e-ISSN 1983-4063 - *www.agro.ufg.br/pat* - Pesq. Agropec. Trop., Goiânia, v. 40, n. 3, p. 274-282, jul./set. 2010

INFLUENCE OF DIFFERENT GRAZING SYSTEMS ON PHYSICAL PROPERTIES AND AGGREGATION IN SAVANNAH SOILS[1]

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RESUMO

INFLUÊNCIA DE DIFERENTES SISTEMAS DE PASTEJO SOBRE AS PROPRIEDADES FÍSICAS E AGREGAÇÃO EM SOLOS DE CERRADO

Objetivou-se avaliar alterações da estrutura do solo, que ocorreram em um Latossolo distrófico típico, causadas por diferentes sistemas de pastejo. No ano de 2004, amostras de solo (0-2 cm, 2-7 cm e 30-35 cm de profundidade) foram colhidas, em fazenda pertencente à Escola de Veterinária da Universidade Federal de Goiás, com as seguintes especificações: I) solo sob pastagem de *Panicum maximum* cv. Tanzânia, em sistema rotacionado de pastagem, posição touceira ("C"); II) solo sob pastagem de *Panicum maximum* cv. Tanzânia, em sistema rotacionado de pastagem, posição entre touceiras ("AC"); III) solo sob pastagem de *Cynodon dactilum* cv. Tifton 85, em sistema contínuo de pastagem; e IV) solo sob vegetação de Cerrado, como referência. A implantação das pastagens, com as gramíneas Tifton 85 e capim Tanzânia, modificaram as propriedades físicas do solo, por meio da redução de macroporos (MAC) e aumento na densidade do solo (SD). Solos sob pastagem com Tifton 85 e capim Tanzânia (posição "C") apresentaram maior diâmetro médio geométrico (MGD), se comparados aos solos sob Cerrado e capim Tanzânia (posição "AC"). As alterações na estrutura do solo foram mais relevantes nas camadas superficiais (0-2 cm e 2-7 cm de profundidade). As taxas de lotação, praticadas nas pastagens com as gramíneas Tifton 85 e capim Tanzânia, foram excessivas, sendo a principal causa da deterioração das propriedades físicas do solo.

PALAVRAS-CHAVE: *Cynodon dactilum*; *Panicum maximum*; pastejo contínuo; pastejo rotacionado; taxa de lotação.

ABSTRACT

The objective of this study was to evaluate soil structure alterations that occurred in a typical Red distroferric Latossol under different grazing systems. In 2004, soil samples from three depths (0-2 cm, 2-7 cm, and 30-35 cm) were collected in a farm owned by the College of Veterinary of the Federal University of Goiás, Goiânia, Goiás State, Brazil, as it follows: I) soil under pasture with *Panicum maximum* cv. Tanzania, in a rotational grazing system, clump position ("C"); II) soil under pasture with *Panicum maximum* cv. Tanzania, in a rotational grazing system, among clumps position ("AC"); III) soil under pasture with *Cynodon dactilum* cv. Tifton 85, in a continuous grazing system; and IV) soil under Savannah, as reference. The implantation of pastures with Tifton 85 and Tanzania grasses changed physical properties of the soil, through the reduction of macropores (MAC) and increase in soil density (SD). Soils under pastures with Tifton 85 and Tanzania grasses ("C" position) presented larger mean geometric diameter (MGD), if compared to the soils under Savannah and pasture with Tanzania grass ("AC" position). Alterations in soil structure were more significant in the topsoil layer (0-2 cm and 2-7 cm depth). Stocking rates practiced in the pastures with Tifton 85 and Tanzania grasses were excessive and also the main reason for deteriorating physical soil properties.

KEY-WORDS: *Cynodon dactilum*; *Panicum maximum*; continuous grazing system; rotational grazing system; stocking rate.

INTRODUCTION

Grasslands cover approximately 19.4 out of 34.1 million hectares of farming soil in the Goiás State (Cózer et al. 2001). The sum of dairy and beef herds, in Brazil, is estimated in 192 million heads, and the Goiás State has the third biggest herd and is the second biggest milk producer of the whole country (Goiás 2003).

1. Trabalho recebido em jan./2009 e aceito para publicação em jul./2010 (n° registro: PAT 5353).
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Pastures degradation has reached around 8 million hectares in the Goiás State (Goiás 2003), basically due to inadequate management. The consequence of that process has been the reduction of both chemical fertility and physical soil structure, hence those soils have become vulnerable to erosion and compaction caused by grazing animals (Balbino et al. 2003).

