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Forage availability and weight gain of goats on caatinga enriched with *Urochloa trichopus* (Hochst.) Stapf subjected to fallowing and fertilized with phosphate

Disponibilidade de forragem e ganho de peso de caprinos em caatinga enriquecida com Urochloa trichopus (Hochst.) Stapf submetida ao diferimento e a adubação fosfatada

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Abstract
The objective of this study was to evaluate the forage availability and performance of goats in thinned Caatinga enriched with *Urochloa trichopus* subjected to grazing fallowing and levels of phosphorus fertilization. Twenty-four F1 crossbred goats (Boer x Non-descript breed), whole, 15.0 ± 2.6 kg body weight were distributed in four paddocks (n = 6) according to body weight, age and physiological status. Animals grazed on Caatinga, under continuous stocking, and were gathered and kept in individual pens overnight. The experiment to evaluate animal performance was a randomized block design with 4 treatments (0, 11, 33 and 60 days of fallowing) and six replications. To determine dry mass production and floristic composition, phosphate fertilization was used in the doses of x P_2O_5 in a randomized block design with five treatments, 0, 30, 60, 90 and 120 kg P_2O_5 with 4 replications. Phosphate fertilization had an effect on the floristic composition of dicots and *U. trichopus* (P<0.05). There was an effect of pasture fallowing on the final weight of goats, with the lowest weight (20.40 kg) observed after 60 days of fallowing (P<0.05). Fallowing is not suitable for an area of vegetation in the caatinga, because there was a decrease in forage availability and quality in the dry period, resulting in a lower performance of animals.
Keywords: Food management; forage availability; native pasture; semiarid

Resumo
Objetivou-se avaliar a disponibilidade de forragem e desempenho de caprinos em Caatinga raleada e enriquecida com *Urochloa trichopus* submetida ao diferimento de pastejo e doses de adubação fosfatada. Foram utilizados 24 caprinos mestiços F1 (Boer x SPRD), inteiros, com peso corporal de 15,0 ± 2,6 kg, distribuídos em quatro piquetes (n = 6) de acordo com o peso vivo, idade e estado fisiológico. Os animais realizaram pastejo na Caatinga, com lotação contínua, sendo recolhidos e colocados em baias individuais permanecendo nesse local durante a noite. No experimento para avaliar desempenho animal foi usado delineamento blocos casualizados com 4 tratamentos (0, 11, 33 e 60 dias de diferimento) e seis repetições. Para determinação produção de massa seca e composição florística foi usado a adubação fosfatada nas dosagens de x P_2O_5 em um delineamento em blocos casualizados com cinco tratamentos, 0, 30, 60, 90 e 120 kg de P_2O_5 com 4 repetições. A adubação fosfatada promoveu efeito para a composição florística de dicotiledôneas e *U. trichopus* (P<0,05). Houve efeito do diferimento de pastagem para o peso final dos caprinos, com o menor peso (20,40 kg) observado aos 60 dias de diferimento (P<0,05). A adubação fosfatada não aumentou a produtividade de matéria seca. O diferimento não é indicado para uma área de vegetação da caatinga, pois mesmo com a vedação, no período seco ocorreu uma diminuição na disponibilidade e na qualidade da forragem, acarretando um menor aporte dos animais.
Palavras–chave: Disponibilidade de forragem; ganho de peso; pastagem nativa; semiárido

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Introduction

The Caatinga Biome in the semiarid region of northeastern Brazil is strongly influenced by the hot, dry climate (BSh'w), characterized by high temperatures (over 30ºC), average relative humidity of 61% and average rainfall of 500 mm/year, distributed in the short rainy season[1,2]. The vegetation in this region is characterized by the predominance of a shrub-tree layer composed of plants with low carrying capacity, resulting in low animal yield[3]. Despite this, it constitutes the basic forage support of most properties dedicated to livestock production in this region.

Goat farming is a widespread activity throughout the Brazilian territory, but it has a greater concentration in the semiarid northeastern Brazil. The rusticity of goats in the face of climatic adversities is secular, due to the process of adaptation, natural selection and also the influence of man[4]. In Brazil, about 90% goat herds are located in the Northeast region, which has 92.5% semiarid region of the country [5]. Thus, in an attempt to improve production systems and consolidate this activity in the region, the aim is to introduce innovative pasture management techniques, with the aim of making them viable and improving this important source of income.

