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Full Length Research Paper

Forage intake and performance of cattle in silvo-pastoral systems and monoculture of Marandu in Pre-Amazon region

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This work aimed to evaluate dry matter intake (DMI) and performance of F1 Nellore x Guzera with live weight (LW) of 180±15 kg (5 months) on pastures of *Brachiaria brizantha* cv. Marandu in silvo-pastoral systems composed of babassu palm (*Attalea speciosa*) and monoculture systems in Pre-Amazonic region of Maranhão state, Brazil. Animals were evaluated in four systems: 0, 80, 131 and 160 adult palms ha^{-1}, characterizing monoculture (MC), low density (LD), average density (AD) and high density palm trees (HD), respectively, during the rainy (RS) and dry season (DS). Comparing seasons, only DMI in MC and AD were affected. DMI was between 2.6% LW for the RS and 2.8% LW for the DS, These values are very close as suggested by NRC, which is 2.7% LW for animals in this category. Higher average daily gain per ha was observed in animals kept in pastures with LD (0.750 g.day^{-1} and 84.37 kg.ha^{-1}, respectively). It was observed that animal performance was influenced by density of palm trees and the DMI by season, probably by the sward structure. Animal performance and production forage biomass were higher in 0 and 80 palm systems. This greater forage biomass allow higher stocking rate and, consequently higher animal production per ha.

Key words: Silvo-pastoral systems, pasture, season, Guzerá, Nelore, matter intake, daily gain.

INTRODUCTION

Animals raised on pasture where the forage is the only food source should consume sufficient amounts of

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nutrients for an acceptable production, because deficiency or low intake of any essential nutrient can affect animal performance. Dry matter intake (DMI) is influenced by palatability, nutritional value and forage availability, and the DMI is the main limiting factor of the animal productivity. In addition, the pastoral environment presents strong influence on these effects. Based on these features, there is a search for alternative systems to minimize negative effects of the environment and forage nutritional aspects, thereby increasing animal productivity.

A feasible alternative to solve problems caused by traditional livestock, where the grass is based on monoculture of forage species, is the silvo-pastoral systems (SPS). These systems are the intentional combination of trees and grazing animals in the same area at the same time and managed in an integrated manner, with the goal of increasing productivity per unit area. On these systems, interactions occur in all directions and at different magnitudes.

In silvo-pastoral systems, the presence of trees may retain and/or improve the quality of the soil by favoring the control erosion, the nutrient cycling and the addition of organic matter; use the solar radiation, more efficiently than in pastures in monocultive and capture nutrients and soil moisture at different depths, decreasing the dependence on external inputs of nutrients or establishing a more positive relationship between the benefit/cost.

According to characteristics of each ecosystem, you can adapt the native forests to SPS, thus preserving common trees of certain regions. In the State of Maranhão, Northeast region of Brazil, for example, the consortium of the mature babassu palm (*Attalea speciosa* Mart.) with pasture is called “traditional SPS”. This palm tree stands out in dry forest of the Amazon forest, mainly in Maranhão, where the state concentrate about 53% of the all babassu forest of the Brazilian territory. Despite the great importance that the babassu palm has in the state, little is known about its ecological properties, its effects on vegetation and soil, its efficient management and the ideal density of palm trees in the pasture. All these factors influence the animal performance, especially in the Pre-Amazonic Maranhão, in which livestock predominates within the state.

Few researches were done on animal under silvo-pastoral system. However, it is recognized that the information on the forage intake by animals in grazing system is important for most efficient recommendations on nutritional plan, regarding animal response and productivity per area (Aroeira et al., 2005; Paciullo et al., 2008).

This work was conducted with the objective of assessing the weight gain and feed intake of cattle grazing *Brachiaria brizantha* CV. Marandu in silvo-pastoral systems and monoculture, during rainy and dry seasons.

MATERIALS AND METHODS

The experiment was conducted at Água-Viva farm, in the municipality of Matinha-Baixada Maranhense region, with geographical position 45°00´40.9´´ W longitude and 03°06´55.5´´ S latitude. Forage species used was *B. brizantha* CV. Marandu and the arboreal species babassu palm *Attalea speciosa* Martius which was already established on the property.