Latossols from "Cerrado" (Brazilian Savannah) still under native vegetation have appropriate physical structure (Carvalho Júnior et al. 1998). However, availability of nutrients in those soils is limiting for ideal growth and yield of cultivated plants. Moreover, the adoption of inadequate grassland management implies in losses of physical quality of the soil, for medium and long terms, hindering the growth of roots, air circulation, and water infiltration (Carvalho Júnior et al. 1998, Bertol et al. 2000, Fregonezi et al. 2001, Müller et al. 2001). The pressure from grazing animals can reach up to 350-400 kPa (Betteridge et al. 1999) and cause changes in density and porosity of the soil, especially in the first 3-6 cm depth (Gradwell 1960, Chancellor et al. 1962, Gradwell 1966, Bertol et al. 1998). Thus, one of the strategies that have been used to recover degraded pastures is the rotational grazing system, where fertilizations are a common practice and even irrigation, during the dry season, has been recommended (when this facility is available), although Lima et al. (2004) have reported that compaction and soil density, in a rotational grazing system pasture under irrigation, increases, if compared to the same pasture without irrigation.

The objective of this study was to evaluate structural alterations occurred in a typical Red Latossol, after four years of the implantation of two pastures: the first with *Panicum maximum* cv. Tanzania, in a rotational grazing system, and the second with *Cynodon dactilum* cv. Tifton 85, in a continuous grazing system, with a soil under Savannah as reference.

MATERIALS AND METHODS

The experiment was conducted in 2004 (dry and rain seasons), in a farm owned by the College of Veterinary of the Federal University of Goiás, Goiânia, Goiás State, Brazil (16º35'12''S, 49º21'14''W, and altitude of 730 m). According to the Köppen classification, the area has a semi-humid tropical climate (Aw). Average annual rainfall is 1,578 mm, being the months from November to March the rainiest, and from June to August the driest ones. Average annual temperature is 23.2ºC, with minimum of 17.9°C and maximum of 28.9°C (Magnano et al. 1983).

The soil is classified as a typical Red distroferric Latossol, loamy texture (Embrapa 2006). Soil samples were: I) soil under pasture with *Panicum maximum* cv. Tanzania, in a rotational grazing system, clump position ("C"); II) soil under pasture with *Panicum maximum* cv. Tanzania, in a rotational grazing system, among clumps position ("AC"); III) soil under pasture with *Cynodon dactilum* cv. Tifton 85, in a continuous grazing system; and IV) soil under Savannah, as a reference. Previously to the implantation of the current grasses, the pastures were planted with *Brachiaria decumbens*.

Grasses in the rotational and continuous grazing systems were established in January (2000). Soil texture and soil chemical attributes are shown in Tables 1 and 2, respectively.

Base saturation was raised to 60%, according to results of soil chemical analyzes. For soil tillage,

Table 1. Soil texture of a Red distroferric Latossol (Goiânia, GO, Brazil, 2000).

Depth (cm) / Horizon	Granulometry (g kg^{-1})		
	Clay	Silt	Sand
0-2	54.2	13.6	32.2
2-7	55.9	13.7	30.4
Bw*	42.0	18.0	40.0

* Source: Lopes et al. (1997).

Table 2. Soil chemical attributes of a Red distroferric Latossol (0-20 cm) (Goiânia, GO, Brazil, 2000).

Ca^{2+}	Mg^{2+}	Al^{3+}	H	pH	P(Mel)	K	CEC*	V**	OM***
cmol$_c$ dm^{-3}				$CaCl_2$	mg dm^{-3}		cmol$_c$ dm^{-3}	%	g kg^{-1}
1.6	0.9	0	2.6	5.1	3.8	59	5.45	48.62	19

* Cation exchange capacity; ** Base saturation; ** Organic matter.

firstly, a heavy disking was carried out, in order to break down the existing vegetation (*Brachiaria decumbens*). Then, limestone was broadcasted, followed by ploughing (30 cm depth), and, finally, two light diskings were applied to level off the soil. In agreement with Vilela et al. (1998), 90 kg of P_2O_5 ha^{-1} were applied: 60 kg ha^{-1} incorporated into the soil and the remaining 30 kg ha^{-1} mixed to the seeds, at the moment of sowing. Besides phosphorus fertilization, 30 kg ha^{-1} of trace minerals (FTE BR 12) were also mixed to the seeds at sowing. After establishment of the grasses, nitrogen was broadcasted in the form of urea (250 kg ha^{-1}, divided into three applications).

