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Vertisol Soil fertility Indicators in Rotational grazing on the Cauto Valley

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ABSTRACT

The behavior of some Vertisol soil fertility indicators was randomly studied for four years, at a milk production unit on the Cauto River Valley, Cuba. *Brachiaria humidicola* cv CIAT 679 pasture was used without irrigation and fertilization. Grazing intensity had mean variation values, of 243 UGM/ha in the rainy season and 190 UGM/ha in the dry season. The daily grazing stripe depended on pasture availability. The occupation time was 2 days. No significant variations were observed in time, or associated to grazing intensity in terms of physical properties of the soil. The apparent density decreased according to the season ($P < 0.05$) and the highest value was observed in the dry season (1.42 and 1.18 g/cm^3). The grazing stripe variable brought benefits to the balance of exchangeable ions, with a higher ratio of Ca^{2+}/Mg^{2+} and Mg^{2+}/K^+. Interaction between season and grazing was produced in mobile forms of soil nitrogen and NO_3^-, NH_4^+ and NFH, higher during the rainy season in the grazing areas. Stripe grazing does not diminish the main soil fertility indicators; however, it does favor nitrogen mobility and mineralization, depending on the most suitable grazing stripe variable for this kind of soil.

Key Words: *soil fertility, rotational grazing, season*

INTRODUCTION

Several authors have reported that many of the factors that limit tropical pasture production are related to soil limitations (Pezo, 1997; Dias-Filho, 2001).

When the pasture lands are subjected to intensive management systems of rotational grazing, the number of organisms living in the dead leaves is sharply increased; the same occurs to soil biota, which benefits soil fertility due to the contribution such organisms make by decomposing and incorporating organic matter into the soil (Sánchez *et al.*, 1996). Nevertheless, the literature reviewed on rotational grazing, does not offer complete information on the variable of defoliation intensity.

It has been acknowledged that increases in defoliation intensity of tropical pastures can improve their structure, quality and purity (Baldo *et al.*, 1998), but it is important to know how much soil, pasture and animal stability are affected by the sharp increases in defoliation intensity. Even by increasing defoliation intensity, whether by reducing the lot size or by increasing the number of animals, may cause several various effects on the behavior of these elements of the production system, which in the case of soil, lack of knowledge prevails.

The purpose was to analyze the behavior of some fertility indicators of a Verstisol soil in rotational grazing conditions using the stripe grazing land variable, in order to adapt the procedures for system management.

MATERIALS AND METHODS

The study was conducted on a cattle farm at the Experimental Station for Pastures and Forages, of the Institute for Agricultural Research *Jorge Dimitrov*, in Granma, 10 ½ km from the city of Bayamo (20º 18' 13" north latitude and 76° 39' 48" east longitude. It consisted in evaluating the influence of rotational grazing on the variation of some Vertisol soil fertility indicators, for four years that applied stripe grazing as a strategy, and where daily stripes of pasture land of variable sizes are assigned to herds, depending on pasture availability (Ray *et al*., 1998).

In the study area, the mean air temperature was 24.2 °C in the dry season (November-April) and 27.7 °C in the rainy season (May-October), with maximum values of 28.6 °C and 32.8 °C, respectively. Annual rainfall ranged between 815 and 1 052 mm. The base pasture was *Brachiaria humidicola* cv. CIAT 679, on dry land and without fertilizing. Vertisol soil, according to soil genetic classification (Hernández *et al*., 1999) is mainly characterized by the accumulation or large quantities of clay type 2:1 (montmorillonite) whose total content is more than 60% in all the soil profile, Therefore, under Granma´s climatic conditions, large and mid-size prismatic block structures, with sliding sides and wide cracks during the dry season, are developed. Outflow is extremely low, thus producing very bad superficial and internal draining, which leads to flooding in the rainy season.

Treatments and design. Two areas were used for the treatments, one experimental, for 40 5/8 Holstein-3/8 Zebú cows, in segmented grazing conditions; and another without grazing, according to a completely randomized designed.

Procedure. The grazing area had 26 stripes of 33 x 132 m each (0.4356 ha), with interior legs. The size of the daily segment for grazing was defined according with the availability of pasture, so biomass supplies could allow an estimated dry matter consumption by the herd of 3 % of mean live weight, in which 90 % of estimated pasture yields were considered, in order to increase availability. During the dry season, under time restrictions for base pasture, the size of the stripe was used to guarantee availability according to the grazing time, due to consumption of complementary feeds. A single segment was calculated for the whole herd so that "*in-line grazing*" could be possible. Accordingly, each stripe was occupied for two days maximum, and the grazing intensity varied, from 243 UGM/ha in the rainy season, to 190 UGM/ha in the dry season.

The complementing area was planted with sugar cane (0.8 ha), *king grass* (2.5 ha) and the protein bank, with *Leucaena leucocephala* (2.2 ha). Proper management allowed the animals to keep grazing between 18-19 h in the rainy season and 16-17 h in the dry season.

