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Evaluation of Sheep Trampling at Different Grazing Periods on Soil Attributes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

With the objective of evaluating the possible deterioration in some physical and chemical soil attributes, caused by sheep trampling in pasture areas compared to preserved areas. The study was conducted at the Instituto Federal de Educação, Ciência e Tecnologia da Paraíba - Campus Sousa, located in the Irrigated Perimeter of São Gonçalo, between the geographic coordinates 06o 50` 22 "S; 38o 17 ` 42" W; at 220 meters of altitude. The statistical design was in Randomized Blocks (DBC), with 3 treatments composed of: T1= no animals (preserved); T2= rainy period sheep grazing; T3= dry period sheep grazing, with six repetitions each. To determine the chemical attributes, soil samples were collected at a depth of 0 - 20 cm to determine (pH, phosphorus, potassium, sodium, calcium, magnesium, aluminum and organic matter) and physical attributes (sand, silt clay, soil density, total porosity, water dispersed clay) except for bulk density was taken from unformed samples at a depth of 0 - 10 cm from the soil. The sheep grazing in the different periods promoted soil compaction expressed by increased soil density, reduced total porosity and lower clay aggregate content. The permanence of grazing animals promoted a reduction in soil chemical quality, notably for phosphorus, calcium, magnesium and SOM contents in grazed sheep during the dry season and an increase in sodium and PST, compared to the area without grazing (preserved).

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1. INTRODUCTION

Its process of occupation and land use characterizes the Brazilian Northeast, specifically the semi-arid region. The agricultural sector for example, played an important role in the level of national production during the colonial period, standing out as a center of economic development of the country with sugar, tobacco, leather and cotton [1]. In the process of modernization of agriculture and cattle ranching, a socioeconomic inequality was established due to the great heterogeneity of the regions, especially in the northeast of the country [2].

In this perspective of different climatic and geographic variations, research institutions are fundamental to mitigate and deepen strategies that enable agricultural productivity in these different regions [3].

In Brazil, most of the beef/veal production came from animals raised on pastures whose area was 158 million hectares. Of this, total 57 million were occupied with native pastures and 101 million with cultivated pastures [4]. Still [4] it is estimated that 80% of Brazilian pastures already have some degree of degradation, this being the main factor responsible for the low carrying capacity of these pastures and one of the biggest problems of Brazilian livestock.

Livestock production based on the use of pastures is one of the most competitive and profitable alternatives for Brazilian livestock, however, the degradation of cultivated pastures has represented a threat to the sustainability of the meat production system in Brazil [5]. Most of the studies addressing the problem relate the degradation process to the interactions among zootechnical (animal stocking rate), plant (loss of vigor, morphological alteration) and soil (chemical attributes) factors, while the problem of soil physical degradation has been left in the background [4].

Understanding how physical and chemical soil attributes respond to intense grazing pressures demystifies several practical issues and may explain the main causes of pasture degradation. Animal trampling promotes changes in these attributes when the minimum pre-consolidation pressure of the soil is not respected, which usually happens and causessoil compaction [6].

Soil compaction is an issue of growing importance due to the increase in agricultural mechanization and animal trampling in agricultural activities, which cause changes in the arrangement of soil particles [7]. The degradation of pasture areas exists throughout the Brazilian territory, but the problem has been aggravated in regions where cattle raising is expanding in agricultural frontiers [8].

In recent years, the accelerated and disorderly growth of the world population has been predominant for the large increases in agricultural and mining production. In this regard, it has been observed negative effects related to the degradation of ecosystems, until then stable and harmonious [9]. Overgrazing is considered a management factor that most affects the persistence of pastures, soil compaction and changes in soil attributes, expressed in practice by animal stocking [10]. Still in this context, there is the lack of planning or good agricultural practices, which can aggravate this problem mainly in areas of the semi-arid region [11,12].

The main consequence of excessive animal trampling is soil compaction, characterized by an increase in soil density as a result of applied loads or pressures [4]. Thus, evaluating the impacts of animal trampling on the soil will enable better management of native or improved pastures, in order to cause the least possible damage to the environment [13].

In the current context, the intercropping of animals in cultivated areas with fruit farming is being a more viable form for the development of the semi-arid region [14-16]. The knowledge pertinent to soil structure is of great importance for sustainable development and greater efficiency in land use, by using the same area with two activities, incorporating another source of income and mitigating the problem of seasonality in the flow of resources observed in fruit farming [7].

