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Article

Pasture structure and sheep performance supplemented on different tropical grasses in the dry season

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Abstract:

The objective was to evaluate the productive and structural characteristics of tropical grasses and the performance of sheep supplemented during the dry season. The treatments consisted of Marandu, Piatã, Massai and Aruana cultivars managed under intermittent stocking with seven occupation days and 35 d of rest, with a variable stocking rate. The evaluated variables were the forage masses, the morphological components, the chemical composition of the pasture and sheep performance. The forage mass was similar among the cultivars, while the leaf blade mass and percentage were higher in the Massai cultivar. There were differences between the cultivars for the NDF, ADF, ADL and ash contents in the two grazing cycles. The lowest gains per animal and gain per area were observed in the Aruana grass pastures, while there were no differences for these variables among the other cultivars. Massai, Marandu and Piatã cultivars can be used as a forage option for the dry period when associated with protein supplementation for sheep being raised for meat.

Key words: *Brachiaria*, *Panicum,* Livestock production.

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Introduction

Sheep breeding may be a promising alternative for livestock production in pastures, as complete usage of cultivated pastures is not a common practice in; there is no pasture cultivation on most of the properties, and native pasture with practically no pasture management is the main forage source(1). Introducing production systems in cultivated pastures can increase the productive capacity of the properties and result in a substantial increase in the profitability of the agricultural activities and will favor the permanence and the improvement in the quality of life of farmers.

Grasses of the *Brachiaria* and *Panicum* genus are among the most used forages in animal production systems in countries of tropical climate due to their adaptation to tropical and subtropical climates and high productivity(2). In spite of this, forage mass aging in the dry season can reduce the leaf supply and crude protein content and increase the fiber content, compromising animal performance(3,4).

Studies on forage supply and their effects on defoliation intensity are scarce in tropical forage grasses in the time of scarcity of water resources(5). The dynamics of defoliation can aid in the understanding of plant and animal interaction; there is a conceptual basis for the causal relationships between pasture structural characteristics and forage consumption(6), characterizing in terms of frequency, plant defoliation severity in the pasture ecosystem(7;8), being related to the spatial distribution of biomass among grazing areas.

In view of this, animal performance in pasture is not uniform during the year, which justifies searching for adapted tropical grasses that are able to minimize the adverse effects of the dry season on pasture animal production when they are associated with supplementation. Therefore, identifying and implementing forage plants with greater support capacity and those enable greater weight gain can result in greater efficiency in the animal production system in pasture.

Based on the above, the objective was to evaluate the productive and structural characteristics of tropical forages of the *Brachiaria* and *Panicum* genera under grazing and the performance of sheep supplemented during the dry season.

Material and methods

Site, treatments and experimental design

The experiment was carried out at the Experimental Area of the Forage Research Group (*GEFOR*) of the Federal University of Rio Grande do Norte - UFRN, in Macaíba/RN, located at 5° 53' 34" S and 35° 21' 50" W and 50 m of altitude. The experimental period was 84 d (10/24/2011 to 01/16/2012), characterized as the dry period of the year.

According to Thornthwaite's climate classification[(9)], the region's climate is dry sub-humid with water surplus from May to August. The annual average historical precipitation is 1,048 mm and potential annual cumulative evapotranspiration of 1,472 mm. the precipitation during the experiment was 33 mm. Rainfall data were obtained using a stainless steel Ville de Paris rain gauge installed at the site.

The area's fertility was estimated by soil analysis, then 80 kg ha^{-1} of P_2O_5 and 50 kg/ha of K_2O in order to raise the base saturation by around 60 %, phosphorus content between 8 and 12 mg dm^3 (P-Mehlich[1]) and potassium content between 80 and 100 mg/dm^3, while 100 kg/ha of N as ammonium sulfate was also applied in two post-grazing applications between April and June 2011. The pastures were implanted in June 2010. Sowing was done with the sowing, and the sowing density considered the recommendation for each cultivar and the CV% (cultural value) of the seeds used.