To measure the effects of grazing, four stripes were chosen from the grazing area, and used in the whole sampling and analysis process. An area of approximately two stripes was not under grazing (witness). Analysis of physical, chemical (mainly nitrogen forms in the soil), were made, and sampling was made diagonally. Physical soil analyses included 5 samples per enclosure.

The texture and macrostructure were determined according to the method described in the Specific Standard No. 408/1981 of the Ministry of Agriculture; apparent density (d), through the cylinder technique; real density (D) by picometer; and total porosity (Pt) was calculated according the expression of Pt = (1-d/D) x 100.

For the chemical indicator analysis 8 samples were taken (0.20 cm of depth from all the areas in every quarter of the year, starting from 12 samples per stripe. PH was determined for H_2O and KCl, using a potentiometer; phosphor (P_2O_5) and potassium (K_2O), following the Oniani method (1964); calcium (Ca^{++}) and magnesium (Mg^{++}), by complexometric titration, with EDTA; and sodium ion activity, by flame photometry (AOAC, 2005).

For nitrogen forms determination, 12 samples in each area were taken at a depth of 0-20 cm, assuming that in poorly developed soils, nitrogen contents follow a similar distribution to organic matter, and deeper accumulations are not significant (Fassbender, 1975). Sample taking was carried out every four months, in the rainy and dry seasons. Nitrate ion (NO_3^-) activity was determined by the phenol-disulfonic acid method; ammonium ion (NH_4^+) activity was determined by the Nessler method (AOAC, 2005); and easily hydrolizable nitrogen activity (NFH) was determined by the *Tiurin-Kononova* method (Kaúrichev, 1984).

Statistical analysis. For data analysis STATISTIC software for Windows, 10.0 (StatSoft 2011) was used. A linear model was used to control the grazing effects (2), year (4) and evaluation period (2), season (2) and possible interactions. For comparison of means, the Newman-Keuls (StatSoft, 2011) test was applied.

RESULTS AND DISCUSSION

The physical properties of the soil are shown in Table 1. The values for the study show that there are no significant variations in time, or associated to grazing intensities to which the system was exposed, which corroborates findings by Brunet *et al*. (1998) about the poor variations the physical properties of the soil undergo in a relatively not very long time. This result is similar to findings by Hernández and Milera (1996), who stated that the implementation of rotation cycles with occupation times that produce grazing intensities of up to 250 UGM/ha cause no soil property variations.

The soil apparent intensity as an indicator is related to soil compression (Fig. 1). A remarkable effect of season was produced, observed to be higher in the rainy season. This behavior does not seem to be linked to the grazing effect, but it is related to the kind of soil studied, characterized by an increase in the total mean porosity in the rainy season. Therefore, mass decreases in the same volume of soil, which happens to apparent density as well. On the contrary, in the rainy season the total mean porosity decreases to the extent of cracking the soil, forming very stable structures with higher apparent density. Crespo *et al.* (2011) reported a value of 1.01 g/cm^3 on typical red ferralitic leached soil during the dry season.

Alegre and Lara (1991) achieved higher apparent density values than the ones in this paper using *B. humidicola* associated with *Desmodium ovalifolium* under high grazing conditions. Costa *et al.* (1999) found an increase in the apparent density of up to 20 cm, regarding pasture utilization time in the eighth year, with similar values to the ones found here in the dry season.

Given the importance of discriminating the influence of rotational grazing for preservation or improvement of some soil fertility indicators, in order to recommend the system on Vertisoles, cationic interactions were determined (Table 2), as an element that may contribute with the capacity for soil cationic exchange. The Ca/Mg relationship shows improvements in terms of nutrient diffusion, and despite poor calcium availability can be observed, it is higher in grazing areas. The Ca/Na relationship shows an improvement in nutrient diffusion, especially potassium, observed in Mg/K and Na/K relationships, in which sodium activity is reduced; whereas potassium activity is increased. Similar results were presented by Costa *et al.* (1999) on Podzol soil.

B. humidicola is also reported as a species that requires lower quantities of P, Ca and K than other bracharia species. The values of these elements found at the end of the study of rotational grazing areas are higher than the critical levels required for this pasture, according to CIAT (1981). This may contribute with the pasture´s more stable persistence and yield levels.

The analysis of nitrogen forms on the soil showed that there was interaction between season and grazing (Table 3). The rotational grazing area is less unstable within the season in comparison to the witness; the highest values achieved for each of indicator show that grazing management favors nitrogen mobility and mineralization. Changing management conditions of the grazing areas seem to cause greater stability of nitrogen forms, and additionally, fresh nitrogen conversion is more effective into mineral nitrogen, due to animal density per area unit applied, which makes possible higher nitrogen intake and contribution through cow pats and urine while grazing. Ramos *et al.* (1993), in a Vertisol fertilization study recommended N application based on grazing pasture removal behavior, and soil N recovery, which corroborates the importance of grazing management techniques that favor balanced processes on these kinds of soils.

