academicJournals

Vol. 11(40), pp. 3929-3939, 6 October, 2016
DOI: 10.5897/AJAR2016.11320
Article Number: 89DE31160932
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Physical properties of a latosol eutrophic red under management systems after different winter crops successful by the soybean crop

Poliana Ferreira Da Costa[1]*, Paulo Sérgio Rabello De Oliveira[2], Jeferson Tiago Piano[2], Loreno Egidio Taffarel[2], Milciades Ariel Melgarejo Arrúa[2], Marcos Vinícius Mansano Sarto[3] and Shaline Séfara Lopes Fernandes[4]

[1]Universidade Federal da Grande Dourados – UFGD – Dourados, Brazil.
[2]Universidade Estadual do Oeste do Paraná – UNIOESTE, Brazil.
[3]Universidade Estadual Paulista Júlio de Mesquita Filho – UNESP, Brazil.
[4]Universidade Estadual de Mato Grosso do Sul – UENS, Brazil.

Received 14 June, 2016; Accepted 17 August, 2016

The objective was to verify the influence of winter crops under management mechanical (roller knife) and chemical (glyphosate), on soil physical properties and yield of soybeans. The experiment was carried out at the field under randomized block design in tracks scheme. The treatments consisted of four different winter crops (oats IPR 126, wheat BRS Tarumãt crambe FMS Bright and forage radish cultivar common) in tracks A and management different (chemical and mechanical) in bands B. The soil properties (macroporosity, microporosity, total porosity and density) were determined by collecting soil core in layers 0-10 and 10-20 cm depth, penetration resistance was determined with the aid of a penetrometer impact to a depth of 30 cm. The soybean harvest was held on 03/12/13, collecting two lines of the floor area of each plot. The evaluations were carried out after the winter crop management and post-harvest of soybeans. There was no significant difference in the interaction of the factors to the values of the porosity in the layer 0-10 cm of soil. As to the values obtained for the penetration resistance of the soil, it was found that the oat (0.91 MPa) and crambe (1.43 MPa) provided significant differences in the layer 0-5 cm depth, after the cycle of winter crops. Winter crops and different managements not affect soybean yield.

Key words: Plantation direct, compaction, conservation systems, soil structure.

INTRODUCTION

The adoption of technologies based on conservationists foundations as the tillage and the use of winter crops are alternatives to increase the sustainability of agricultural systems (Torres et al., 2014; Boer et al., 2007).

The success of the system lies in the fact that the straws accumulated by cover crops and crop residues

*Corresponding author. E-mail: poliferreiradacosta@hotmail.com

from commercial fields create favorable environments for the recovery and the maintenance of the quality of soil and water (Kliemann et al., 2006), beyond allowing favorable conditions for crop development and effective erosion control (Brancalião and Moraes, 2008) Because of the enormous benefits for soil biodiversity, this technology has expanded to various regions of the world, especially in countries such as Argentina, Brazil, Paraguay and Uruguay, which adopt this system in about 70% of the total cultivated area (Derpsch et al., 2010).

In general, the soil when in its natural state, under vegetation present physical characteristics as permeability, structure, soil density and pore space, agronomically desirable. However, as the soils are being worked (Andreolla et al., 2000) and the continuous adoption of soil management systems conventional, considerable physical changes are occurring (Silva et al., 2008).

The structure of the soil is one of the most important properties for the adaptation of the species, and it is by means of physical properties that can be done their monitoring, such as soil bulk density, microporosity, aggregate stability, resistance of soil, permeability, among others. These properties can indicate overgrowth, crusting, susceptibility to productivity loss, environmental degradation and mainly compression (Laurindo et al., 2009).

The process of soil compaction, to increase its density and its mechanical resistance to penetration (PR), as well as to reduce the volume of macropores, the capacity of water infiltration, the aeration and hydraulic conductivity affects the root development, resulting in reduction of crop productivity (Beutler et al., 2005).

For decompressing the ground the use of species of winter crops, especially with the use of crop rotation in species with root system quite aggressive, it is necessary, since this practice protects the soil against erosion, brings benefits to fertility and soil structure due to the elevation of the organic matter content, and improves the thermal amplitude of soil maintaining its moisture, enabling better performance of succeeding crops (Amossé et al., 2013).

According to Campiglia et al. (2010), the benefits of winter crops may still be supplemented, as the maintenance of high rates of infiltration of water through the combined effect of the root system and vegetation cover and promote large and continuous inflow of vegetal mass on the ground.

Among the winter crops that deliver these benefits may be indicated the crambe (*Crambe abyssinica* Hochst) considered a rustic plant widely used as fodder in crop rotation and soil cover (Varisco and Simonetti, 2012), the radish (*Raphanus sativus* L.) that in addition to favoring the inflow of organic matter to the soil has adverse allelochemicals reducing the infestation of weeds (Martins et al., 2016) and oats can also be indicated how to plant cover crops, all these cultures have great development in the southern region of Brazil.

Although there are already research related to direct planting in Paraná State is important to test this factor associated with winter cover and handlings checking and monitoring the physical properties of the soil (macroporosity, microporosity, total porosity and density) under the effects of white oat cultivation IPR 126, crambe, oilseed radish and wheat double purpose BRS Tarumã, in function of mechanical and chemical handlings succeeded by the soybean crop.

MATERIALS AND METHODS

The study was conducted at the Experimental Farm "Professor Antonio Carlos dos Santos Person " (latitude 24º 33 ' 22' ' S and longitude 54º 03' 24 ' ' W , with an altitude of approximately 400 m) at the Universidade Estadual do Oeste do Paraná - *Campus* Marechal Cândido Rondon in Eutrophic Red Latosol (LVe) (Embrapa, 2013). The intercropping antecedents in the area constituted in no-tillage system. In the Table 1 is described the chemical and physical characteristics of the area before the experiment. Due to the low of V% (percentage of saturation of bases) liming was performed 30 days before sowing at a dosage of 2 Mg ha $^{-1}$ (large 80 %) to raise it to 70%.

The area of conducting of the experiment has a history in which for a period of four years, traditionally, the winter corn were grown (for silage production) in the off season and soybeans in the summer crop. These crops were always performed under the no-tillage system.