The pasture under the rotational grazing system was formed by thirty pens of 0.33 ha each. Stocking rate was 6 LU/ha (livestock units; 1 LU = 450 kg of live weight) and grazing was performed by Holstein-Friesian lactating cows. The pasture under continuous grazing system consisted of a total area of 0.51 ha (41 m x 125 m) and the stocking rate, in this case, was 2 LU/ha, where grazing was performed by Holstein-Friesian dry cows. In the dry season, the irrigation system (sprinklers) was turned on once a week, providing a precipitation of 4 mm, which allowed cows to stay in the pastures during the whole experimental length. Tanzania grass and Tifton 85 pastures were 100 m apart from each other.

Soil samples were collected to evaluate porosity and aggregation, in 12 mini-trenches, in the 0-2 cm, 2-7 cm, and 30-35 cm depth layers (totaling 36 samples/ sampling site), under pasture with Tanzania grass ("C" position), taken as closely as possible to the clumps, while in the "AC" position, there was a standardization of 0,25 m below the clump, towards the steepness of the land. "C" and "AC" positions were sampled with the objective to determine possible differences in soil properties under the influence of the same grass species (Tanzania grass).

For evaluation of porosity, cylinders of 39.27 cm^3 were used for sampling the 0-2 cm layer, while cylinders of 98.17 cm^3 were used for the 2-7 cm and 30-35 cm layers. After sampling, cylinders filled with soil were wrapped in plastic to maintain intact the soil structure. In the laboratory, samples were saturated and taken to the tension table, where they were submitted to 6 kPa (Oliveira 1968), for determination of microporosity (< 50 µm), according to Bouma (1991), and field capacity (Oliveira et al. 2003).

Soil density, total volume of pores and macroporosity were determined according to Embrapa (1997). For determination of permanent wilting point, a Richards's chamber was used, under 1,500 kPa. In this methodology, samples were grounded in a 2 mm screen and, after saturation, they were placed in rubber rings and laid out on ceramic plates, until equilibrium was reached. Samples were then dried at 105-110°C, for 48 hours, in a forced air oven, for determination of gravimetric humidity. Following suggestions by Santos (1997), total available water was calculated by the expression TAW = $\theta_6 - \theta_{1500}$ (TAW = total available water ($m^3\,m^{-3}$); θ_6 = volumetric water content equivalent to the tension of 6 $m^3\,m^{-3}$; and θ_{1500} = volumetric water content equivalent to the tension of 1,500 $m^3\,m^{-3}$).

For stability of aggregates analyses, samples of approximately 350 cm^3 were taken from each depth of the appraised sites. In the laboratory, samples were slightly crumbled manually and grounded in an 8 mm screen. Aggregates with diameter smaller than 8 mm (25 g) were pre-moistened by capillarity, in a tray with humid sand covered by a filter paper. Moistened aggregates were submitted to agitation (Yoder 1936), following the method described by Kemper & Rosenau (1986). For that, a set of five sieves was used, with the following classes of diameter: 2.0 mm, 1.0 mm, 0.5 mm, 0.25 mm, and 0.105 mm.

Aggregates retained in each sieve were transferred to previously weighted cans, dried at 105-110°C, for 48 hours, in forced air ovens, and then the aggregates dry mass retained in each sieve was weighted.

Aggregates stability was represented by mean geometric diameter (MGD), according to the equation MGD = 10^x, where

$$x = \sum_{n}^{n=1}\left(\frac{(n \log d)}{\Sigma n} \right),$$

d is the mean diameter of any particular class of aggregates separated by sieving, and *n* the percentage of aggregates from each class size represented as a fraction of the total dry mass of the sample.

Particles density was determined by following the volumetric balloon method with ethyl alcohol, described by Embrapa (1997). Four composite depth samples were used in each sampling site.

Statistical data analyzes were accomplished using SAS (2002) through PROC GLM. Means were compared by using the Duncan test ($p < 0.05$).