According to Alvim *et al.* (1990), *B. humidicola* is characterized for its low response to N application, and for absorbing and using both forms of nitrogen (NH_4^+ y NO_3^-), better than other bracharias. Acordingly, favorable results in rotational grazing in mobile soil N forms help infer that the application of variable management of stripe grazing is a contribution to improving the main elements required for the species in question, which coincides with Dias-Filho (2000), in that in order to increase cultivated tropical pasture sustainability, soil management should be based on practices that maximize the nutrient cycle, minimize losses and prioritize nutrient uptake in the system.

CONCLUSIONS

The use of rotational stripe grazing does not diminish the behavior of the main indicators of soil fertility; however, it does favor nitrogen mobility and mineralization, which is related to variable management of the grazing stripe, suitable for the kind of soil in its interaction with the climatic variables.

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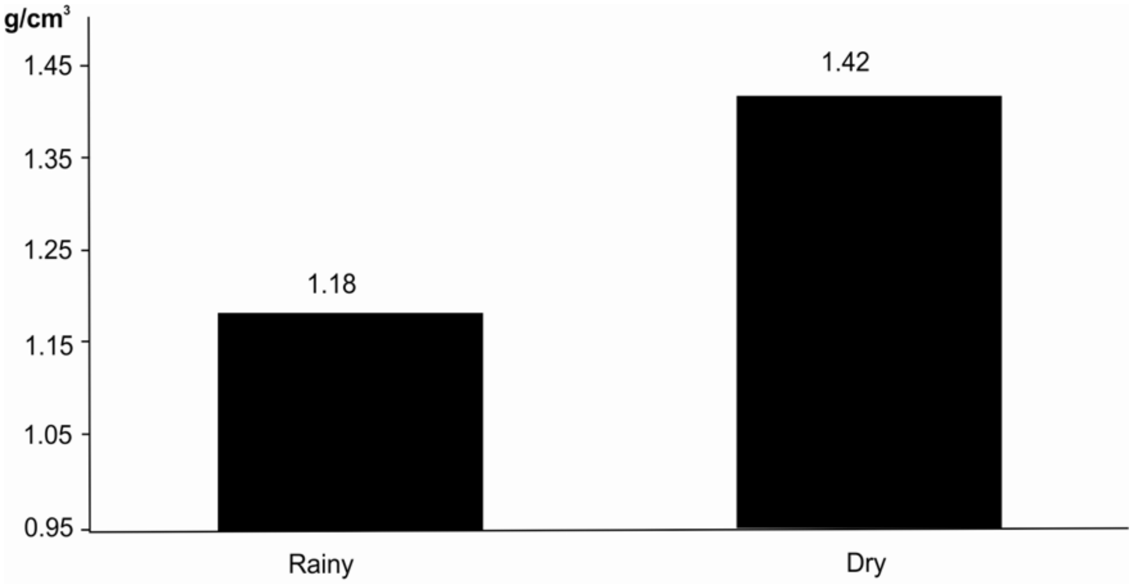

Fig. 1. Behavior of apparent density according to the season

Table 1. Physical properties of the soil in rotational grazing and witness (non-grazing) areas during the initial and final evaluation periods

Indicators	Rotational grazing area		Non-grazing area (witness)		±EE
	1st year	4th year	1st year	4th year	
Texture (%)					
2-0.2 mm	0.30	0.26	0.29	0.20	0.04
0.2-0.02 mm	32.88	34.95	34.78	32.78	1.38
0.02-0.002 mm	24.68	26.48	25.81	28.12	0.84
< 0.002 mm	41.85	40.56	39.38	38.90	0.97
Real density (g/cm^3)	2.38	2.66	2.36	2.41	0.10
Capillary elevation (mm)	164.5	124.4	160.0	126.0	9.96
Plasticity index (%)	41.9	35.9	38.8	34.8	2.25

Table 2. Inter cationic relationships in rotational grazing and non-grazing areas

Relation	Rotational grazing area		Non-rotational area (witness)	
	1st year	4th year	1st year	4th year
Ca/Mg	1.50	1.44	1.43	1.19
Ca/Na	26.15	18.95	14.49	12.39
Mg/K	19.25	28.18	26.17	23.26
Na/K	1.10	2.14	2.59	2.25

Table 3. Behavior of soil nitrogen forms according to the season in rotational grazing and non-grazing (witness) areas

Indicators (mg/100 g)	Rotational grazing area		Non-grazing (witness)		± EE
	Rainy	Dry	Rainy		Dry
NH_4^+	2.87^a	2.69^{ab}	1.21^c	2.67^b	0.10*
NO_3^-	1.46^b	2.02^a	1.32^c	1.31^c	0.65*
NFH	20.06^a	19.91^a	16.23^b	17.20^b	0.32*