The local climate, classified according to Koppen, is Cfa, subtropical humid mesothermal dry winter with rainfall well distributed throughout the year and hot summers. The average temperatures of the quarter more cold vary between 17 and 18°C, the quarter more hot between 28 and 29°C, in its turn, the annual temperature ranged between 22 and 23°C. The total average annual precipitation normal pluvial for the region vary from 1600 to 1800 mm. with quarter more humid presenting totals between 400 to 500 mm (IAPAR, 2006). The climate data of the experimental period were obtained in automatic climatological station of the University of Paraná, distant approximately 100 m of the experimental area and are presented in Figure 2.

The experiment was started in autumn-winter of 2012 and the area has been desiccated 30 days before sowing, using glyphosate-isopropylamine salt in the dose of 3.0 L ha^{-1} with a volume of 250 L ha^{-1}.

The experimental design used was randomized blocks in schematic of tracks, with three repetitions. On tracks A (5 x 40 m), four winter crops were allocated (IPR 126 oats, crambe Bright FMS, forage radish cultivate common wheat and BRS Tarumã). In ranges B (20 × 23 m), were allocated the managements of winter crops (chemist with isopropylamine and mechanical glyphosate -salt using knife roll). The plots were formed by a combination of bands A and B (5 × 20 m), each block had an area of 920 m² (23 × 40 m). During the development of the cultures was not performed any application of the herbicide. Winter crops were sown in the day 19/04/12, with drill seeder, coupled to the tractor on direct sowing system on maize straw. 60 kg ha^{-1} of oats` seed, 15 kg ha$^{-1}$ of crambe` seed, 15 kg ha^{-1} of radish` seeds of and 90 kg ha$^{-1}$ of wheat` seeds, with 0.17 m between lines were used. The fertilizer for growing oats, f. radish, fodder wheat and radish, was performed according to CQFS -SC (2004). For the correction of soil fertility 200 kgha^{-1} a formulated 8-20-20 (N, P_2O_5 and K_2O, respectively) were used. The fertilization in coverage was carried out using 90 kg ha^{-1} of N as urea.

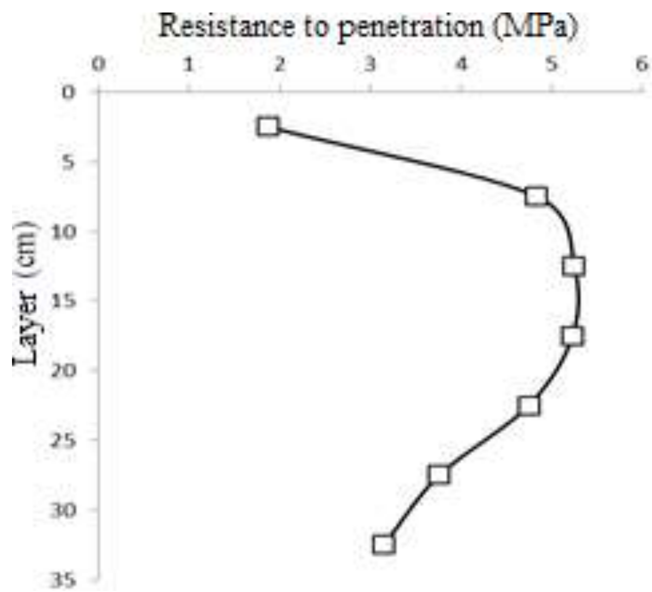

Figure 1. Soil resistance to penetration (MPa), at layer 0 to 35 cm depth, prior to deployment of winter crop, in Marechal Cândido Rondon (in March 2012).

Table 1. Chemical and physical characteristics of the soil (0 - 10; 10 - 20 cm), in the experimental area, prior to deployment of winter crop, in Marechal Cândido Rondon in March 2012.

Chemical characteristics of the soil											
Layer	P	MO	pH	H+Al	Al^{3+}	K^{+}	Ca^{2+}	Mg^{2+}	SB	CTC	V
cm	mg dm^{-3}	g dm^{-3}	$CaCl_2$				$cmol_c$ dm^{-3}				%
0-10	24.49	32.64	4.55	9.40	0.46	0.53	4.56	1,54	6,63	16,02	41,66
10-20	25.86	32.64	4.65	8.62	0.34	0.44	5.32	1,67	7,42	16,04	46,32

Physical characteristics of the soil							
Layer	Macropores	Micropores	Porosity of soil	Density of soil	Sand	Silt	Clay
cm		dm^{-3} m^{-3}		Mg m^{-3}		g kg^{-1}	
0-10	0.08	0.45	0.54	1.29	52.52	266.48	681.00
10-20	0.10	0.43	0.53	1.29	49.39	199.11	751.50

The values of resistance to penetration in the layer from 0 to 35 cm, before installation of the treatments are presented in Figure 1.

The treatment was performed 90 days after sowing, being the mechanic performed with knife roll and chemical with the application of the herbicide glyphosate-isopropylamine salt 480 g L^{-1} in the dose of 3.0 L ha^{-1}, with a volume of 250 L ha^{-1}.

After 30 days of culture management, the first collection was held for determination of properties physical properties. The density values (Ds-kg dm^{-3}) were evaluated by the method of volumetric ring (Blake, 1965) and the macroporosity (S-cm^3 cm^{-3}), from the relationship S = a - q, where the (cm^3 cm^{-3}) is the total porosity, calculated by the ratio a =1-(Ds/Dr), where Dr (kg dm^{-3}) is the real density and q (cm^3 cm^{-3}) is the water content in soil volume when subjected to a matric potential of -60 cm water column (Vomocil, 1965).

Sowing of soybean using the soybean cultivar BMX Potencia RR was held on 22/11/12. The area was previously desiccated using glyphosate-isopropylamine salt in the dose of 3.0 L ha^{-1} with a volume of 250 L ha^{-1}. For the base fertilization was used 347 kg ha^{-1} of a commercial formulated 2-20-20 (N, P_2O_5 and K_2O), being performed on the basis of chemical analysis of the soil (SFREDO, 2008). The seeds were treated with fungicide Carbendazim (150 g L^{-1}) + Tiran (350 g L^{-1}) 2 ml kg^{-1} of seed, insecticide Fipronil (250 g L^{-1}) 0.8 ml kg of $seed^{-1}$ and inoculated with Bradyrhizobium. The spacing, as well as the density of sowing, were carried out in accordance with the recommendation for the cultivar (BRASMAX, 2012).