The objective of this study was to evaluate the possible deterioration in the physical and chemical attributes of the soil caused by sheep

trampling in pasture areas compared to preserved areas.

2. METHODOLOGY

2.1 Place of the Experiment

The study was conducted at the Instituto Federal de Educação, Ciência e Tecnologia da Paraíba-Campus Sousa, located in the Irrigated Perimeter of São Gonçalo, between the geographical coordinates 06 o 50` 22 "S; 38 o 17 ` 42" W; at an altitude of 220 meters. The climate is characterized as semi-arid, hot, type Bsh of the Koppen Classification. The average annual rainfall is 654 mm, with rain concentrated in the period from January to June. The average annual temperature is 27°C, with a maximum of 38°C, while the average relative humidity is 64%. The predominant vegetation of the region is caatinga.

2.2 Installation and Conduction of the Experiment

For the execution of this work, we used the structure that is being developed in the veterinary research area, which began on April 14, 2021. The experimental unit consisted of two areas with 38m x 148m each, totaling 5,624 m^2 , grazing daily 20 animals of two breeds, being 14 of the Santas Inês breed and 6 of the morada nova breed of the same age group. The group of animals grazed in the picket for 180 days, distributed between the rainy period (04/14 to 07/14/2021) and the dry period (07/15 to 10/15/2021). The area without animals (preserved) located in the same institution, preserved for over 60 years, absent of agricultural activities and animal grazing, having in its floristic composition herbaceous plants, with a predominance of the sabiá species (*Mimosa caesalpiniaefolia).*

2.3 Statistical Design and Analyzed Variables

The experiment was in Randomized Block Design (CBD), with 3 treatments composed of: T1= no animals (preserved); T2= rainy period sheep grazing; T3= dry period sheep grazing, with six repetitions each. To determine the chemical attributes, soil samples were collected at a depth of 0 - 20 cm to determine (pH, phosphorus, potassium, sodium, calcium, magnesium, aluminum and organic matter) and physical attributes (sand, silt clay, soil density, total porosity, water dispersed clay) except for bulk density was taken from unformed samples at a depth of 0 - 10 cm from the soil.

The soil samples were air dried, sieved on a sieve (2 mm mesh) and analyzed in the Soil, Water and Plant Laboratory (LASAP) at the Instituto Federal da Paraíba (IFPB) Campus Sousa.

2.4 Statistical Analysis

The results will be submitted to Analysis of Variance (ANOVA) and the means will be compared using the Tukey test at 0.01 probability using the SISVAR [17] computerprogram.

3. RESULTS AND DISCUSSION

It is observed in the granulometric composition studied, that there was significant effect between the fractions of sand, silt and clay, compared to the area without pasture (preserved) (T1), showing no difference when compared between the periods T2 and T3 (Table 1). This behavior can be understood by the period of six months of permanence, which can be considered small to the point of not causing changes. Different results were observed by Prado and Natale [11], who, in a medium textured soil, did not find significant differences in sand, silt and clay content in a dystrophic Red Latosol.

Pereira Junior et al. [7] evaluating the physical attributes of soil in different agroecosystems (native forest, guava orchard, cashew orchard and irrigated rice cultivation), verified a significant effect only for the sand fraction, under a fluvial neosol.

The soil density reflects the arrangement of the particles, which in turn defines the characteristics of the porous system reflecting the degree of compaction of the soil. In this reality we can observe in Table 2, significant effect ($p<0.01$) for soil density. Treatment T1 showed the lowest value in soil density, probably due to the absence of anthropic action and the presence of burlap, differing statistically from the other T2 and T3, which showed higher values influenced by the different periods of sheep grazing. It is noteworthy that the values of soil density were above 1.65 Kg dm^{-3}, a value considered an impediment to good root development of plants.

Ferreira et al. [18] evaluating the impact of ovine and bovine trampling found an increase in soil

density caused by ovine grazing in an area of coconut grove, under a fluvial neosol. The effect of bovine trampling on pastures, according to Carneiro et al. [19] and Figueiredo et. al. Carassai et al. [20], in research on grazing intensity and grazing methods with lambs in crop-livestock integration, that the highest soil density values were recorded in the deeper layers (5-10 cm).