Experimental design, animals and housing

Animals (Nelore x Guzerá with average of 180 ± 15 kg) were evaluated in four systems which are Marandu grass monoculture and three densities of babassu palms trees with more Marandu grass (SPS), corresponding to 0, 80, 131 and 160 adult palms.ha^{-1}, respectively. These systems characterize monoculture (MC), low density (LD), average density (AD) and high density palm trees (HD). Animals were placed on experimental units in completely randomized design (CRD) with subdivided plots arrangement, getting on the plots the densities of palms and in the subplots, the rainy and dry seasons. The data were grouped in two periods: the rainy season (April to June/July 2013) and dry season (June/July 2013 to October 2013).

Data regarding the average monthly rainfall calculated from a data series of 30 years and rainfall and temperature during the experimental period are presented in Figure 1. The annual precipitation varied from 2,000 mm annually, with the greatest concentration during the experimental period between the months of April to June. The maximum and the minimum temperatures were about 32 and 23ºC, respectively.

The total area used in the experiment was eight hectares, subdivided into four paddocks of two hectares, managed under continuous stocking, with five Nelore x Guzerá per experimental unit. Over time, regulators animals were placed and removed of each paddock to avoid possible sub or super grazing. The remainder of animals was kept in a reserve paddock (6 ha) and used in the experimental units as regulators animals, whenever there was need of stocking rate adjustment to keep the pastures in the predetermined height of 35 cm. All animals received water and mineral mixture *ad libitum*, and health management as recommended by Embrapa beef cattle.

Before the establishment of the experiment, samplings were made for characterization of soil fertility in the 0-20 cm layer. As can be seen in Table 1, all paddocks presented soil with characteristics of average fertility and independent of the treatment, the corrections of soil acidity were performed on the basis of the data of the analysis performed by lifting method of base saturation to 70%. The preparation of the area and corrective practices were carried out between October and November 2011, and the replanting of the grass in open areas within the paddocks, where the soil was exposed (no grass), was conducted between the months of January and February of 2012.

The fertilization in paddocks of monoculture, 80, 131 and 160 palms/ha was as follows: nitrogen (N) in the form of urea in 150, 150, 150 and 150 kg.ha^{-1}, respectively; phosphorus (P_2O_5) in the

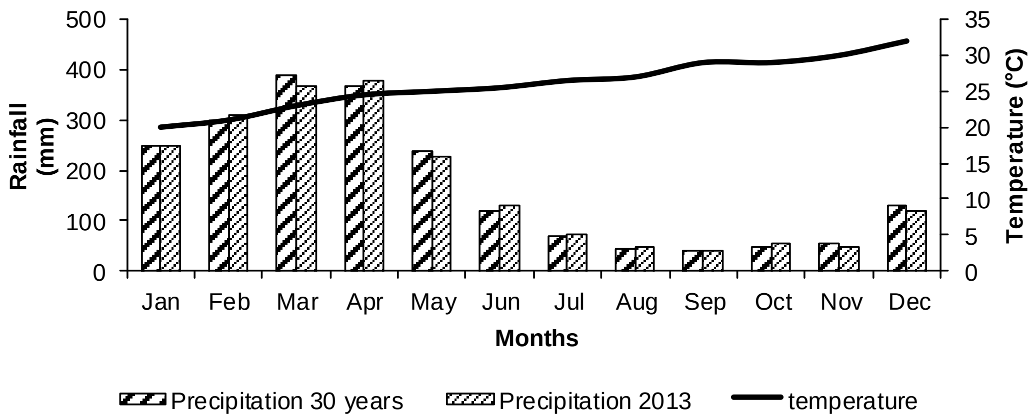

Figure 1. Average monthly rainfall calculated from a data series of 30 years and observed monthly rainfall and temperature during the experimental period in the year of 2013. Source: INMET (adapted).

Table 1. Chemical soil attributes in silvo-pastoral systems with different densities of babassu palms and monoculture before the experiment.