For the sowing was used a seeder fertilizer coupled to a tractor, with the seeds deposited at a depth of average of 4 cm. During the crop development cycle fungicide applications were performed (triazole) at a dose of 0.65 L ha^{-1} with spray volume of 250 L ha^{-1} and (estrobilurina + triazol) in the dose of 0.30 L ha^{-1} with volume of 250 L ha^{-1} of commercial product. The soybean harvest was performed on 03/12/13, collecting two lines of the useful area of

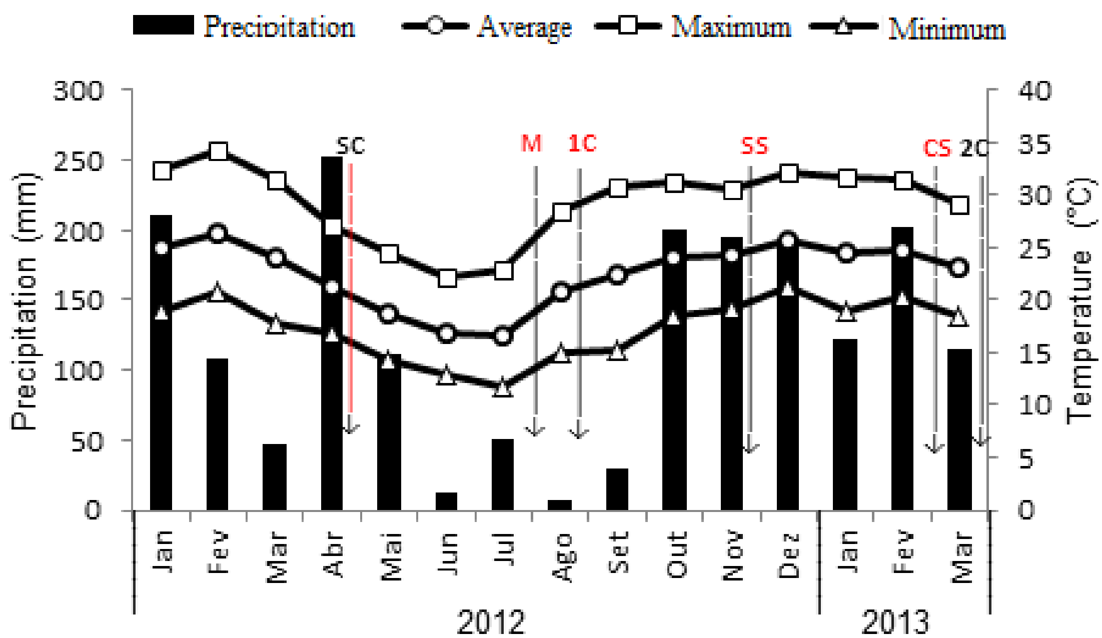

Figure 2. Monthly average temperatures maximum, minimum and average and precipitation accumulated during the months of the experimental period. SC: Seeding of winter crops. M: The realization of the managements of winter crops. 1C: First data collection. SS: Soybean sowing. CS: Soybean harvest. 2C: second data collection. Source: Automatic climatological station of the Nucleus of Experimental Stations of UNIOESTE, Marechal Cândido Rondon-PR.

each plot, which totaled 0.90 m² with this were estimated the quantity produced per hectare. For the determination of the weight of one thousand seeds and yield of soybean was realized the trail of the material with trailed crop beater. After the trail was determined the thousand seed weight according to Brazil (1992), and productivity (kg ha^{-1}), with discounts of impurity and moisture.

To 15 days after soybean harvest volumetric rings were collected for the determination of soil physical parameters as well as, performed the determinations of soil resistance to penetration. The determination of resistance to penetration and other physical properties of the soil was performed according to Embrapa (1997). The determination of soil resistance to penetration was performed with the use of an impact penetrometer model Stolf, with needle tip cone thin (60°), at three points in each plot. To minimize differences in soil moisture between treatments and between the depths, evaluation was performed three days after a precipitation, with humidity next of field capacity. The points were taken randomly, up to 30 cm of depth, and the data obtained in the field in the unit of impacts/decimeter processed in MPa, using the equation described by Stolf (1991).

The data obtained were submitted to statistical analysis using the SISVAR program (Ferreira, 2011), and the averages compared by the Tukey test at 5% level of probability.

RESULTS AND DISCUSSION

There was no difference (p>0.05) for average values of macroporosity, total porosity, microporosity and bulk density in the layer of 0 - 10 and 10 - 20 cm, on the basis of the factors studied after the managements of cover plants (Table 2). With regard to the results obtained after the harvesting of the soybean crop was found significance between the factors, for the values of macroporosity in the superficial layer of 0 - 10 cm of soil (Table 3). For the other physical characteristics of the soil (microporosity, total porosity and density) average values obtained were similar, not showing influences suffered by the treatments applied. There being thus possible to differentiate the most effective species, as well as more efficient management systems, improvement of soil physical properties.

It was expected that the different winter crops involve changes in the physical characteristics of the soil, because the root system of crops requires an adequate supply of oxygen to maintain its physiological operation once that, its roots perform gaseous exchanges through a system porous that must also ensure an adequate supply of nutrients and water (Torres and Saraiva, 1999). However the results obtained are similar to those found by Sanchez (2012), that evaluated the influence in the physical properties of the soil by the winter crops observed that the use of these plants, in its first cycle of cultivation, not promoted changes in soil bulk density, microporosity, total porosity, however, in the layer from 0.10 to 0.20 m were verified larger values of macroporosity in treatments of oat and ryegrass.

The values found (Table 3) demonstrate that there was little variation between the results. These results corroborate with the study conducted by Bertol et al. (2004), in which the authors have not observed variation in the physical properties of the soil by the use of different

Table 2. F values calculated for the soil properties in the layer 0-10 and 10-20 cm after the managements of winter crops.

Source of variation	DF	Macroporosity		Microporosity		Porosity total		Soil density	
		0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
Block	2	0.690	0.870	0.360	4.060	0.020	0.080	0.760	0.690
Crops (C)	3	4.130	0.760	0.340	0.500	1.100	0.130	0.370	0.570
Error 1	6	2.969	4.442	2.186	1.675	8.032	6.361	0.006	0.002
Management (M)	1	0.006	5.070	0.330	0.200	0.450	0.450	0.630	0.240
Error 2	2	8.310	1.063	16.681	4.235	9.981	4.114	0.004	0.004
C X M	3	0.280	1.340	0.350	1.320	2.720	8.050	0.860	1.780
Error 3	6	5.926	3.321	2.777	1.621	1.263	0.999	0.004	0.002
CV 1 (%)		20.330	27.920	5.770	3.040	5.410	5.030	6.290	3.650
CV 2 (%)		34.010	13.660	9.300	4.830	6.030	4.050	4.950	4.870
CV 3 (%)		28.720	24.140	3.790	2.990	2.140	1.990	5.000	3.330

CV 1: Coefficient of variation for crops; CV 2: Coefficient of variation for managements; CV 3: Coefficient of variation for crops with managements.