Total porosity (Table 2) showed a significant effect ($p<0.01$). The higher soil densities reflect lower values for total porosity. Such behavior was observed in T2 and T3 with higher density inferring a lower total porosity. This may have occurred because the area was used intensively for 60 days with sheep grazing, to the point of not differing in the different periods. Pereira Junior et al. [21] found that compaction caused by sheep trampling induced an increase in soil density, decrease in total porosity and change in pore size distribution in the 0 - 5 cm layer, under a Fluvial Neosol.

Also in Table 2, water dispersed clay (WDA), in the grazing systems T2 and T3 expressed lower results, differing from T1, indicating a better accumulation of clay particles, influenced by the organic matter content of the soil that acts as an aggregate of these particles. A similar result was found by Ferreira et al. (8), when comparing areas grazed by cattle and sheep with native forest in the sertão of Paraiba. Pereira Junior et al. (2006), also observed a reduction of the water dispersed clay (WLA) submitted to management practices in different agro-ecosystems, in an area with the introduction of animals for grazing, in a Neosol in the municipality of Sousa/PB.

For soil pH, there was no significant difference ($p<0.01$), among treatments, ranged from slightly acidic (T1 and T2) to neutral (T3), the sheep grazing in the different periods did not induce any use impediment for different crops (Table 3). Evaluating the soil attributes, under different conditions of use through bovine grazing in rangeland, rotational bovine grazing, sheep grazing in coconut groves, rotational sheep grazing, Ferreira et al. [18], found little change in soil pH, which ranged from 6.3 to 7.2 compared to native forest area.

Bandeira et al. [22], analyzing the soil attributes and edaphic macrofauna in different covers, showed that the area reforested with sabiá was the one that presented the lowest pH value (6.7), different from those cultivated with fruit trees (7.3), vegetables (7.5) classified as weak alkalinity, but the burned area (8.4) is already considered highly alkaline.

Table 3 also shows that phosphorus (P) contents differed among treatments ($p<0.01$). They ranged from high T1 and T3 to very high T2, probably in this rainy season provided solubility of this element, to the point of increasing availability in the levels of phosphorus in the soil. Pereira Junior [19] in a research with sheep found that as the number of animals per area increased, the phosphorus contents decreased, clearly indicating that there was an export of phosphorus by the consumption of palatable species consumed bythe animals.

For the K contents^{+}, there was no significant difference for grazing in rainy period (T2) and dry period (T3), compared to area without grazing (T1), however the values present high values (Table 4). It is assumed that sodium can be a limiting factor to the growth of most crops. The results of sodium (Na+), in Table 3, also showed significant difference ($p<0.01$), being high in treatments (T2 and T3) compared to T1.

Table 1. Mean values of sand, silt and clay (textural analysis) of the soil under different periods of sheep grazing, compared to a preserved area at a depth of 0 - 20 cm, in the municipality of Sousa - PB, 2021

	g Kg-¹			
Treatments	**Sand**	**Silt**	**Clay**	**Textural Class**
T1	643^{b}	220^{a}	134 ^{a}	Sandy frank
T2	700^{a}	192^{b}	110 ^{b}	Sandy frank
T3	700^{a}	193^{b}	108 ^{b}	Sandy frank
F	*	*	*	-
CV (%)	4,2	8,9	14.01	-

*T1= no grazing (preserved) T2= sheep grazing rainy period; T3= sheep grazing dry period, CV= Coefficient of Variation. Averages followed by the same letter in the column do not differ by Tukey test, ** = (p<.01) probability, * = (p<.05) probability, ns= not significant*

Table 2. Average values of pH, phosphorus (P), potassium (K^+) and sodium (Na^+) ofthe soil, under different periods of sheep grazing, compared to a preserved area at a depth of 0 - 20 cm, in the municipality of Sousa - PB, 2021

		pH P K+ Na^+		
Treatments	**H_2O**	**mg dm^{-3}**	**----------$cmol_c$ dm^{-3} ----------**	
T1	6,8 a	480 b	0,73 a	0,15 b
T2	6,8 a	1001 a	0,71 a	0,69 a
T3	7,0 a	434 b	0,65 a	0,63 a
CV (%)	2,4	11,2	29,5	25,1
F	ns	*	ns	*

*T1= no grazing (preserved) T2= sheep grazing rainy period; T3= sheep grazing dry period, CV= Coefficient of Variation. Averages followed by the same letter in the column do not differ by Tukey test, ** = (p<.01) probability, * = (p<.05) probability, ns= not significant.*

Santos et al. [10], analyzing physical and chemical soil attributes of areas under pasture in the Microregion of Brejo Paraibano, found that the substitution of native forests by agricultural use led to widespread impoverishment of the soil, among them Ca, Mg, Kand Na.