Four tropical forage grasses were evaluated: Marandu and Piatã ***(****Brachiaria brizantha* cv.) and Aruana and Massai ***(****Panicum maximum* cv.) The experimental area of 2.88 ha was divided into two blocks of 1.44 ha, with four modules of 0.36 ha for each cultivar, which was subdivided into six peaks of the same area (0.06 ha). In the rainy season preceding the experiment (01/01/2011 to 09/30/2011), the pastures were grazed by sheep managed under intermittent stocking[(10)] with pre-grazing height goal of 50 cm and post-grazing of 25 cm, so that approximately 50 % of the available mass was removed[(11)]. In the dry period the pastures were managed under rotational stocking with seven occupation days and 35 d of rest, with variable stocking rate. The adjustment of the stocking rate was done weekly according to the forage mass, maintaining at least six test animals per experimental plot.

Forage mass

All evaluations in the pastures were performed immediately before the animals entered the pasture (pre-grazing) and in the post-grazing period after the animals exited from the paddock. The pasture height was measured using a one-meter ruler graduated in centimeters, in 40 representative points paddock. The canopy height at each point corresponded to the average height of the leaves' curvature around the ruler.

The forage mass (FM) was obtained by cutting output to the forage soil contained in four representative areas in four paddock of each module, a metal frame 1 m long by 0.5 m wide (0.5 m^2 of area). The collected samples were identified and weighed to obtain the green weight. To evaluate the dry forage mass, approximately 50 % of the green mass collected from each sample was packed in paper bags and dried in a forced air ventilation oven at 55 ºC for 72 h, then they were reweighed.

Morphological composition

For evaluating the morphological components of the pasture in the pre-grazing, the four collected samples (after removal of the subsamples to determine the dry mass) constituted two composite samples. The composite samples were manually separated into leaf blade, stem (stem + sheath) and dead material to determine the masses and percentages of participation of each component in the pasture structure. The quotient between leaf blade mass and stem mass was obtained to determine the leaf:stem ratio. Post-grazing forage harvesting and the respective evaluations of the morphological components, the leaf:stem and green:dead material ratios occurred in a manner similar to pre-grazing.

Nutritive value

Whole plant subsamples were used to evaluate the chemical composition, ground in a Wiley mill with a 20 mesh screen and later analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and ash (ASH), using methodologies described by AOAC (1995)[12].

Animal live weight gain and stocking rate

Thirty-two (32) male Santa Inês breed sheep with an initial mean live weight of 26.57 ± 4.05 kg were used, with four animals distributed per module. They went through a period of 7 d of adaptation to concentrate and handling. The animals were kept in the pasture during the daytime period (0730 to 1630 h) and were collected from a covered sheepfold to be supplemented and kept at night. Protein supplementation (39.1 % corn in milled grain, 30.0 % cotton cake, 25.1 % soybean meal, 3.0 % mineral supplement and 2.8 % of livestock urea) was formulated according to recommendations of the NRC (1985)[8] for gains of 150 g/d, with the amount being offered to the animals adjusted weekly according to the weight obtained at each weighing, were supplied an amount of 1.38 % of PV concentrate (with DM base). The bays had an area of 9 m^2 and were equipped with a feeder, water fountain and salt lick.

The average daily weight gain (g day^{-1}) was monitored weekly and calculated by the difference in the weight of the animals at the beginning and end of the experiment divided by the grazing days. The stocking rate (animals 30 kg ha^{-1}) was calculated by dividing the mean animal load values of the grazing period by 30 to express in animal units of the category used per hectare. The average weight gains per area (kg day ha^{-1}) was obtained by multiplying the average daily gain of the test animals by the number of animals kept per hectare during the experimental period.