One of the alternatives is the fallowing of pasture, which is an easy-to-perform, low-cost management strategy that guarantees forage stock during the period of scarcity. The use of fallowing occurs at the time of year with greatest forage shortage in a region and will determine the duration of the pasture growth period[6,7]. Another suggestion is phosphate fertilization, which allows for greater flexibility in the period of fallowing of pasture[8], since phosphorus is crucial for plant metabolism, playing a key role in cell energy transfer, respiration and photosynthesis. It is also a structural component of the nucleic acids of genes and chromosomes, as well as of many coenzymes, phosphoproteins and phospholipids[9].

The low availability of phosphorus for growing plants is a predominant characteristic in Brazilian soils. Thus, the application of nutrients in adequate amounts and proportions, such as P_2O_5, is a fundamental practice to increase forage production[10]. *Urochloa trichopus* grass is well accepted by ruminants and supports grazing close to the ground[11] and, in recent years, it has been gaining ground with producers in the Northeast region[32]. Due to these aspects, it has been gaining the semiarid northeastern region, and it can be used in pasture fallowing, as it presents tender stems and abundant foliage, high production of dry matter in the rainy season, high protein content and digestibility[12].

In this context, the objective was to evaluate forage availability and performance of goats in thinned Caatinga enriched with *Urochloa trichopus* subjected to fallowing and fertilized with phosphorus.

Material and Methods

The experiment was conducted between March and August 2014, at Lameirão Farm, experimental unit of the Center for Rural Health and Technology of the Universidade Federal de Campina Grande (UFCG), geographically located at coordinates 7°02'56.8" South and 37°29'36.2" West, in the municipality of Santa Teresinha, in the state of Paraíba.

According to the Köppen climate classification, the climate in the region is BSh' hot and dry (semiarid), with a short summer-fall rainy season[13]. The maximum average annual temperature is 32.9 °C, the minimum is 20.8 °C, and relative humidity is 61%[14].

The experiment was carried out in an area of 2.4 hectares of caatinga enriched with bushveld signalgrass (*Urochloa trichopus* (Hochst.) Stapf), which was divided into four paddocks of 0.6 hectares each.

At the beginning of the rainy season, bushveld signalgrass was sown. For this purpose, seeds were sown by broadcasting in order to facilitate the contact of the seed with the soil and always seeking a distribution as uniform as possible in the area.

Soil samples from the experimental areas, in the 0-20 cm deep layer, were taken for physical and chemical analysis carried out at the Soil and Water Analysis Laboratory (LASAG/CSTR/UFCG)[16] (Table 1). The soil of the experimental area was classified as Litholic Neosol[15].

Table 1. Soil analysis of experimental areas

Layer (cm)	Area	pH	P	K^+	Ca	Mg^+	Na^+	H+Al	V
			mg/dm³	cmol$_c$/dm³					(%)
0 – 20	I	6.8	31.4	0.77	6.4	3.0	0.43	1.6	86.9
	II	6.7	39.5	0.92	10.6	3.0	0.48	1.5	90.9
	III	6.1	31.6	0.50	4.0	1.8	0.52	2.1	76.5
	IV	6.1	42.9	0.59	7.5	3.5	0.43	2.2	84.5

Twenty-four F1 crossbred goats (Boer x Non-descript breed), uncastrated, 15.0 ± 2.6 kg initial body weight were distributed into four paddocks (6 animals per paddock) according to body weight, age and physiological status. Animals grazed on thinned Caatinga enriched with *Urochloa trichopus*, under continuous stocking, from 8 to 16 hours and later gathered and housed in individual pens with a feeder and a drinking trough, overnight, where they received a concentrate supplementation (1% body weight).

Four treatments were used in the pasture fallowing management system:

Regarding the first rainfall events in the region, causing the regrowth of the Caatinga vegetation, the time in days (20 days after the first rainfall events) was considered for placing the animals in the first paddock, thus constituting the periods of fallowing, treatment 1 (fallowing O, zero), treatment 2 (11 days fallowing in relation to treatment 1); treatment 3 (33 days fallowing in relation to treatment 1); treatment 4 (60 days fallowing in relation to treatment 1).

In each paddock, animals had access to water and mineral salt *ad libitum*. The value, in mm, of rainfall during the experimental period is illustrated in Figure 1.

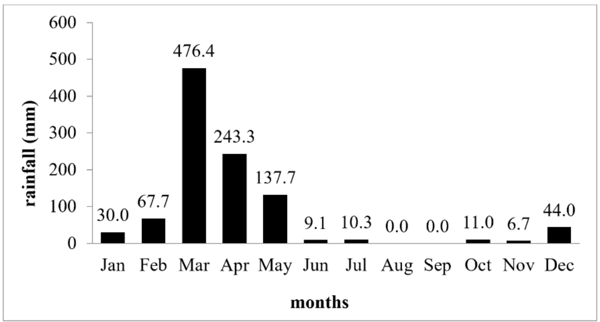

Figure 1. Rainfall (mm) in the municipality of Santa Teresinha, state of Paraiba, during the experimental period.