Table 3. F values calculated for the soil properties in Layer 0 to 10 and 10 to 20 cm, after the harvesting of the soybean crop.

Source of variation	DF	Macroporosity		Microporosity		Porosity Total		Soil density	
		0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
Block	3	1.250	0.840	0.570	0.350	1.560	1.840	4.320	0.500
Crops (C)	2	1.670	0.680	0.410	0.690	0.990	0.880	0.140	0.770
Error 1	6	3.324	11.518	10.483	13.432	8.689	2.765	0.014	0.016
Management (M)	2	3.620	1.350	1.470	1.030	0.930	1.260	3.570	0.450
Error 2	6	0.314	12.860	5.467	5.943	3.264	2.496	0.001	0.005
C X M	4	0.80*	0.340	0.990	1.510	1.880	1.660	2.180	0.550
Error 3	12	3.670	6.850	2.647	15.148	3.513	12.138	0.010	0.004
CV 1 (%)		28.300	49.480	7.190	8.520	5.730	3.340	9.220	9.460
CV 2 (%)		8.690	52.280	5.190	5.670	3.510	3.170	1.940	5.160
CV 3 (%)		29.740	38.160	3.610	9.050	3.640	6.990	7.620	4.810

*Significant at 5% probability by the F test, respectively. CV 1: Coefficient of variation for the crops; VC 2: Coefficient of variation for the managements; VC 3: Coefficient of variation for the crops with the managements.

cultivation systems, understood as rotation and succession with cultures of coverage in a production cycle, concluding that it would be necessary to carry out experiments for longer period of time to be able to check the results of the action of the plants on the physical properties of the soil.

Macroporosity

The values of macroporosity values obtained on the Layer 0 - 10 cm after completion of the managements of winter crops showed no significant difference between the treatments and the same occurred in the layer of 10 - 20 cm (Table 4).

For the found values of macroporosity after soybean harvest, the cultures that stood out were the forage radish in camanda of 0 - 10 cm (0.07 m^3m^{-3}) in the mechanical handling and the crambe in this same layer with the use of chemical management (0.07 m^3 m^{-3}). These same cultures showed higher values (0.09 m^3m^{-3}) also in the layer of 10 - 20 cm (Table 5). It is believed that regarding the macroporosity wheat presented higher results, because it is long cycle and with the mechanical handling may have suffered a stimulus for regrowth and rooting.

Considering the optimal values for the full development of plants, ranging from 0.07 to 0.17 m^3 m-^{3} (Drewry et al., 2003), in all layers, macroporosity values (Tables 4 and 5) found in this study (average of 0.06 m^3 dm^{-3}) are considered low which increases the risk of deficit of O_2 in the roots and reduces the continuity of pores and the permeability of soil (Lanzanova et al., 2007). The reduction of macroporosity in agricultural production systems tend to reflect negatively, reducing the total porosity and increasing soil density (Reichert et al., 2003).

The lower volume of macropores, with consequent greater volume of pores on the surface of the soil under no-tillage, can reduce the rate of water infiltration in this

Table 4. Macroporosity, microporosity, total porosity and density for the cultures of oats, crambe, radish and wheat, after being submitted to mechanical and chemical managements in the layer of 0 - 10 cm and in the layer of 10 - 20 cm of soil.

Crops	Macroporosity (m^3 m^{-3})		Microporosity (m^3 m^{-3})		Total porosity (m^3 m^{-3})		Density (mg m-^{3})	
Layer 0 - 10 cm								
	Management		Management		Management		Management	
	Mechanic	Chemical	Mechanic	Chemical	Mechanic	Chemical	Mechanic	Chemical
Oat	0.06	0.06	0.43	0.45	0.49	0.52	1.23	1.23
Crambe	0.09	0.08	0.43	0.45	0.53	0.53	1.19	1.19
F. radish	0.08	0.09	0.43	0.43	0.51	0.52	1.18	1.23
Wheat	0.10	0.09	0.43	0.43	0.53	0.53	1.15	1.16
Layer 10 - 20 cm								
	Macroporosity (m^3 m^{-3})		Microporosity (m^3 m^{-3})		Total Porosity (m^3 m^{-3})		Density (mg m^{-3})	
Oat	0.07	0.06	0.42	0.43	0.49	0.49	1.29	1.29
Crambe	0.06	0.07	0.42	0.43	0.48	0.51	1.31	1.26
F. radish	0.09	0.06	0.42	0.41	0.52	0.48	1.24	1.28
Wheat	0.09	0.07	0.41	0.43	0.50	0.50	1.25	1.31

Averages followed by the same capital letter in line and tiny in column in each characteristic do not differ by the Tukey test at 5% of probability of error.

Table 5. Macroporosity, microporosity, total porosity and density to the cultures of oats, crambe, forage radish and wheat at layer 0 to 10 cm and in the layer of 10 to 20 cm of the soil after the implementation of the collection of soybean.

Crops	Macroporosity (m^3 m^{-3})		Microporosity (m^3 m^{-3})		Total Porosity (m^3 m^{-3})		Density (m^3 m-^{3})	
Layer 0 – 10 cm								
	Management		Management		Management		Management	
	Mechanic	Chemical	Mechanic	Chemical	Mechanic	Chemical	Mechanic	Chemical
Oats	0.05	0.04	0.43	0.46	0.48	0.51	1.26	1.3
Crambe	0.06	0.07	0.43	0.44	0.49	0.51	1.38	1.21
F. radish	0.07	0.06	0.45	0.45	0.53	0.52	1.20	1.30
Wheat	0.07	0.05	0.45	0.46	0.52	0.51	1.30	1.25
Layer 10 - 20 cm								
	Macroporosity (m^3 m^{-3})		Microporosity (m^3 m^{-3})		Total Porosity (m^3 m^{-3})		Density (m^3 m^{-3})	
Oats	0.05	0.07	0.44	0.43	0.5	0.51	1.31	1.3
Crambe	0.09	0.05	0.38	0.44	0.47	0.5	1.34	1.35
F. radish	0.09	0.05	0.43	0.41	0.52	0.47	1.25	1.34
Wheat	0.06	0.04	0.43	0.44	0.49	0.49	1.36	1.36

Average followed by the same capital letter in line and tiny in column in each characteristic, do not differ by the Tukey test at 5 % of probability of error.

system of management, in relation to conventional tillage (Bertol et al., 2004).

