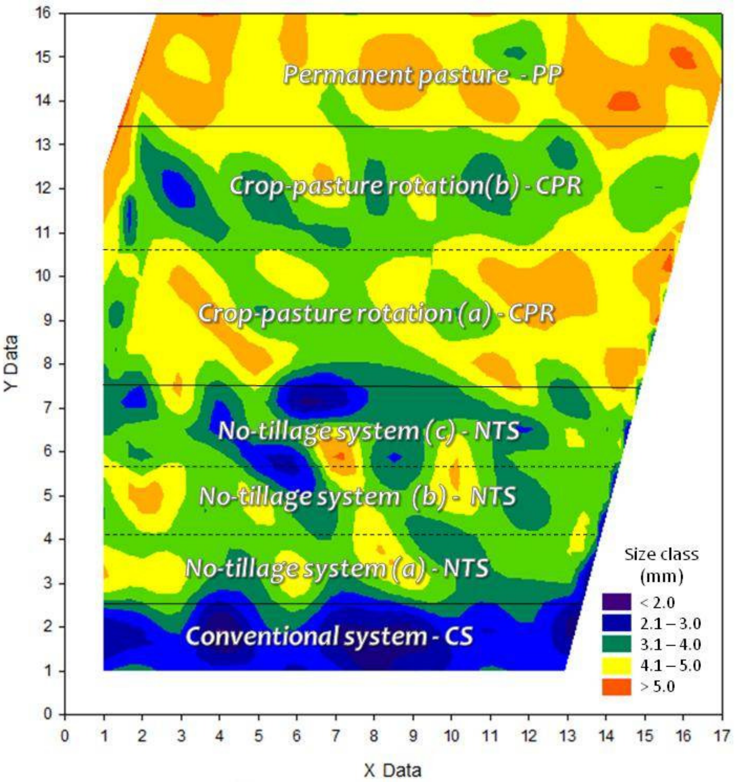

Figure 3. The spatial distribution of mean weight diameter (MWD) of aggregates and the limits of management systems conduced for 14 years on Oxisol in Dourados, Brazil.

stimulates the formation of more complexes and diverse structure as macro aggregates (> 0.25 mm). These structures are at a level of organization higher (Haynes and Beare 1996). Management systems to influence the intensity of flows of matter in soil resulting in different degrees of organization of the mass of soil aggregates.

Conclusion

The higher existence of the macro aggregates probably can be related to the presence and activity of the roots system of the plants and to the absence of revolving the soil with action of disc harrows. This sense production systems incorporating pasture and crop in no-till can be recognized as an alternative for improving soil quality.

References

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References

Carpenedo, V.;Mielniczuk,J. (1990) Estado de agregação e qualidade de agregados de Latossolos roxos, submetidos a diferentes sistemas de manejo. Revista Brasileira de Ciência do Solo, **14**, 99-105.

Haynes,R.J.; Beare,M.H. (1996), Aggregation and organic matter storage in Meso-thermal, Humid soils. In.: Carter, M. R.; Stewart, B. A. (Eds.) *Structure and organic matter storage in agricultural soils*. 213-262.

Kemper,W.D.; Chepil,W.S. (1965) Size distribution of aggregation. In.: Black, C. A. (Ed). *Methods of soil analysis*. 499-510.

Salton, J.C.; Mielniczuk, J. ; Bayer, C.; Fabrício, A.C.; Macedo, M. C. M.; Broch, D. L.; Boeni, M.; Conceição, P. C. (2005). Matéria orgânica do solo na integração lavoura-pecuária em Mato Grosso do Sul. Dourados: Embrapa Agropecuária Oeste, 2005 (Boletim de Pesquisa and Desenvolvimento).

Salton, J. C.; Fabrício, A. C.; Hernani, L. C. (2001) Rotação lavoura pastagem no sistema plantio direto. *Informe Agropecuário*, **22**, 92-99.

Six, J., Elliott, E.T., Paustian, K. and Doran, J.W., 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. *Soil Science Society of America Journal* **62**, 1367–1377

Six, J.; Bossuyt, H.; Degryze, S.; Denef, K. **(**2004) A history of research on the link between (micro)aggregates, soil biota, and soil organic matter dynamics *Soil and Tillage Research,* **79**, 7-31

Silva, I.F.; Mielniczuk,J. (1997) Ação do sistema radicular de planta na formação e estabilização de agregados do solo. *Revista Brasileira de Ciência do Solo*, **21**, 113-117

Tisdal, J.M.; Oades, J.M.(1982) Organic matter and water-stable aggregates in soil. *Journal of Soil Science*, **33**, 141-163.