System[1]	pH	M.O	P	K	Ca	Mg	H+Al	Al	B	CTC
	$CaCl_2$	--------g $dm^{3-(1)}$----------			------------- $mmol_c\ dm^{3-(1)}$ -----------------					
MC	4.8	23	21	32	17	6	42	2	19	68
LD	5.2	23	9	40	21	9	27	1	20	61
MD	5.0	22	23	26	22	10	42	2	20	77
HD	4.8	23	11	37	20	7	44	1	28	75

System[1]	V	S	Cu	Fe	Zn	Mn	B
	----- % -----		------------------------------ mg $dm^{3-(1)}$ ------------------------------				
MC	38	5	0.4	104	4.4	47.3	0.19
LD	56	7	0.4	149	4.2	33.6	0.20
MD	45	6	0.4	61	4.6	54	0.20
HD	41	10	0.4	105	4.1	44	0.28

[1]Babassu palm density: MC = Grass monoculture (no trees); LD = Low density (80 palms.ha^{-1}); AD = Average density (131 palms.ha^{-1}); HD = High density (160 palms.ha^{-1}).

form of simple superphosphate in 150, 150, 150 and 100 kg.ha^{-1}; potash (K_2O) in 60, 60, 60 and 60 kg.ha^{-1}; and dolomite (limestone) in 1100, 270, 1550 and 1260 kg.ha^{-1}.

Canopy height was measured weekly, with ruler graduated in centimeters, in 30 random points by paddock. The height of each point corresponded to the average height of the canopy around the ruler.

Sampling and measurements

Forage biomass assessments were held every 28 days. To determine the productivity of forage (PF) representative samples of the paddocks were taken using squares of 0.25 m^2. The squares were placed at random in representative points of grazing at the time of sampling and the plants contained within each square were cut low to the ground every 28 days. After weighting, samples were separated into morphological components leaves, stems and dead material. These components were also dried in an oven and the proportion of each component was expressed as a percentage of the total weight. In possession of the proportions of each component in dry matter, it was determined the relationship leaf: stem ratio (LSR).

For the estimation of dry matter intake (DMI) only 20 of 40 animals were used, being five (repetitions) per system. Chromium oxide (Cr_2O_3) was administered orally, with the help of a rubber pipe, straight into the esophagus in doses of 10 g, once a day. The procedure was held for eight days, and in the first five days, the balance of intake and excretion of the indicator was obtained, and from the sixth day, samples of fresh feces were collected (around 300 g) directly from the rectum of animals, so that there was no contamination with dried feces or soil. The first day sampling was at 4:00 pm, the second at noon and the last was at 8:00 am, three days of collection was done. Then, the samples were frozen at -18°C. Then, the samples were homogenized, packed in aluminum dishes and pre-dried in oven of forced ventilation of 65°C up to present the constant weight. Then, they were processed in mill type "Wiley" with 1 mm sieve and grouped in proportion to have the composite samples of each animal.

The chromium concentration was estimated using an atomic absorption spectrophotometer, as methodology proposed by Williams et al. (1962), described by Silva and Queiroz (2009). Fecal total production was determined by the following equation proposed by Berchielli et al. (2005): Total feces production (g DM/d) = Amount of Cr_2O_3 (g)/ Concentration of Cr_2O_3 in fecal DM (g/gDM). The DMI was estimated by the following equation: DMI = Fecal production/(1 – IVDMD). For the calculation of the rate of recovery of fecal indicator, the following equation was used: Rate of recovery = (Fecal production by indicator x 100)/Fecal production by total collection. The calculation of recovery rate consisted of using data produced with total administered chrome and total excreted chrome, estimated by calculated fecal production (FPc).

The average weight of the animals in a period was used as reference to relate intake as proportion of live weight. Evaluation of the palatability was realized on collection of selected forage by animals in the form of simulated grazing during the months of June and September 2013. Dry matter (DM) and crude protein (CP) contents were calculated by Kjeldahl digestion, according to recommendations of the AOAC (1990) and neutral detergent fiber (NDF) and acid detergent fiber (ADF) following the procedures of Van Soest (1994). The *in vitro* digestibility of dry matter (IVDMD) was according to Tilley and Terry (1963).

Every 30 days, all animals were weighed to follow their performance. Performance was calculated by average daily gain ($kg^{0,75}$) of animals. Also, the number of days on which the animals remained regulators in pasture was counted, to enable the estimation of the rate of manning of pastures, where along the experiment and in accordance with the availability of forage these animals walked in and out of pastoralist environments. Animal weight gain (WG) per hectare ($kg.ha^{-1}$) was obtained by multiplying the average daily gain by the number of animals (evaluators and regulators) maintained in the paddocks by month.