Microporosity

With relation to the microporosity, in general there was no significant difference (p>0.05), as well as the different managements also did not influence the results. In the mechanical control values were established with an average of 0.43 $m^3 m^{-3}$, and the chemical management with an average of 0.44 m^3 m^{-3} in the layer 0 - 10 cm in the evaluation performed after the handling of the cultures. The same occurred for the layer of 10 - 20 cm of this same evaluation in which the average remained at 0.42 m^3 m^{-3}, for both the mechanical management as for the chemical management, not differentiating among cultures (Table 4). For the evaluation performed after soybean harvest, the layer 0 - 10 and 10 - 20 cm, the values showed no differences. The cultures with larger sized were the crops of oats (0.46 m^3 m^{-3}) and wheat (0.46 m^3 m^{-3}) in the chemical management in the layer of 0 - 10 cm. In the layer 10 - 20 cm excelled the culture of oats in mechanical handling and cultures of crambe and wheat in chemical management with the average of 0.44 m^3 m^{-3} for each of these cultures (Table 5).

It can be inferred that the ideal soil is the one with values of 0.10 to 0.16 m^3m^{-3} for macroporosity, up to 0.33 m^3m^{-3} for microporosity and approximately 0.50 m^3m^{-3} for total soil porosity (Kieh, 1979). Thus, the values of microporosity in this work, in practically all layers studied, are above the ideal conditions. The volume of micropores that are relatively high, present in all the treatments studied indicates the possibility of occurrence of capillarity in soil (Bertol et al., 2004). The microporosity is related to the water storage in the soil, influencing the development of plants especially in critical water availability times (Veiga, 2005). This factor has acted as a supply in the early establishment of winter crops, since this development time of the occurrence of precipitation was reduced over the subsequent months, as can be seen in Figure 2. Bertol et al. (2004) found a greater microporosity under no-tillage compared to conventional soil preparation, at layer 0 to 10 cm.

For Albuquerque, Ender and Sangoi (2001), the increase of the microporosity can be considered a reflection of the reduction of structure and assigned to the reduction in the volume of macropore, that makes harmful to the development of the plants. Similar results were obtained by Silva et al. (2008), evaluating soil management systems in crop succession and its influence on soil physical properties, they found that microporosity was not affected, regardless of the studied layer.

Total porosity

As there was no difference in the values of macroporosity and microporosity, total porosity was not affected (Table 4). Changes in soil porosity limit nutrient absorption, infiltration and redistribution of water, gas exchange and root development (Bicki and Siemens, 1991).

Whereas the ideal soil should be roughly 0.50 m^3m^{-3} for total soil porosity (Kiehl, 1979), the results found for this factor are considered ideal or very close to the ideal. In the evaluation performed after the management, the average of the different cultures in the layer 0 - 10 cm consisted of 0.51 m^3m^{-3} for mechanical handling and chemical management obtained an average of 0.52 m^3m^{-3}. In the layer of 10 - 20 cm the averages of winter crops were of 0.50 m^3m^{-3} when used the mechanical handling and 0.49 m^3m^{-3} when used chemical management (Table 4).

For the evaluation performed after the soybean harvest, the total porosity values established on the average of 0.51 m^3m^{-3} in the 0-10 cm both in mechanical handling and for chemical management. In the layer of 10 - 20 cm values were of 0.50 m^3m^{-3} and 0.49 m^3m^{-3} for the managements mechanical and chemical respectively (Table 5). These results are similar to those obtained by Sanchez (2012), that by checking the physical properties of the soil and yield of soybean in succession to winter crops have been obtained in the layer of 0 - 10 cm of soil, results show that the treatments showed no significant differences in porosity with medium that varied between 0.61 and 0.69 m^3m^{-3}, having a cycle of winter cover crops, until the moment of its flowering, not producing any change in this property.

Soil density

The values of density obtained for both layer of 0 - 10 cm as to layer of 10 - 20 cm showed no significant difference between the treatments. For the evaluation performed after the crop management mean values were 1.19 Mg m^{-3} and 1.20 Mg m^{-3} for the mechanical and chemical handlings respectively in the 0 - 10 cm. And in the layer of 10 - 20 cm the averages were of 1.27 Mg m^{-3} for the mechanical handling and 1.28 Mg m^{-3} for the chemical management (Table 4). The same occurred in the evaluation carried out after soybean harvest, there was no difference for soil density (Table 5), in both managements and in different cultures, with an average of 1.27 Mg m^{-3} for the depth of 0 - 10 cm and 1.32 Mg m^{-3} for the layer of 10 - 20 cm.

The density values for all treatments are well below critical levels. For Reinert and Reichert (2001), the values considered ideal for the development of the cultures are approximately 1.45 Mg m^{-3} for clay soils. Reinert et al. (2008) in studies with different species of coverage of winter in Clayey found that the root growth was normal until the limit of density of 1.75 Mg m^{-3}. Soils with high density cause restrictions on root growth of crops being that the root system focuses near the surface (Seidel et al., 2009). However, Argenton et al. (2005) found that in Rhodic Oxisol, the deficiency of aeration begins with soil density close to 1.30 Mg m^{-3}, while Klein (2006), for the same soil class based on limiting water range, noted that the limiting density was 1.33 Mg m^{-3}. In compacted soil, the number of macropores is reduced, the micropores are larger amount and density is also higher (Jimenez et al., 2008).

Resistance to penetration

There was a significant effect ($p<0.05$) of culture on the resistance to penetration in the layer of 0 - 5 cm depth,

Table 6. F values calculated for the soil resistance to penetration after the managements and after the harvesting of the soybean crop.