All procedures for the animal research were approved by the Internal Ethics Committee in Animal Experimentation of the Center for Rural Health and Technology: Protocol 029/2012.

The supplement offered to the animals was prepared with ground corn, soybean meal (Table 2) and mineral mixture for goats (Caprinofós, Tortuga, São Paulo, Brazil) (Table 3), and was used only for animal maintenance.

Table 2. Proportions of ingredients in the concentrate mixture.

Ingredient	Percentage (%)
Ground corn	70
Soybean meal	28
Mineral mix for goats	2
Total	100

Table 3. Chemical composition of ingredients of the experimental diet

Component	Soybean meal	Ground corn
Dry matter (g/kg NM)	937.7	904.9
Organic matter (g/kg DM)	881.7	894.1
Mineral matter (g/kg DM)	56.0	10.8
Crude protein (g/kg DM)	467.5	80.9
Ether extract (g/kg DM)	104.4	40.5
Neutral detergent fiber corrected for ash and protein (g/kg DM)	131.8	113.2
Acid detergent fiber corrected for ash and protein (g/kg DM)	85.2	35.6

NM = Natural matter; DM = Dry matter

Table 4. Composition of the mineral mixture offered to the animals in the experimental diet.

Guarantee Levels (Mineral quantity/kg product)						
Magnesium (mg)	Iron (mg)	Cobalt (mg)	Cooper (mg)	Manganese (mg)	Sodium monensin (mg)	Zinc (mg)
5,040	1,500	100	400	1,000	100	2,000
Selenium (mg)	Iodine (mg)	Fluorine (mg)	Calcium (g)	Phosphorus (g)	Sulfur (g)	Sodium (g)
11.7	61	750	150	75	13.8	148

Regarding the application of P_2O_5: In the 10 m x10 m plots, the phosphorus level (kg/ha) to be applied was randomly selected, the amount was broadcast throughout the plot, soon after the first rain at the experimental site.

The availability of dry matter of herbaceous components (dicots, bushveld signalgrass and other grasses) was evaluated according to the methodology recommended by Araújo Filho[17] (2013), which consists of a rectangular metal frame measuring 1.00 m in length and 0.25 m in width (0.25 m^2), which was thrown from transects traced in the North, South, East and West directions from the center point of the paddock. Fifteen samples were taken per paddock at different evaluation times, corresponding to 40 samples/ha. In each paddock of 0.6 ha, five plots of 10 x 10 m were allocated, where levels of 0, 30, 60, 90 and 120 kg/ha phosphorus were applied and the availability of dry matter and the floristic composition of herbaceous components were determined. Three samples were collected from each plot using a 0.25m^2 square.

The cut for sample collection was carried out close to the ground. After cutting, samples were placed on a bench and separated into herbaceous dicots, *Urochloa trichopus* and other grasses. Afterwards, samples were stored in identified paper bags and weighed on a precision scale to compose the data related to the green mass. Soon after weighing, samples were dried in a forced air oven at 55 °C to constant weight, which occurred after 72 hours[18]. Then, samples were weighed again to obtain the dry mass.

To assess animal performance, animals were weighed at the beginning of the experiment and every 15 days, until the end of the experimental period, for later calculations of total weight gain (TWG), and average daily gain (ADG), using the equations:

TWG = initial weight gain - final weight gain

ADG = total weight gain / days in experiment

In the experiment to evaluate animal performance, a randomized block design with 4 treatments (0, 11, 33 and 60 days of fallowing) and six replications was used.

For data on dry mass availability and floristic composition based on availability, a split plot randomized block design was used, with fallowing periods assigned to plots and the five levels of phosphorus to the subplots.

The analyzed variables were tested by analysis of variance (ANOVA). Data were analyzed using the Statistical Analysis System 9.2 (SAS 9.2), considering probability values lower than 5% as significant according to Tukey's test.

Results and discussion

According to Bezerra et al.[19], phosphorus plays a key role in the life cycle of plants, being present in metabolic processes of plants directly or indirectly related to energy expenditure. Also, according to these authors, phosphorus fertilization is necessary to achieve high phytomass productivity, due to its important role in plant morphogenesis, promoting an increase in metabolism and rates of enzymatic reactions. In this study, there was no interaction effect (P>0.05) between phosphorus levels and fallowing for dry mass availability and floristic composition of dicots, bushveld signalgrass and other grasses. Phosphorus fertilization of the caatinga enriched with bushveld signalgrass did not influence (P>0.05) the dry mass availability of dicots, other grasses and bushveld signalgrass (Table 5).