Statistical analysis

The experimental design was a randomized complete block (RCB), the data were submitted to analysis of variance and the means were compared by the Tukey test, adopting a 5% level of significance. The following model was used for the forage variables:

$$Yijk=\mu+Fi+Ij+FIij+Ck+eijk$$

in which:
Yijk = observed value of cultivar *i* and cycle *j* in the block *k*;
μ = general constant (population mean);
Fi = effect of cultivar *i*, i= 1, 2, 3, 4; Ij= effect of cycle *j*, j= 1, 2;
FIij = interaction of cultivar *i* and cycle *j*;
Ck = effect of block *k*, k= 1, 2;
eijk = random error associated with each observation Yijk[13].

For the variables evaluated in the animals, the model:

Yijk=μ+Fi+Cj+eijk

in which:
Yijk = observed value of the cultivar *i* in block *j* in the repetition *k*;
μ = general constant (population mean);
Fi = effect of the cultivar *i*, i= 1, 2, 3, 4;
Cj = effect of the block *j*, k = 1, 2;
eijk = random error associated with each observation Yijk(13).

Results and discussion

There was interaction between cultivar and cycle for all structural variables of pasture in the pre-grazing (P<0.05), except for the stem mass. The highest heights in the first cycle were observed in the Massai cultivar, and the highest pasture height in the second grazing cycle was observed in the Marandu cultivar (Table 1).

Table 1: Grass structure in *Brachiaria brizantha* and *Panicum maximum* pastures at pre-grazing

Variables	Marandu	Piatã	Aruana	Massai	SEM
	Cycle 1				
Canopy height, cm	30.3^{Bb}	31.6^{Ab}	32.2^{Ab}	39.5^{Aa}	1.6
Total forage mass, kg/ha DM	4689.2^{Aab}	3728.1^{Aab}	2775.5^{Ab}	5706.8^{Aa}	549.6
Leaf blade mass, kg/ha DM	376.0^{Abc}	535.4^{Ab}	79.8^{Ac}	1170.1^{Aa}	80.4
Stem mass, kg/ha DM	821.0^{Aa}	931.0^{Aa}	1024.4^{Aa}	552.0^{Aa}	162.9
Dead material mass, kg/ha DM	3492.2^{Aab}	2022.2^{Aab}	1671.3^{Ab}	3984.8^{Aa}	447.6
Leaf blade/Stem ratio	0.5^{Ab}	0.6^{Ab}	0.1^{Ab}	2.4^{Aa}	0.2
	Cycle 2				
Canopy height, cm	37.1^{Aa}	34.5^{Aab}	30.0^{Ab}	32.2^{Bb}	1.6
Total forage mass, kg/ha DM	3584.4^{Aa}	3288.0^{Aa}	2005.3^{Aa}	4569.5^{Aa}	549.6
Leaf blade mass, kg/ha DM	222.4^{Ab}	154.9^{Bb}	0.0^{Ab}	611.1^{Ba}	80.4
Stem mass, kg/ha DM	576.0^{Aa}	737.2^{Aa}	829.8^{Aa}	504.2^{Aa}	162.9
Dead material mass, kg/ha DM	2786.0^{Aab}	2396.0^{Aab}	1775.4^{Ab}	3454.2^{Aa}	447.6
Leaf blade/Stem ratio	0.4^{Aab}	0.2^{Aab}	0.0^{Ab}	1.2^{Ba}	0.2

SEM= standard error of the mean.
Means followed by lower case letters in the row (cultivars) and upper case in the column (cycles) differ by the Tukey test (P<0.05).

The largest forage mass was observed in the Massai cultivar and the lowest in Aruana, not differing from the Marandu and Piatã cultivars; this result can be explained by the high population density of Massai cv. tillers[14], as Massai cv. produced greater forage mass during the rainy season when compared to the others[15], and the structural characteristics of the canopy in the dry season reflect the responses observed in the higher forage production season[16]. When evaluating Mombasa grass and Massai pastures grazed by cattle, Euclides *et al*[17] observed higher total forage mass in the Massai cultivar in relation to Mombaça guinea grass in pre-grazing condition. This shows the high productive potential of this cultivar even in conditions of water stress. Fernandes *et al*[18] point out that this cultivar is an excellent alternative for sheep production systems supplemented in pastures during the dry season. The lowest forage mass and the morphological constituents of Aruana cv. can probably be explained by the higher requirement in fertility and water than the other cultivars, which characterizes less drought tolerance[19].