RESULTS AND DISCUSSION

Means of macropores (MAC) in the soil under Savannah were higher ($p < 0.05$) than in the soils under pastures with Tifton 85 and Tanzania grasses (for both "C" and "AC" positions), for all depths evaluated (Table 3). High MAC values are common in Savannah Latossols (Resende et al. 2002). The highest means for total volume of pores (TVP) were also found in the soil under Savannah, with values of 0.69 $m^3 m^{-3}$, 0.63 $m^3 m^{-3}$, and 0.60 $m^3 m^{-3}$, respectively for the 0-2 cm, 2-7 cm, and 30-35 cm depth layers ($p < 0.05$).

Regarding MAC = 0.10 $m^3 m^{-3}$, as the lowest value for satisfactory growth of cultivated plants (Black 1975, Forsythe 1975, Kiehl 1979, Lipiec & Hatano 2003), it can be observed that MAC was restrictive in the soils under pastures with Tifton 85 and Tanzania grasses ("AC" position), for both the 0-2 cm and 2-7 cm layers (Table 3). Although not measured in the present study, the reasonable explanation for the low MAC value in those soils is the lower quantity of roots, resulting in less accumulation of organic carbon, which plays a major role in the formation and stabilization of macroaggregates, since it is known as an efficient cementing agent (Campos et al. 1995). Furthermore, low MAC in the soils under pastures with Tifton 85 and Tanzania grasses ("AC" position) had an effect in the increase of SD in the 0-2 cm and 2-7 cm layers (Figure 1), which can indicate soil structure degradation.

Higher MAC values were expected in the soil under pasture with Tifton 85 (when compared to the one under Tanzania grass, "C" and "AC" positions), taking into account its lower stocking rate (2 LU/ha), as well as its root system constituted by rhizomes (Vilela & Alvim 1998). However, there was no difference in MAC between those two soils

Table 3. Means of macroporosity (MAC), microporosity (MIC), total volume of pores (TVP), permanent wilting point (PWP), total available water (TAW), and particles density (PD), in three depths of a Red distroferric Latossol under two grazing systems and Savannah (Goiânia, GO, Brazil, 2004).

Sites	MAC	MIC	TVP	PWP*	TAW**	PD
	$m^3 m^{-3}$				kg dm^{-3}	
			Depth: 0-2 cm			
Savannah	0.43 a***	0.26 c	0.69 a	0.14 c	0.12 b	2.52
Tifton 85	0.09 c	0.40 a	0.49 c	0.25 a	0.15 a	2.65
Among clumps	0.09 c	0.39 ab	0.49 c	0.25 a	0.14 a	2.67
Clumps	0.17 b	0.38 b	0.55 b	0.24 b	0.14 a	2.64
C.V. (%)	31.04	6.50	8.11	10.28	17.07	-
			Depth: 2-7 cm			
Savannah	0.33 a	0.30 b	0.63 a	0.18 b	0.12 b	2.65
Tifton 85	0.11 b	0.40 a	0.51 b	0.25 a	0.15 a	2.76
Among clumps	0.06 c	0.41 a	0.47 c	0.25 a	0.16 a	2.67
Clumps	0.08 bc	0.40 a	0.48 c	0.25 a	0.15 a	2.69
C.V. (%)	35.13	5.82	6.56	8.37	14.96	-
			Depth: 30-35 cm			
Savannah	0.25 a	0.36	0.60 a	0.21 b	0.15	2.79
Tifton 85	0.20 b	0.37	0.57 b	0.23 a	0.14	2.81
Among clumps	0.16 c	0.37	0.52 c	0.23 a	0.14	2.76
Clumps	0.19 bc	0.36	0.55 bc	0.23 a	0.14	2.80
C.V. (%)	21.39	4.73	5.11	7.32	10.84	-

* Water kept at 1,500 kPa; ** Water available between 1,500 kPa and 6 kPa (Field capacity = MIC); *** Means with different letters in the same layer differ according the Duncan test ($p < 0.05$).

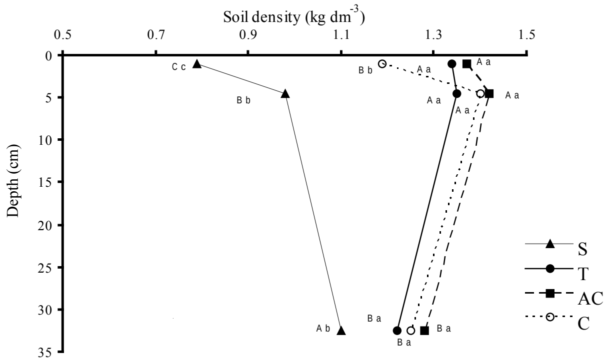

Figure 1. Soil density of a Red distroferric Latossol in the depths of 0-2 cm, 2-7 cm, and 30-35 cm, under S = Savannah; T = pasture under a continuous grazing system (Tifton 85); AC = pasture under a rotational grazing system (Tanzania grass; "AC" position); C = pasture under a rotational grazing system (Tanzania grass; "C" position) (Goiânia, GO, Brazil, 2004). * Capital letters compare the effect of depth in each site and small letters compare sites in the same depth.