After the management							
Source of variation	**DF**	**Layers (cm)**					
		0-5	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**
Block	2	0.820	0.280	0.570	3.010	2.520	1.970
Crops	3	4.810*	1.360	0.210	0.670	0.710	0.720
Error 1	6	0.058	0.409	1.456	0.654	0.929	0.671
Management	1	0.480	0.610	4.330	9.920	1.980	1.200
Error 2	2	0.052	0.013	0.356	0.286	1.255	1.405
C X M	3	1.550	0.280	0.960	0.750	1.120	0.900
Error 3	6	0.095	0.313	0.468	1.033	0.384	0.398
CV 1 (%)		19.850	20.340	31.890	19.540	24.890	24.990
CV 2 (%)		18.890	3.640	15.780	12.910	28.920	36.150
CV 3 (%)		25.440	17.810	18.700	24.560	16.000	19.240
After soybean harvest							
Source of variation	**DF**	**Layers (cm)**					
		0-5	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**
Block	2	0.210	0.070	0.430	0.500	1.960	1.430
Crops	3	0.190	0.660	1.720	0.980	1.080	0.990
Error 1	6	0.271	1.377	0.557	0.920	0.779	2.291
Management	1	5.360	0.130	0.350	0.150	0.010	1.260
Error 2	2	0.025	1.024	1.401	2.607	1.598	0.507
C X M	3	0.350	0.060	0.310	1.680	1.180	0.180
Error 3	6	0.497	1.051	2.344	1.156	1.650	3.646
CV 1 (%)		44.170	39.140	18.770	23.820	21.610	36.070
CV 2 (%)		13.310	33.740	29.770	40.090	30.950	16.970
CV 3 (%)		59.790	34.190	38.510	26.690	31.450	45.500

*Significant at 5% probability by the F test, respectively. CV 1: Coefficient of variation for the crops; VC 2: Coefficient of variation for the managements; VC 3: Coefficient of variation for the cultures with the managements.

after the harvest of winter crops (Table 6). In this layer, the values obtained for the soil penetration resistance, demonstrate that the oat and crambe showed significant differences, offering modifications to the ground in this property, with values of 0.91 and 1.43 Mpa respectively after the harvesting of the crops of winter. This positive effect of oat, in decreasing soil resistance, was also ratified by Neiro et al. (2003), that evaluated the soil resistance to penetration in a Oxisol, with rotation and succession of crop under no-tillage verified that the treatment with crop rotation (wheat/oat/corn/soybean) presented lower values of resistance to penetration in the layer of 15 to 20 cm. This result obtained for oats, probably due to the positive effect of the root system of culture of oats, which acts by conducting biological soil scarification, reducing soil compaction in this treatment.

It is important to stand out that crambe has taproot system being eficiente in the unpacking to deeper layers of the soil, however these roots that have large diameter provide greater constrain to development and penetration in compacted soil. Already the oats is a plant with dense and branched roots type that shows efficient penetration and decompression of the upper layers of the soil, thus justifying the results obtained in this research.

According to the USDA (1993), the value considered as limiting factor and causing strong restriction to root growth for many annual crops is 2.0 Mpa, but can vary according to the texture and organic matter content of the soil. De Maria et al. (1999), studied soil preparation systems (heavy harrow and direct seeding) and concluded that there was soil compaction between 10 and 35 cm (2.09 and 1.86 MPa) and 10 and 20 cm (2.52 MPa) respectively, evaluated through the resistance of soil (Figure 3).

Genro Junior et al. (2004) found the resistance to penetration in a clayey Oxisol under no tillage with crop rotation, a great temporal variation and was associated with the variation of soil moisture for each condition of soil density or state of compaction. In this same evaluation the authors obtained the largest state of soil compaction at layer around 10 cm depth and the lowest in the superficial layer, up to 7 cm. Beutler and Centurion

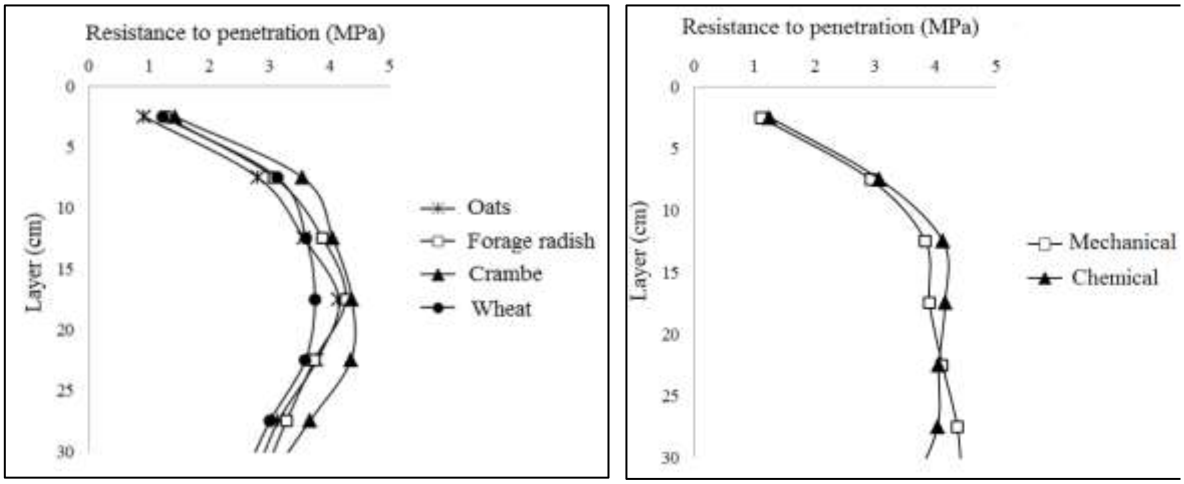

Figure 3. Soil resistance to penetration (MPa), at layer 0 to 30 cm depth, after the harvest of winter crops (A) and after the harvest of soybean (B). Oats, crambe, forage radish and wheat: winter crops. Managements: mechanical and chemical.

Table 7. Values of productivity (kg ha^{-1}) and weight of a thousand grains (g) for the soybean crop under the influence of the different cultures of winter and handlings employees.