The highest leaf blade mass (LBM) was observed in Massai cv., ($P<0.05$). being 67, 54 and 93 % higher than the Marandu, Piatã and Aruana cultivars, respectively, in the first grazing cycle. Even with lower LBM in the second cycle compared to the first ($P<0.05$), this cultivar was higher in 63, 74 and 100 % in relation to the Marandu, Piatã and Aruana cultivars, respectively, indicating a more favorable condition for grazing on Massai cv., since the leaf blade is the component with greater nutritional value in detriment to the others (Table 1).

The stem mass (SM) did not differ between cultivars ($P<0.05$) with a mean of 746.9 kg/ha DM. The absence of effect for SM is a reflection of the low elongation rate of this component in the grasses of the *Brachiaria brizantha* and *Panicum maximum* species during the dry season[20].

The dead material mass (DMM) was similar among the Massai, Marandu and Piatã cultivars, but when compared to Aruana cv., the Massai cultivar presented 88 % more DMM in the first grazing cycle. The high DMM in Massai cv. may have been a result of higher forage production of Massai cv. during the rainy season that preceded the experiment[9], which senesced during the dry period and resulted in higher DMM. For Gurgel *et al*[16], the amount of dead material in the dry period is influenced by the forage mass produced during the rainy period.

The leaf blade:stem (LB/C) ratio was higher ($P<0.05$) in the Massai cultivar in the first grazing cycle which was due to the Massai cultivar having presented the highest LBM, and there was no difference between the cultivars for SM. There were no differences between the *Brachiaria* cultivars and the Massai cultivar in the second cycle, with only the Aruana cultivar showing a lower value since this cultivar had no leaf blades in its morphological composition in the second grazing cycle. The leaf blade/stem ratio is a variable of great importance for managing forage plants due to the fact that it is associated with the ease with which the animals harvest the preferred forage (leaves). The values found were higher than 1.0 for Massai cv. (Table 2), characterizing favorable conditions to grazing in this cultivar, even in the dry season of the year. Values lower than one, imply a fall in the quality of fodder offered[19].

Post-grazing canopy height did not differ between forages or between cycles (*P*>0.05), with a mean value of 30.3 cm (Table 3). There were no significant differences (*P*>0.05) in post-grazing for TFM, SM and DMM, indicating that regardless of the cultivar, SM and DMM may have been a physical barrier to lower canopy height[3], since there was only a 10% reduction in the pre-grazing canopy height (Table 2) to that of post grazing.

Table 2: Grass structure in *Brachiaria brizantha* and *Panicum maximum* pastures at in post-grazing

Variables	Marandu	Piatã	Aruana	Massai	SEM
	Cycle 1				
Canopy height, cm	29.6^{Aa}	29.3^{Aa}	30. 9^{Aa}	30.6^{Aa}	1.5
Total forage mass, kg/ha DM	4676.4^{Aa}	2650.5^{Aa}	3104.7^{Aa}	4645.5^{Aa}	633.2
Leaf blade mass, kg/ha DM	175.4^{Ab}	96.8^{Ab}	33.0^{Ab}	547.7^{Aa}	52.5
Stem mass, kg/ha DM	790.9^{Aa}	554.3^{Aa}	1453.7^{Aa}	513.4^{Aa}	217.5
Dead material mass, kg/ha DM	3710.2^{Aa}	1866.5^{Aa}	1617.9^{Aa}	3584.3^{Aa}	473.0
Leaf blade/Stem ratio	0.2^{Ab}	0.2^{Ab}	0.0^{Ab}	1.1^{Aa}	0.3
	Cycle 2				
Canopy height, cm	29.8^{Aa}	31.5^{Aa}	30.7^{Aa}	30.1^{Aa}	1.7
Total forage mass, kg/ha DM	3454.1^{Aa}	2194.0^{Aa}	2294.9^{Aa}	4032.3^{Aa}	708.0
Leaf blade mass, kg/ha DM	23.5^{Ab}	0.0^{Ab}	0.0^{Ab}	458.7^{Aa}	58.7
Stem mass, kg/ha DM	636.1^{Aa}	425.9^{Aa}	1031.4^{Aa}	570.9^{Aa}	243.2
Dead material mass, kg/ha DM	2794.6^{Aa}	1768.1^{Aa}	1263.5^{Aa}	3002.6^{Aa}	528.8
Leaf blade/Stem ratio	0.0^{Ab}	0.0^{Ab}	0.0^{Ab}	0.9^{Aa}	0.1