Table 5. Availability (kgDM/ha) and floristic composition (%) of herbaceous dicotyledonous forage, other grasses and *Urochloa trichopus* according to levels of P_2O_5 per hectare.

Levels of P_2O_5 (kg/ha)	Forage availability (kgDM/ha)				Floristic composition (%)		
	Herbaceous dicotyledonous forage	Other grasses	*Urochloa trichopus*	Total	Herbaceous dicotyledonous forage	Other grasses	*Urochloa trichopus*
0	2033.10a	232.60a	3.57a	2269.30a	87.21ab	12.50a	0.28b
30	1478.40a	77.91a	13.49a	1569.80a	94.13a	4.71a	1.15b
60	1725.00a	75.40a	4.09a	1804.50a	94.69a	5.07a	0.23b
90	1541.40a	246.47a	134.29a	1922.20a	77.38b	11.97a	10.64a
120	1625.00a	114.39a	132.33a	1871.80a	87.51ab	5.17a	7.30ab
CV (%)	47.71	121.65	242.76	42.98	13.98	125.80	220.55

Mean values followed by different lowercase letters, in the same column, are significantly different by Tukey's test at 5% probability.

Our results differ from those found by Araújo et al.[20], who evaluated the use of phosphorus in grasses and legumes grown in semiarid neosoil, in which phosphate fertilization increased the production of dry mass of grasses and legumes. They also described that the responses of forage species to phosphorus fertilization vary widely from place to place, depending on the cultivated species, the management level and especially the availability of phosphorus in the soil.

The floristic composition in dicots and *Urochloa trichopus* (Table 5) was influenced by phosphorus fertilization, where the level of 90 kg/ha P_2O_5 favored the highest percentage of *Urochloa trichopus* and the smallest percentage of dicots. Considering that phosphorus plays an important role in root development and in grass tillering, its deficiency in the soil limits the productive capacity of pastures[21]. In this situation, phosphate fertilization is essential so that this element does not limit the response of the forage plant, but with applications of low levels of phosphorus in the process of restoring a degraded pasture, the response of plants is very slow, resulting in low productivity[22].

In native Caatinga, the effect of grazing by any species should not have significant effects on the vegetation, as long as the relationship between supply and demand for pasture is respected. Under overgrazing conditions, goats and sheep can induce changes in the floristic composition of the Caatinga[23,24]. Santos et al.[25], in studies carried out with species on native pasture and on diet, reported that it is important to determine the strategies for using the materials to increase the results of forage production and animal performance, thus improving the development of ruminant production in the semiarid region.

The availability of dicots and other grasses reduced as the days of fallowing increased (60 days), which is justified, considering that the herbaceous broad-leaved vegetation of the caatinga, in its phenology, depends on climatic variation, mainly rainfall, accelerating the senescence process, reducing their availability. *Urochloa trichopus* grass, on the other hand, showed no variation in availability, although at the beginning of the fallowing (day 0), the grass forage mass value of 18.59 kgDM/ha showed a tendency to increase with the progress in the fallowing period, with values above 58 kgDM/ha (Table 6). The low amount of forage mass is justified by the lower occurrence of grass in the experimental area (floristic composition), considering that, at the beginning of the experiment, the grass was under regrowth, with higher water content and lower dry matter content in its composition.

Table 6. Availability (kgDM/ha) and floristic composition (%) of herbaceous dicotyledonous forage, other grasses and *Urochloa trichopus* according to different days of fallowing per hectare.

Days of fallowing	Forage availability (kgDM/ha)				Floristic composition (%)		
	Herbaceous dicotyledonous forage	Other grasses	*Urochloa trichopus*	Total	Herbaceous dicotyledonous forage	Other grasses	*Urochloa trichopus*
0	2379.00a	135.80ab	18.59a	2533.30a	94.08a	5.04b	0.87a
11	1576.40b	263.47a	63.98a	1903.80a	80.09b	14.86a	5.04a
33	1895.20ab	138.58ab	89.07a	2122.90a	89.37ab	6.39b	4.23a
60	871.80c	59.62b	58.59a	990.00b	89.19ab	5.25b	5.55a
CV (%)	47.71	121.65	242.76	42.98	13.98	125.80	220.55

Mean values followed by different lowercase letters, in the same column, are significantly different by Tukey's test at 5% probability.

The total availability of kgDM/ha in the fallowing periods had a significant effect, with the lowest availability with 60 days of fallowing, as rainfall reduced from 243.3 to 9.1 mm, which may have resulted in lower growth and higher senescence of the vegetation, considering that the animals were placed in the area 60 days after the beginning of the fallowing and 80 days after the beginning of the rains.