Crops	Productivity (kg ha^{-1})			Weight of thousand grain (g)		
	Management		Average	Management		Average
	Mechanic	Chemistry		Mechanic	Chemistry	
Oat	1938.27	1918.00	1928.14^{a}	117.02	111.14	114.08^{a}
Crambe	2132.23	2007.61	2069.92^{a}	108.32	114.28	111.30^{a}
F. radish	2391.21	2503.58	2447.40^{a}	115.75	127.79	121.77^{a}
Wheat	1595.25	2629.38	2112.32^{a}	103.50	119.53	111.52^{a}
Average	2014.24^{A}	2264.64^{A}		111.15^{A}	118.19^{A}	

*Medium followed by the same capital letter in line and tiny in column in each characteristic, do not differ by the Tukey test at 5% of probability of error.

(Table 7), it was found that there was no significant difference between the results, that is, the different cultures of winter and the different managements not influenced in the weight of a thousand grains of soybean, that is, as there was no change to the physical soil, also did not change the absorption of water and nutrients and did not affect soybean.

The small differences in macroporosity were not enough to affect the weight of a thousand grains and soybean yields. The weight of a thousand grains is one of the key factors to achieve good yields, since this variable is directly correlated with the productivity. This variable may be used to estimate if there was a good efficiency during the process of grain filling, besides expressing indirectly the size of these seeds and its good physiological status as covered by Marques et al. (2008).

With respect to productivity all managements provided yields statistically similar, the results did not differ significantly (Table 7). In a study conducted by Debiasi et al. (2010), assessing the productivity of soybean and corn after winter cover and decompression mechanical soil, the authors verified that the increased soybean yield was obtained in the treatments which had winter crop, fact that was assigned to the best soil aggregation, resulting from higher soil organic matter levels observed in these treatments, as well as to better physical condition of the surface of the soil.

However for this job a single cycle of cultivation of winter crops not promoted changes in soybean yield. Improvements on the soybean crop and even on the physical properties of the soil, by the influence of winter crop, materialize itself an experimental period greater to be observed, and there is the need of more than one crop cycle.

Conclusions

In the studied conditions was found the interaction between the factors (crops × managements) modifies the macroporosity in camanda of 0 - 10 cm after the harvest of the soybean. The use of cover crops plants in winter with chemical or mechanical handlings and soybean cultivation in succession does not alter the macroporosity, microporosity, total porosity and density, but the oats decreases the resistance to penetration. The soybean yield is not affected by the cultivation of cover plants and managements of winter.

Conflict of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The work receives financial support from the Higher Education Personnel Improvement Coordination - CAPES Brazil.

REFERENCES

Amossé C, Jeuffroy, MH, David C (2013). Relay intercropping of legume cover crops in organic winter wheat: effects on performance and resource availability. Field Crops Res. 145:78-87.

Albuquerque JA, Sangoi L, Ender, M (2001). Efeitos da integração lavourapecuária nas propriedades físicas do solo e características da cultura do milho. Rev. Bras. Ciênc. Solo Viçosa 25(3):717-723.

Andreolla F, Costa LM, Olszevski N, Jucksch I (2000). A cobertura vegetal de inverno e a adubação orgânica e, ou, mineral influenciando a sucessão feijão/milho. Rev. Bras. Ciênc. Solo Viçosa 24(4):867-874.

Argenton J, Albuquerque JA, Bayer, C, Wildner LP (2005). Comportamento de atributos relacionados com a forma da estrutura de Latossolo Vermelho sob sistemas de preparo e plantas de cobertura. Rev. Bras. Ciênc. Solo Viçosa 29(3):425-435.

Bertol I, Albuquerque JA, Leite D, Amaral AJ, Zoldan JR, W. A (2004). Propriedades físicas do solo sob preparo convencional e semeadura direta em rotação e sucessão de culturas, comparadas as do campo nativo. Rev. Bras. Ciênc. Solo Viçosa 28(1):155-163.

Beutler AN, Centurion JF (2003). Efeito do conteúdo de água e da compactação do solo na produção de soja. Pesqui. Agropecu. Bras. Bras. 38(7):849-856.

Beutler AN, Centurion JF, Roque CG, Ferraz MV (2005). Densidade relativa ótima de Latossolos Vermelhos para a produtividade de soja. Rev. Bras. Ciênc. Solo Viçosa 29(6):843-900.

Bicki TJ, Siemens JC (1991). Crop response to wheel trapnc soil compaction. Transactions of the Am. Soc. Agric. Biol. Eng. St. Joseph 34(3):909-913.

Boer CA, Assis RL, Silva GP, Braz AJBP, Barroso ALL, Filho AC, Pires FR (2007). Ciclagem de nutrientes por plantas de cobertura na entressafra em um solo de cerrado. Pesqui. Agropec. Bras. Bras. 42(9):1269-1276.

Brancalião SR, Moraes MH (2008). Alterações de alguns atributos físicos e das frações húmicas de um Nitossolo Vermelho na sucessão milheto-soja em sistema plantio direto. Rev. Bras. Ciênc. Solo Viçosa 32(1):393-404.

Brazil (1992). Ministério da Agricultura, do Abastecimento e da Reforma Agrária. Regras para Análise de Sementes. Brasília, SNDA/DNDV/CLAV.

BRASMAX (2012). Cultivares Disponível em <http://www.brasmaxgenetica.com.br> Acesso em 23 jun 2013.

Campiglia E, Mancinelli R, Radicetti E, Caporali F (2010). Effect of cover crops and mulches on weed control and nitrogen fertilization in tomato (Lycopersicon esculentum Mill.). Crop Prot. 29(4):354-363.

CQFSRS/SC (2004). Comissão de química e fertilidade do solo. Manual de recomendações de adubação e calagem para os estados do Rio Grande do Sul e Santa Catarina. 10. ed. Porto Alegre, Sociedade Brasileira de Ciência do Solo - Núcleo Regional Sul 394 p.

DE Maria IC, Castro OM, Souza DH (1999). Atributos físicos do solo e crescimento radicular de soja em Latossolo Roxo sob diferentes métodos de preparo do solo. Rev. Bras. Ciênc. Solo Campinas 23(3):703-709.

Debiasi H, Levien, R, Trein CR, Conte O, Kamimura KM (2010). Produtividade de soja e milho após coberturas de inverno e descompactação mecânica do solo. Pesqui. Agropecu. Bras. Bras. 45(6):603-612.

Derpsch R, Friedrich T, Kassam A, Hongwen L (2010). Current status of adoption of no-till farming in the world and some of its main benefits. Int J Agric. Biol. Eng. 3(1):1-26.

Drewry JJ, Littlejohn RJ, Singleton RM, Monagham RM, Smith RC (2003). Dairy pasture responses to soil physical properties. Austr. J. Soil Res. 42:99-105.