SEM= standard error of the mean.
Means followed by lower case letters in the row (cultivars) and upper case in the column (cycles) differ by Tukey's test (*P*<0.05).

Massai cv. obtained higher LBM in post-grazing in relation to the other cultivars in the two grazing cycles, which in turn showed no differences between them. This can be explained by the fact that there was a greater amount of LBM in the Massai cultivar in the pre-grazing period (Table 1), and the initial stocking rate was not enough to promote the harvest of this constituent in the same proportion as in the Marandu, Aruana and Piatã cultivars (Table 2). The highest LB/S ratios were observed in the Massai cultivar due to the higher LBM in comparison to the other cultivars, since there was no difference in the SM, but the LB/S ratio values were extremely low, except for those of the Massai cultivar in the first cycle.

There was no difference between cultivars for crude protein (CP) contents in the first grazing cycle, but there was a significant (*P*<0.05) effect among cultivars in the second cycle. This result is associated to the reduced leaf blade participation in the forage mass of this cycle, as this component is the one with the highest CP content. All observed values were below the 7 % value considered critical[21],

Table 3: Chemical composition of *Brachiaria brizantha* and *Panicum maximum* pastures in pre-grazing (%)

Variables (%)	**Marandu**	**Piatã**	**Aruana**	**Massai**	**SEM**
	Cycle 1				
Crude protein	3.3^{Aa}	3.6^{Aa}	4.7^{Aa}	3.8^{Aa}	0.3
Neutral detergent fiber	76.9^{Aab}	73.2^{Abc}	71.8^{Ac}	79.3^{Aa}	1.0
Acid detergent fiber	44.5^{Aab}	40.7^{Ab}	46.3^{Aa}	46.3^{Ba}	0.8
Acid detergent lignin	8.0^{Aab}	7.5^{Ab}	10.4^{Aa}	8.5^{Aab}	0.5
Ash	4.4^{Ab}	5.0^{Ab}	7.2^{Aa}	5.8^{Ab}	0.3
	Cycle 2				
Crude protein	3.3^{Aab}	3.0^{Ab}	4.6^{Aa}	3.1^{Ab}	0.3
Neutral detergent fiber	77.5^{Aab}	72.6^{Ac}	74.1^{Abc}	79.6^{Aa}	1.0
Acid detergent fiber	45.9^{Abc}	43.6^{Ac}	49.0^{Aab}	50.8^{Aa}	0.8
Acid detergent lignin	8.8^{Ab}	9.0^{Ab}	11.7^{Aa}	10.5^{Aab}	0.5
Ash	4.1^{Ab}	4.8^{Ab}	6.7^{Aa}	4.8^{Ab}	0.3

SEM= standard error of the mean.

Means followed by lower case letters in the row (cultivars) and upper case in the column (cycles) differ by Tukey's test (P<0.05).