The values of Ca^{+2} and Mg^{+2} showed significant difference (p<0.01), with high levels among treatments, tending to reduce from grazing in the dry period (T3), compared to grazing sheep in the rainy period (T2) and without grazing - preserved (T1), the Mg^{+2} followed the same trend when comparing T2 with T3 (Table 4). It is worth noting that although calcium and magnesium expressed high values and even higher than T1, reductions occurred, probably due to the removal of pasture by animal consumption, number and a longer stay of animals and not returned by plant cycling and animal waste, in view of the fact that calcium is largely excreted by animal feces in which is poorly soluble in water, making the release very slow also found by Pereira Junior [19]. Corroborating this study,

Table 3. Average values of pH, phosphorus (P), potassium (K^+) and sodium (Na^+) ofthe soil, under different periods of sheep grazing, compared to a preserved area at a depth of 0 - 20 cm, in the municipality of Sousa - PB, 2021

		pH P K+ Na^+		
Treatments	**H_2O**	**mg dm^{-3}**	**----------$cmol_c$ dm^{-3} ----------**	
T1	6,8[a]	480 [b]	0,73 [a]	0,15 [b]
T2	6,8[a]	1001[a]	0,71 [a]	0,69 [a]
T3	7,0[a]	434 [b]	0,65 [a]	0,63 [a]
CV (%)	2,4	11,2	29,5	25,1
F	ns	*	ns	*

*T1= no grazing (preserved) T2= sheep grazing rainy period; T3= sheep grazing dry period, CV= Coefficient of Variation. Averages followed by the same letter in the column do not differ by Tukey test, ** = (p<.01) probability, * = (p<.05) probability, ns= not significant*

Table 4. Average values of calcium (Ca^{+2}), magnesium (Mg^{+2}), Sodium saturation (STP)and soil organic matter (SOM) in the soil, under different periods of sheep grazing, compared with a preserved area at a depth of 0 - 20 cm, in the municipality of Sousa - PB, 2021

Treatments	**Ca^{+2}**	**Mg^{+2}**	**PST**	**MOS**
	---------- cmolc dm^{-3}----------%			**g.kg**
T1	11,3 [a]	1,8 [c]	1,0 [b]	39,0[a]
T2	13,3 [a]	8,8 [a]	3,0 [a]	3,1 [b]
T3	7,9 [b]	5,7 [b]	4,0 [a]	1,0 [c]
CV (%)	14,1	23	8,4	19
F	**	**	**	**

*T1= no grazing (preserved) T2= sheep grazing rainy period; T3= sheep grazing dry period, CV= Coefficient of Variation. Averages followed by the same letter in the column do not differ by Tukey test, ** = (p<.01) probability, * = (p<.05) probability, ns= not significant.*

Santos et al [23], in areas of pasture, found a reduction in calcium and magnesium in three soil depths (0-10, 10-20 and 20-30), in semi-degraded pasture (PSD), degraded pasture (PD) compared to native forest (MN).

Sodium saturation (STS) differed statistically between treatments (Table 4). It can be seen that grazing between rainy periods (T2) and dry periods (T3) did not change statistically, indicating no restriction with respect to sodium levels in the soil, being within the limit range of less than 7 considered as soils without problems in the environments studied.

There was a significant difference for soil organic matter (SOM), it is possible to identify that T1 has a high level of organic matter, due to be a place of preservation without human intervention, on the other hand, it is noticeable the reduction of SOM from T2 to T3, with the end of the rainy season and beginning of the drought, there was a reduction in the availability of green pasture, inducing the sheep take advantage of the pasture residues in decomposition, as well as the period of 60 days permanent in the area, which probably contributed to this reduction. Analyzing animal grazing, Ferreira et al. [18], found that in environments with sheep grazing influenced the reduction of soil organic matter, compared to bovine grazing and native forest.

4. CONCLUSION

Sheep grazing in the different periods promoted soil compaction expressed by increased soil density reduced total porosity, and lower aggregate clay content.

The permanence of grazing animals promoted a reduction in the chemical quality of the soil, notably for phosphorus, calcium, magnesium and SOM contents in grazed sheep during the dry season, and an increase in sodium and PST, compared to an area without grazing (preserved).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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