($p > 0.05$), suggesting that the stocking rate in the soil under pasture with Tifton 85 was too high, especially in the rainy season, when the soil is vulnerable to compaction due to excess of moisture combined with animals grazing (Kondo & Dias Júnior 1999, Oliveira et al. 2004).

That same explanation can be extended to the soil under pasture with Tanzania grass, in the "AC" position. Besides facing an even higher animal pressure because of the stocking rate (6 LU/ha), this soil did not have the protection from the grass (clumps). Since cows walk preferably among clumps, the pressure per unit area was even higher in the "AC" position and part of that pressure was transmitted to the 2-7 cm layer, in agreement with the findings reported by Imhoff et al. (2000). MAC are the main route for roots growth, hence MAC reduction stimulates the development of side roots, which are less efficient in absorption of water, nutrients and gaseous exchanges (Camargo & Alleoni 1997).

The reason for MAC reduction, in the soil under pasture with Tanzania grass ("C" position), in the 2-7 cm layer (0.08 $m^3 m^{-3}$; Table 3), when compared to the 0-2 cm layer (0.17 $m^3 m^{-3}$; Table 3), was the continuous and repetitive pressure made by animals among clumps (as previously mentioned) and its transmission to the 2-7 cm layer, increasing SD in this layer (Figure 1), fact also observed by Bertol et al. (2000). These results demonstrated that the stocking rate in the soils under pasture with Tanzania grass ("C" and "AC" positions) were harmful to the soil structure, mainly through increase in SD, in the first two layers (0-2 cm and 2-7 cm depth). On the other hand, SD in the soil under Savannah increased as sampling went deeper (Figure 1), basically because there was reduction in the accumulation of organic matter added to the soil under Savannah, also in agreement with Bertol et al. (2000).

In the 30-35 cm layer, all sampling sites presented higher MAC values than the minimum ones (Table 3). So, it can be stated that reductions in MAC and increases in SD, caused by grazing animals, happen just in the superficial soil layer, as reported by Carvalho Júnior et al. (1998), Fregonezi et al. (2001), Müller et al. (2001), and Balbino et al. (2004). However, the soils under pastures with Tifton 85 and Tanzania grasses ("C" and "AC" positions) presented a higher TAW rate than the soil under Savannah, for both the 0-2 cm and 2-7 cm layers (Table 3, $p < 0.05$), in agreement with Resende et al. (2002). Sometimes, compaction might be beneficial, in terms of water retention in Latossols, nevertheless it has to be pointed out that TAW should be always compared with porosity, because, in the present study, the increase in TAW was directly related to both reductions in MAC and increases in SD, in the soils under pastures with Tifton 85 and Tanzania grasses ("C" and "AC" positions).

In Figure 1, soil density (SD) was lower in the soil under Savannah, if compared to the soils under pastures with Tifton 85 and Tanzania grasses ("C" and "AC" positions), in all depths evaluated ($p < 0.05$). There was no difference in SD between soils under pastures with Tifton 85 and Tanzania grasses ("AC" position), in the 0-2 cm and 2-7 cm depth layers ($p > 0.05$), what should be related to the transmission of the pressure made by cows to deeper layers of the soil (Imhoff et al. 2000). However, in the 0-2 cm layer, SD was lower ($p < 0.05$) in the soil under pasture with Tanzania grass ("C" position), in relation to the soils under pastures with Tifton 85 and Tanzania grasses ("AC" position), possibly due to the effect of the protection offered by the grass in the "C" position. SD increased from the 0-2 cm to 2-7 cm layer ($p < 0.05$), in the pasture with Tanzania grass ("C" position), in agreement with Balbino et al. (2004).