Statistical analyses

The data were grouped into two periods: rainy season (April to June/July 2013) and dry season (June/July 2013 to October 2013). Initially, the data were submitted to normality test (Crame-Von Misses) and scapular (Levene) to show the assumptions and were submitted to variance analysis by F-test. In the case of significant difference, comparison of averages was by SNK at 5% probability. The statistical analyses were conducted with the PROC GLM from SAS 9.0 (2002), with the option of repeated measurements in time, characterized by periods of assessment in each season of the year.

RESULTS AND DISCUSSION

There was no influence of period, density of palm trees and monoculture on chemical composition of the Marandu grass (P>0.05) during the voluntary intake trials (Table 2). This result is surprising, regarding the variation of the nutritional value of grass in SPS exposed to shading as compared to monoculture (Paciullo et al., 2007; Soares et al., 2004). According to Moreira et al. (2009), shaded plants present more levels of crude protein as the shading results in a larger cell size of the plants, increasing its cellular content and, consequently, crude protein.

Competition for nutrients is something common among tree species and grasses in SPS, in which the root system of the species used is well developed and possibly ended up competing with the Marandu grass for water and nutrients. Its root system is composed of two types of roots, a thick one responsible for storage of carbohydrates and a broad set of thin roots responsible for "pumping" of mobile nutrients leached to the deeper layers of the soil. By growing up together, the tree component and grass present competition for nutrients and water depending on the species, which probably occurred in the SPS. Therefore, their nutritional values are not different from the monoculture, being evident in dry season, as observed with a greater amount of senescent grass around the babassu plants. This competitive effect is not a possible allelopathic effect, it is for nutrients and water and as confirmed by Da Silva and Firmo (2008) who studied the allelopathic effects of Marandu grass on germination of babassu and did not find positive responses.

Moura (2004) noted that in areas with large densities of babassu, there was a negative linear effect of increasing density on protein content, indicating a possible competition for water and nutrients. Such effect did not occur in this work because the layout of palm trees at random may have interfered with this competition. In the dry season, the animals ingested larger quantities of forage on Mono and AD palms than in rainy season (P<0.05) (Table 3).

In all the systems, the forage production during cycles was above the average required according to the number of animals in each pastoral environment. The most critical system in relation to forage availability was HD during the dry season (Figure 2). However, the stocking rate in this environment was adjusted according to the availability of forage in that time. According to Gomide et al. (2001), intake is reduced when the supply of forage is less than 4-6% of live weight (LW). In this work, in any moment, this critical range of availability was reached, because there was a strict control of the quantity of animals in each silvo-pastoral system.

The forage intake was not affected by Marandu grass, since the nutritional value did not differ among treatments

Table 2. Chemical composition (% of dry matter) of the Marandu grass, collected in simulated grazing on silvo-pastoral systems with different densities of the babassu palms and monoculture in rainy and dry periods.

Season	System[1]				CV[2] (%)	MSE[3]	P-value
	MC	LD	AD	HD			
Crude protein (%DM[7])							
Dry	6.42	6.71	6.42	7.29	20.03	1.34	0.0549
Rainy	7.71	7.58	7.88	9.19		1.98	0.0612
Neutral detergent fiber (%DM)							
Dry	72.60	70.79	68.30	70.53	14.02	12.23	0.0745
Rainy	69.83	59.91	69.74	68.35		11.76	0.0713
Acid detergent fiber (%DM)							
Dry	56.07	53.71	51.64	54.17	5.05	18.32	0.0675
Rainy	52.98	52.94	54.26	53.03		16.98	0.0634
Lignin (%DM)							
Dry	8.87	7.98	10.04	7.91	20.07	2.32	0.0512
Rainy	7.82	8.23	9.09	9.29		2.45	0.0543
Cellulose (%DM)							
Dry	47.21	47.21	47.21	47.21	21.3	19.98	0.0682
Rainy	45.16	45.16	45.16	45.16		20.17	0.0743
Hemicellulose (%DM)							
Dry	16.53	16.53	16.53	16.53	23.5	9.87	0.0534
Rainy	16.86	16.86	16.86	16.86		8.85	0.0577

[1]Babassu palm density: MC = Grass monoculture (no trees); LD = Low density (80 palms.ha^{-1}); AD = Average density (131 palms.ha^{-1}); HD = High density (160 palms.ha^{-1}).[2] CV = Coefficient of variation; [3] MSE= Means standard errors.