EMBRAPA (1997). Empresa Brasileira de Pesquisa Agropecuária. Manual de métodos de análises de solos. 2.ed. Rio de Janeiro, RJ, Serviço Nacional de Levantamento e Conservação de Solos 212 p.

Embrapa (2013). Centro Nacional de Pesquisa em Solos. Sistema Brasileiro de Classificação de Solos (SiBCS). Rio de Janeiro: Embrapa Solos.

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciênc. Agrotecnol. Lavras 35(6):1039-1042.

Genro Junior SA, Reinert DJ, Reichert JM (2004). Variabilidade temporal da resistência à penetração de um Latossolo Argiloso sob semeadura direta com rotação de culturas. Rev. Bras. Ciênc. Solo, Viçosa 28(3):477-484.

IAPAR (2006). Cartas climáticas do Paraná. Disponível em: http://200.201.27.14/Site/Sma/Cartas_Climaticas/Classificacao_Climáticas.html. Acesso em: 30 mai. 2013.

Jimenez RL, Gonçalves WG, Araújo FJV, Assis RL, Pires FR, Silva GP (2008). Crescimento de plantas de cobertura sob diferentes níveis de compactação em um latossolo vermelho. Rev. Bras. Eng. Agríc. Ambient. Campina Grande 12(2):116-121.

Kiehl EJ (1979). Manual de edafologia, São Paulo, Ceres 215 p.

Klein VA (2006). Densidade relativa - Um indicador da qualidade física de um Latossolo Vermelho. Rev. Ciênc. Agroveter. Lages 5(1):26-32.

Kliemann HJ, Braz AJPB, Silveira PM (2006). Taxas de decomposição de resíduos de espécies de cobertura em Latossolo Vermelho Distroférrico. Pesqui. Agropec. Trop. Goiânia 36(1):21-28.

Lanzanova ME, Nicoloso RS, Lovato T, Eltz FLF, Amado TJC, Reinert DJ (2007). Atributos físicos do solo em sistema de integração lavoura-pecuária sob plantio direto. Rev. Bras. Ciênc. Solo Viçosa 31(5):1131-1140.

Laurindo MCO, Nóbrega LHP, Pereira JO, Melo D, Laurindo ÉL (2009). Atributos físicos do solo e teor de carbono orgânico em sistemas de plantio direto e cultivo mínimo. Eng. Agric. Viçosa 17(5):367-374.

Marques MC, Bueno MR, Freitas MCM, Hamawaki OT (2008). Competição intergenotípica de soja em três épocas de semeadura em Uberlândia - MG. In: VIII Encontro interno e XII Seminário de iniciação científica. Anais... V Semana acadêmica, 2008, Uberlândia. pp. 199-199.

Martins D, Gonçalves CGE, Silva Junior AC Da (2016). Coberturas mortas de inverno e controle químico sobre plantas daninhas na cultura do milho. Rev. Ciênc. Agron. 47(4):649-657.

Neiro ES, Mata JDV, Tormena CA, Gonçalves ACA, Pintro JC, Costa JM (2003). Resistência à penetração de um Latossolo Vermelho distroférrico, com rotação e sucessão de culturas, sob plantio direto. Acta Scientiarum: Agronomy Maringá 25(1):19-25.

Reichert JM, Reinert DJ, Braida JA (2003). Qualidade dos solos e sustentabilidade de sistemas agrícolas. Ciênc. Ambient. 27(1):29-48.

Reinert DJ, Reichert JM (2001). Propriedades físicas de solos em sistema plantio direto irrigado. In.: Carlesso R, Petry M, Rosa G, Ceretta CA. Irrigação por Aspersão no Rio Grande do Sul. Santa Maria pp.114-131.

Reinert DJ, Albuquerque JA, Reichert JM, Aita C, Andrada MMC (2008). Limites críticos de densidade do solo para o crescimento de raízes de plantas de cobertura em argissolo vermelho. Rev. Bras. Ciênc. Solo Viçosa 32(5):1805-1816.

Sanchez E (2012). Propriedades físicas do solo e produtividade de soja em sucessão a plantas de cobertura de inverno. 2012. 48p. Dissertação (Mestrado em Agronomia) - Programa de Pós-Graduação em Agronomia, Universidade Estadual do Centro-Oeste, Guarapuava 2012.

Seidel EP, Abucarma VM, Basso WL, Gerhardt IFS, Piano JT (2009). Diferentes densidades de solo e o desenvolvimento de plântulas de milho. Synergismus Scyentifica 4(1):1-3.

Sfredo GJ (2008). Calagem e adubação da soja. Londrina: Embrapa Soja, 2008. 12 p. (Circular Técnica 61).

Silva MG, Arf O, Alves MC, Buzetti S (2008). Sucessão de culturas e sua influência nas propriedades físicas do solo e na produtividade do feijoeiro de inverno irrigado, em diferentes sistemas de manejo do solo. Bragantia Campinas 67(2):335-347.

Stolf R (1991). Teorias e testes experimentais de fórmulas de transformação dos dados de penetrômetro de impacto em resistência do solo. Rev. Bras. Ciênc. Solo Campinas15(3):229-235.

Torres E, Saraiva OF (1999). Camadas de impedimento mecânico do solo em sistemas agrícolas com a soja. Londrina: Embrapa Soja, 1999. 58 p. (Embrapa Soja, Circular Técnica, 23).

Torres FE, De Souza LC, De Andrade LH, Pedroso FF, De Matoso OA, Torres LD, Benett KS (2014). Influência da cobertura do solo e doses de nitrogênio na cultura do milho safrinha. Rev. Bras. Ciênc. Agrár. 9(1):36-41.

United States Department of Agriculture (1993) - USDA, Soil survey manual. Washington, DC, USA, Soil Survey Division Staff 437 p. (Handbook, 18).

Varisco MR, Simonetti APMM (2012). Germinação de Sementes de crambe soluçar Influência de Diferentes Substratos e fotoperíodos. Acta Iguazu 1(2):36-46.

Veiga M (2005). Propriedades de um Nitossolo Vermelho após nove anos de uso de sistemas de manejo e efeito sobre culturas. 2005. 110p. Tese (Doutorado em Ciência do Solo) – Programa de Pós-Graduação em Ciência do Solo, Universidade Federal de Santa Maria, Santa Maria, 2005.