The relation between MAC and SD is presented in Figure 2. When SD was higher than 1.36 kg dm^{-3}, MAC was lower than 0.10 $m^3 m^{-3}$. According to

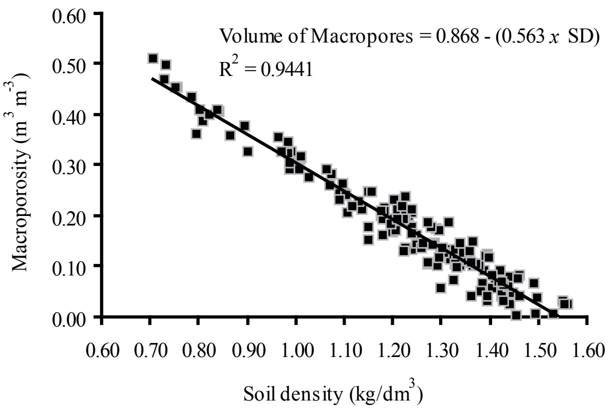

Figure 2. Macroporosity, in relation to soil density (SD), in the 0-2 cm, 2-7 cm, and 30-35 cm depths of a Red distroferric Latossol under two grazing systems and Savannah (Goiânia, GO, Brazil, 2004).

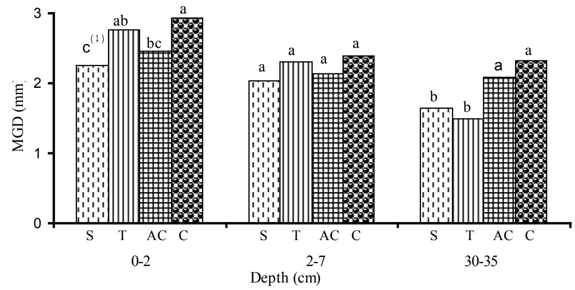

Figure 3. Mean geometric diameter (MGD) of aggregates in three depths of a Red distroferric Latossol under S = Savannah; T = pasture under a continuous grazing system (Tifton 85); AC = pasture under a rotational grazing system (Tanzania grass; "AC" position); C = pasture under a rotational grazing system (Tanzania grass; "C" position) (Goiânia, GO, Brazil, 2004). [1] Means with different letters in the same layer differ by the Duncan test ($p < 0.05$).

Black (1975), Forsythe (1975), Kiehl (1979), and Lipiec & Hatano (2003), when MAC is equal or below 0.10 $m^3 m^{-3}$, there is restriction in root growth. Besides, when considering SD = 1.40 kg dm^{-3} as a bottom line to plants cultivated in loamy soils (Arshad et al. 1996), the corresponding MAC value would be 0.08 $m^3 m^{-3}$, hence below the minimum proposed by Black (1975), Forsythe (1975), Kiehl (1979), and Lipiec & Hatano (2003). The linear equation in Figure 2 shows that when SD reached 1.54 kg dm^{-3}, macropores were no longer detected in the vertical axis of Figure 2. In this study, few samples presented SD = 1.54 kg dm^{-3}, mainly in relation to the soil under pasture with Tanzania grass ("AC" position), in the 0-2 cm and 2-7 cm depth layers.

SD presented positive correlation with micropores ($r = 0.920$, in the 0-2 cm and 2-7 cm layers, and $r = 0.631$, in the 30-35 cm layer) and correlation values helped to support the explanation that only from a certain degree of compaction or SD there is a corresponding increase in micropores (MIC). In this study, the increase in MIC resulted in increase in TAW ($p < 0.05$), in the soils under pastures with Tifton 85 and Tanzania grasses ("C" and "AC" positions), in the 0-2 cm and 2-7 cm layers, when compared to the soil under Savannah (Table 3).

In Figure 3, the mean geometric diameter (MGD) of aggregates, in the 0-2 cm layer of the soils under pastures with Tanzania grass ("C" position) and Tifton 85, was higher than in the soils under Savannah and pasture with Tanzania grass, in the "AC" position ($p < 0.05$), in agreement with Pereira (1997), who used aggregates smaller than 8 mm in his methodology and reported higher MGD in soils under pasture with *Brachiaria decumbens*, when compared to a soil under Savannah. Moreover, the soil under pasture with Tanzania grass ("C" and "AC" positions) presented higher MGD than soils under Savannah and Tifton 85 ($p < 0.05$). Overall, MGD ranged from 2.45 mm to 2.93 mm (0-2 cm depth), 2.14 mm to 2.39 mm (2-7 cm depth), and 1.49 mm to 2.33 mm (30-35 cm depth). MGD presented positive correlation with aggregates between 8-2 mm ($r = 0.946$; 0.950 and 0.973, for the 0-2 cm, 2-7 cm, and 30-35 cm depth layers, respectively). The great amount of aggregates retained in the sieves with larger meshes (mainly 2 mm) can explain the positive correlation between MGD and aggregates varying from 8 mm to 2 mm. The correlation coefficients for MGD with aggregates of 8-2 mm, in this research, were close to the ones reported by Angulo et al. (1984).