Table 3. Average values of dry matter intake (kg DM) crossbred cattle (Nellore x Guzerá), in silvo-pastoral systems in rainy and dry seasons.

System[1]	Season		CV[3] (%)	MSE[4]	P-value
	Rainy DMI[2] (kg)	Dry DMI (kg)			
MC	6.82^{Ba}	7.41^{Aa}	37.69	2.32	0.0234
LD	6.43^{Aa}	6.72^{Aa}		3.31	0.0681
AD	6.29^{Ba}	6.55^{Aa}		3.29	0.0133
HD	6.52^{Aa}	6.45^{Aa}		3.56	0.0627

Means followed by the same uppercase letter (lines) and minuscule (columns) do not differ by SNK at 0.05. [1]Babassu palm density: MC = Grass monoculture (no trees); LD = Low density (80 palms.ha^{-1}); AD = Average density (131 palms.ha^{-1}); HD = High density (160 palms.ha^{-1}).[2]DMI = Dry matter intake; [3]CV = Coefficient of variation; [4]MSE= Means standard errors.

and by forage availability. This variation observed for the dry matter intake of animals kept in monoculture and AD palm trees is more related to the structure of the pasture during the two periods. On monoculture, there was a greater forage production in DS than in RS, with an increase of 3.22%, which increase grazing period on

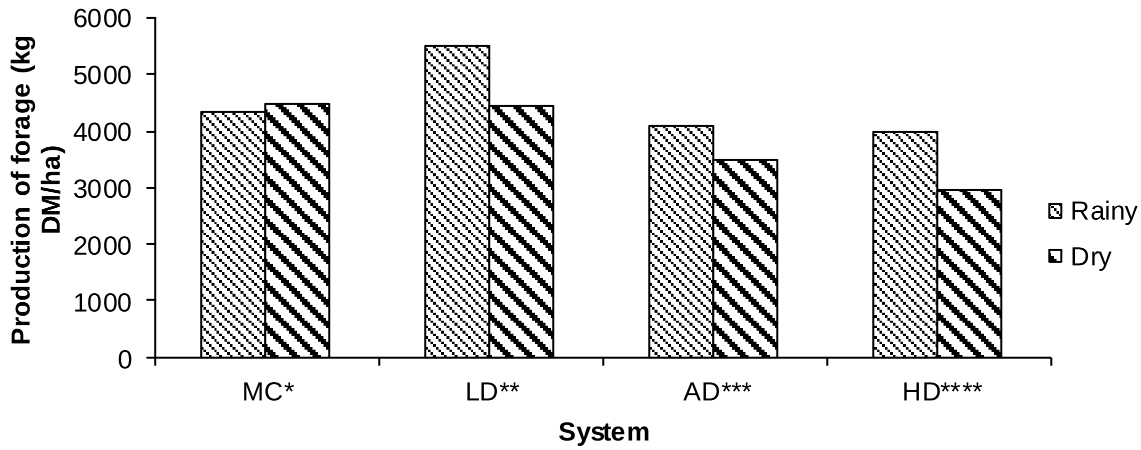

Figure 2. Production of forage in silvo-pastoral systems and monoculture. *monoculture; **80 palm trees.ha^{-1}; ***131 palm trees.ha^{-1}; ****160 palm trees.ha^{-1}.