In this period, there was low availability of dry mass of herbaceous vegetation (990.00 kgDM/ha), when compared to 0 days of fallowing (2533.30 kgDM/ha), which is expected since some species of herbaceous vegetation of the caatinga have a short life span, germination, emergence, growth, flowering and senescence, very fast after the onset of rains. Results superior to those found here were reported by Carvalho Júnior et al.[26] working with the effect of supplementation on carcass traits and non-carcass components of F1 Boer x Non-descript breed goats finished on native pasture, when they obtained a total availability of 3347.9 kg DM/ha native Caatinga. In turn, Pereira Filho et al.[27] analyzed alternate sheep-goat grazing in the region of Sobral, state of Ceará, and found a phytomass production of around 3,000 kg/ha for thinned native pasture in rainy seasons.

The fallowing affected the animal performance in the final weight, in which 60 days of fallowing reduced the final weight of the animals (Table 7). Probably what caused the reduction in final weight was the lower availability of dry mass (Table 6), in the treatment with 60 days of fallowing, even not reflecting in the other variables. It is important to highlight that up to 33 days of fallowing, the final weight was not altered, most likely due to the high forage supply that exceeded the minimum of 3.5 times the necessary[33], allowing the animals to express all their ability to select species more palatable and of better nutritional value[34].

Table 7. Productive performance of grazing goats subjected to four periods of fallowing

Days of fallowing	Productive performance				
	FBW (kg)	TWG (kg)	ADG (g/day)	ADG (kg $BW^{0.75}$)	ADG (g/kg BW)
0	26.66a	5.74a	58.92a	5.42a	2.45a
11	27.74a	6.34a	60.38a	5.44a	2.44a
33	24.96a	4.84a	43.21a	4.15a	1.90a
60	20.40b	3.42a	51.56a	5.56a	2.64a
CV (%)	8.54	41.89	43.33	43.67	43.75

Final body weight = FBW; Total weight gain = TWG; Average daily gain = ADG; Average daily gain per kilogram metabolic body weight = ADG/kg $BW^{0.75}$, Average daily gain per kilogram body weight = ADG/kg BW. Mean values followed by different lowercase letters, in the same column, are significantly different by Tukey's test at 5% probability.

Results similar to those observed in the study were reported by Santos et al.[28], who evaluated the effect of supplementation in Santa Inês lambs finished on native pasture, and found a final body weight of 23.63 kg in animals receiving 1% supplementation, and by Silva et al.[29], who studied *Urochloa decumbens* and reported a forage reduction in the dry season, with seasonality in animal production and animal weight in the last evaluation period.

Santos et al.[7] argued that the fallowing leads to the accumulation of mature stems and dead material and a decrease in the availability of leaves, with a consequent reduction in animal consumption and performance. Pastures managed at different heights provide different forage masses, interfering with the availability and accessibility of pastures to animals, affecting intake by grazing animals and the animal[30,31]. On the other hand, the botanical composition of the diet for goats, sheep and cattle in the caatinga tends to adjust to the frequency, availability and supply of dry matter[35], with emphasis on species with better nutritional value[36,37], especially in protein[38].

Conclusion

Fallowing is not indicated for an area of caatinga vegetation, because even with the closure of the pasture, in the dry period, there was a decrease in forage availability and quality, resulting in a lower performance of animals, since the areas were in a rest period until their entry.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization: R. M. dos S. Pessoa, D. S. da Silva, J. M. P. Filho; Data curation: R. M. dos S. Pessoa; Formal analysis: D. S. da Silva, J. M. P. Filho, A. M. de A. Silva; Investigation: R. M. dos S. Pessoa, J. M. de S. Ferreira, G. V. do Nascimento; Methodology: R. M. dos S. Pessoa, D. S. da Silva, J. M. P. Filho, A. M. de A. Silva J. M. de S. Ferreira, G. V. do Nascimento; Project management: R. M. dos S. Pessoa, D. S. da Silva, J. M. P. Filho; Resources: D. S. da Silva, J. M. P. Filho, A. M. de A. Silva; Supervision: D. S. da Silva, J. M. P. Filho; Visualization: R. M. dos S. Pessoa, A. M. de A. Silva, J. M. de S. Ferreira, G. V. do Nascimento; Writing – original draft: R. M. dos S. Pessoa, J. M. de S. Ferreira, G. V. do Nascimento; Writing – review & editing: R. M. dos S. Pessoa, D. S. da Silva, J. M. P. Filho, A. M. de A. Silva, J. M. de S. Ferreira, G. V. do Nascimento.

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