The higher MGD values found in the soils under pastures with Tanzania grass ("C" position) and Tifton 85, in the 0-2 cm layer (Figure 3), have occurred due to the fact that the Tanzania's root system contains 76% of live roots and 82% of dead roots, in the first 20 cm depth (Pagotto 2001), while Tifton 85 has a root system formed by rhizomes.

During sampling, it was noticed, in the soil under pasture with Tanzania grass ("AC" position), that the aggregates presented a solid aspect, indicating that they might have been formed by the action of compression forces and then cemented by organic matter, thus originating big aggregates, but with poor porosity. According to Carpenedo & Mielniczuk (1990), compression forces can originate dense aggregates, whith predominance of micropores.

In the 30-35 cm layer, DMG in the soils under pastures with Tanzania grass ("C" and "AC" positions) was higher than in the soils under pasture with Tifton 85 and Savannah (Figure 3). That difference can be attributed to the Tanzania's root system, which contains 24% of live roots and 18% of dead roots, in the 20-40 cm depth (Pagotto 2001).

The percentages of stable aggregates in water are shown in Table 4. There were higher contents of stable aggregates in water at 8-2 mm, in the soil under pasture with Tanzania grass ("C" position), in the 0-2 cm (77.1%), 2-7 cm (68.7%), and 30-35 cm (65.5%) layers, when compared to the soil under Savannah ($p < 0.05$). On the other hand, in the classes of aggregates between 2 mm and 0.25 mm, the soil under Savannah presented higher contents of stable aggregates in water, if compared to the other sampling sites (0-2 cm and 2-7 cm layers).

CONCLUSIONS

1. The implantation of pastures with Tifton 85, under a continuous grazing system, and Tanzania grass, under a rotational grazing system, has changed the physical soil properties, in comparison with the soil under Savannah, especially in the superficial layers (0-2 cm and 2-7 cm depth).
2. The depletion of physical properties in the soils under those pastures can be attributed to the stocking rates, which were excessive and determinant to reduce the volume of macropores and increase soil density.

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Table 4. Distribution of aggregates stable in water in three depths of a Red distroferric Latossol under two grazing systems and Savannah (Goiânia, GO, Brazil, 2004).

Sites	Classes of aggregates (mm)					
	8-2	2-1	1-0.5	0.5-0.25	0.25-0.105	< 0.105
	%					
	Depth: 0-2 cm					
Savannah	63.6 b*	9.4 a	10.8 a	9.4 a	4.6 ab	2.1
Tifton 85	73.0 a	8.0 ab	6.5 b	6.6 bc	4.0 b	1.9
Among clumps	69.8 ab	6.8 b	6.4 b	7.4 ab	6.2 a	3.4
Clumps	77.1 a	6.9 b	5.2 b	4.5 c	3.4 b	2.9
C.V. (%)	12.3	30.7	37.9	38.1	48.0	78.0
	Depth: 2-7 cm					
Savannah	58.6 b	11.3 a	12.7 a	10.1 a	5.5	1.84 b
Tifton 85	65.2 ab	9.7 b	8.6 b	8.9 ab	5.4	2.20 ab
Among clumps	63.3 ab	8.1 c	7.8 b	8.5 ab	9.0	3.26 a
Clumps	68.7 a	7.4 c	7.5 b	7.7 b	5.8	2.93 ab
C.V. (%)	13.0	21.0	21.5	29.4	68.5	60.3
	Depth: 30-35 cm					
Savannah	53.5 b	9.1 b	11.5 a	13.8 a	9.4 a	2.7 ab
Tifton 85	47.2 b	11.7 a	12.4 a	15.7 a	9.9 a	2.9 a
Among clumps	61.2 a	9.8 b	10.2 ab	9.7 b	7.0 b	2.1 bc
Clumps	65.5 a	9.5 b	9.2 b	8.2 b	6.1 b	1.5 c
C.V. (%)	14.2	17.6	23.9	26.1	28.7	37.9

* Means with different letters in the same layer and aggregates class differ by the Duncan test ($p < 0.05$).

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