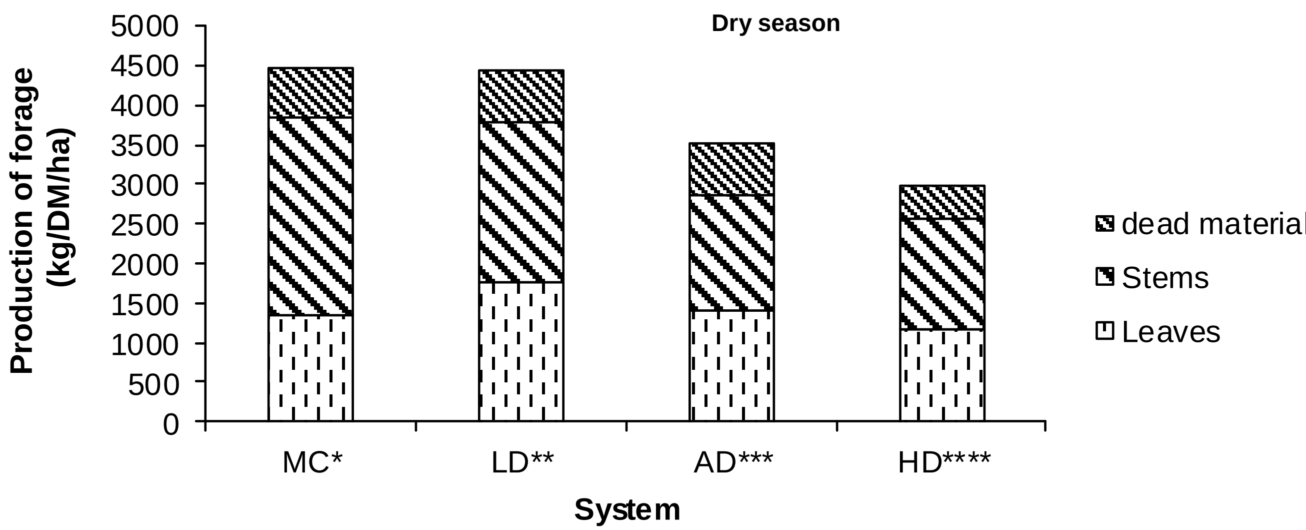

Figure 3. Production of forage in relation to amounts of leaves, stems and dead material in silvo-pastoral systems and monoculture during the dry season. *Monoculture; **80 palm trees.ha^{-1}; ***131 palm trees.ha^{-1}; ****160 palm trees.ha^{-1}.

fields and, consequently, the DMI. However, there was a greater participation of stem fraction, which was about 1,120 kg.ha^{-1} greater than the fraction of leaves and there was in addition, a significant 14.28% of dead material (Figure 3).

Stems as compared to leaves fraction increased during the dry season in all the systems, but in the AD palms, this relationship was less pronounced, being only 5.4% higher. Already in the other systems, there were 45.16; 13.75 and 17.14% higher proportion of stems for monoculture, LD and HD palms, respectively, justifying the greater DMI in the AD palms during the dry season.

Regarding the availability of stems, it is worth mentioning the greater participation during the rainy season only in monoculture, with 160 kg.ha^{-1} higher than the leaves fraction, which probably could have interfered with the DMI, but as compared to the SPS, there was no difference. In the AD and HD palms, there was a greater