The highest NDF values were observed in the Massai cultivar in the two grazing cycles (Table 3), the lowest values in the Aruana cv., and intermediate values in the other cultivars in the two grazing cycles. According to Batistotti *et al*[21], the epidermis of the Massai cultivar is very secure to the rest of the leaf by a thick-walled cell support formed by the sclerenchyma and a vascular bundle of sheath cells (girder structure), where Massai grass presents higher frequency of the girder structure, being one of the probable causes for the greater participation of the NDF fraction.

The highest ADF values were observed in the Massai cultivar in the second grazing cycle, but there was no difference in the first cycle between the Massai and Aruana cultivars, while intermediate ADF values were observed in the Marandu grass. The ADF is within the NDF fraction, and as the Massai grass presented higher NDF content, higher ADF values were expected. On the other hand, a greater stem and dead material mass was observed in the Aruana cultivar; these components are rejected, resulting in a decrease in the cellular content and increase in the cellular wall[22].

The highest lignin levels were observed in the Aruana cultivar in the two grazing cycles and intermediate values in the Massai cultivar. This may be related to the fact that the chemical analysis was carried out on the whole plant, and the Aruana grass pastures presented higher amounts of stem, being the component with greater cell wall thickening, thus raising the lignin forage content.

Although the Massai cultivar obtained higher structural fraction values and these fractions could lead to limitations in consumption and performance of the animals(3,4) in the dry period of the year, what determines the animal performance the most is the amount of forage available for grazing, with the pasture being primarily used for attending base fiber requirements.

There was no difference between the cultivars for the final weight of the animals, with a mean of 32.4 kg (Table 4). The lowest average daily gain (ADG) was observed in sheep kept in Aruana grasses. No differences were observed between the animals kept in the Marandu and Piatã cultivars, and intermediate ADG values were observed in the animals kept in the Massai pasture. The lower performance observed in the Aruana cultivar can be explained by the lower leaf blade mass in the first cycle of grazing and absence of leaf blades in the second cycle, being the constituent of greater preference by the animals and which has higher nutritional value.

Table 4: Sheep performance in pastures of of *Brachiaria brizantha* and *Panicum maximum*

Variables	**Marandu**	**Piatã**	**Aruana**	**Massai**	**SEM**
Final weight, kg	34.7[a]	31.9[a]	29.5[a]	34.0[a]	3.8
Average daily weight gain, g/d	133.7[a]	142.0[a]	82.1[b]	122.4[ab]	1.9
Stocking rate, UA/ha	8.9[ab]	5.4[b]	6.4[b]	9.6[a]	1.0
Gain by area, g/ha/d	1189.9[a]	766.8[ab]	525.4[b]	1175.0[a]	73.4

M SEM= standard error of the mean.

[ab] Means followed by distinct letters differ from each other by the Tukey test (*P*<0.05).

The stocking rates in the Massai and Marandu cultivars were higher than in the Aruana cultivar (*P*<0.05). This result can be attributed to the higher forage mass and leaf blade mass of these cultivars in pre-grazing (Table 3). In addition, there was not enough forage to keep animals in the Aruana cultivar during the last 35 d of the experiment, so a zero stocking rate was used in this period. This leads to confirm the lack of aptitude by this cultivar for livestock production in pasture in the dry period without using irrigation.

The live weight gain per hectare was lower in the Aruana grasses when compared to the Marandu and Massai cultivars, and these did not differ from the Piatã cultivar. This result can be attributed to the lower ADG and stocking rate observed in the Aruana cultivar, since pasture productivity is a result of the combination of individual performance and stocking rate for each situation(3,4). Piatã cultivar presented a lower stocking rate than those of the Massai and Marandu pastures; however, the individual gain compensated for this difference, with a reflection observed in the area gain, since the weight gain per area is the product of the stocking rate for the individual gain.

Conclusions and implications

Pastures are recommended as Massai, Marandu and Piatã cultivars can be used as a forage option associated with protein supplementation for producing sheep raised for meat in the dry period of the year, because they present more adequate structures for sheep grazing, which reflected in higher animal productivity.

Conflict of Interest and Acknowledgements

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