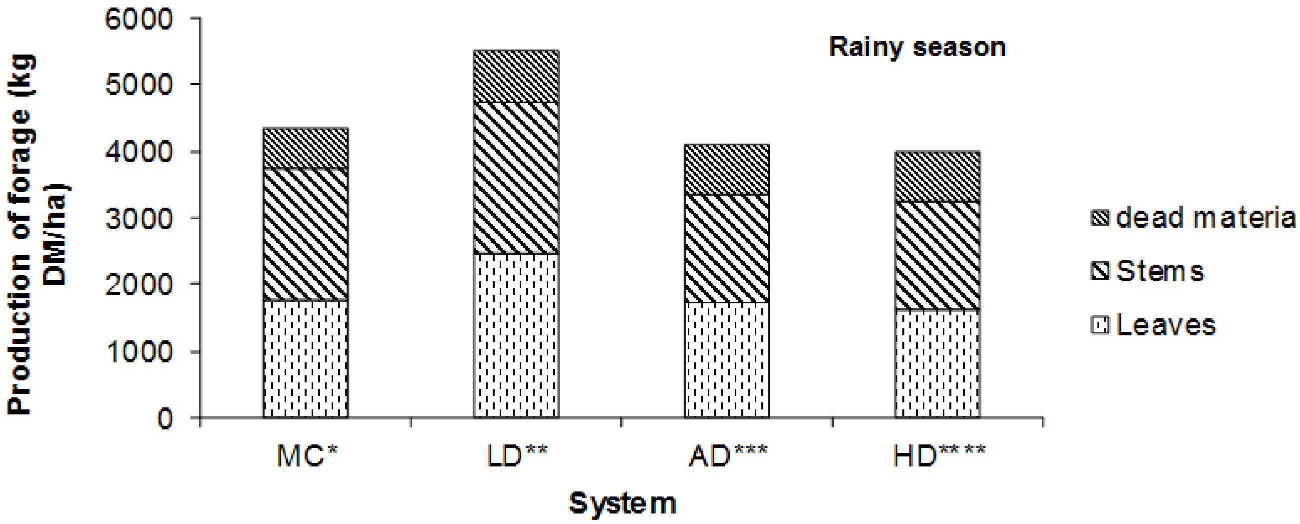

Figure 4. Production of forage in relation to amounts of leaves, stems and dead material in silvo-pastoral systems and monoculture during the rainy season. *Monoculture; **80 palms.ha^{-1}; **80 palm trees.ha^{-1}; ***131 palm trees.ha^{-1}; ****160 palm trees.ha^{-1}.

Table 4. Recovery rate of chromium oxide for crossbred cattle (Nellore x Guzerá) in silvo-pastoral systems in the rainy and dry season.

System[1]	RR[2] (%)		Mean	CV[5] (%)	[6]MSE	P- value
	RS[3]	DS[4]				
MC	92.35	93.23	92.29		21.76	0.0745
LD	91.32	92.41	91.86		17.87	0.0713
AD	90.78	91.45	91.11	27.8	20.98	0.0645
HD	91.00	92.21	91.60		19.87	0.0675
Mean	91.36	92.32				

Means followed by the same uppercase letter (lines) and minuscule (columns) do not differ by SNK at 0.05. [1]Babassu palm density: MC = Grass monoculture (no trees); LD = Low density (80 palms.ha^{-1}); AD = Average density (131 palms.ha^{-1}); HD = High density (160 palms.ha^{-1}), [2]RR = Recovery rate; [3]RS = Rainy season; [4]DS = Dry season; [5]CV = Coefficient of variation; [6]MSE= Means standard errors.

concentration of dead material over the period, with 770 and 630 kg.ha^{-1}, respectively (Figure 4).

The values of the recovery rate of indicator, during the experimental period for the four evaluated systems are in Table 4. There were no differences for both season and densities (P>0.05). In this work, it is observed that there was on average, a higher concentration of Cr_2O_3 during the dry season due to the amount of fiber in forage being higher on average in that period, where the NDF was 70.55 and 66.97% for dry and rainy season, respectively. In addition, the lignin and FDA contents were high in all the systems, which contributed to this difference between the periods, as the fibrous carbohydrates and lignin retain greater quantity of the indicator in the feces.

Detmann et al. (2001), by applying this methodology, estimated that DMI was 3.11% LW for beef cattle (F1 Limousin x Nellore) in *Brachiaria decumbens* pasture. Therefore, as much as this technique has its negative points, the values found here are acceptable according to the literature. Whereas, in grazing conditions, real intake is not known, and the values estimated by chromic oxide can only be compared to those obtained from tables of requirements in similar studies and methods. The data concerning the average daily gain (ADG) and gain per area (WG, kg.ha^{-1}) in each system are in Table 5. In general, it was observed that animals kept in LD palms had higher ADG, gaining on average, 0.75 kg$^{0.75}$.day^{-1}, followed by monoculture (0.65 kg$^{0.75}$.day^{-1}), AD palms

Table 5. Weight gain of crossbred cattle (Nellore x Guzerá) in silvi-pastoral systems composed of Marandu grass and different densities of babassu palm trees and monoculture.

System[1]	ADG[2] ($g.kg^{0,75}$)	WG[3] ($kg.ha^{-1}$)	CV[4] (%)
MC	0.65 [b]	73.12 [b]	
LD	0.75 [a]	84.37 [a]	25.5
AD	0.63 [b]	70.87 [b]	
HD	0.58 [b]	65.25 [b]	
P-value	0.0234	0.0324	
[5]MSE	0.202	14.23	

Means followed by the same letter do not differ by SNK at 0.05. [1]Babassu palm density: MC = Grass monoculture (no trees); LD = Low density (80 $palms.ha^{-1}$); AD = Average density (131 $palms.ha^{-1}$); HD = High density (160 $palms.ha^{-1}$), [2]Average daily gain; [3]Weight gain; [4]Coefficient of variation; [5]MSE= Means standard errors.

(0.63 $kg^{0.75}.day^{-1}$) and HD palms (0.58 $kg^{0.75}.day^{-1}$), which did not differ among them (P>0.05).

The ADG is within the expected value for animals in this category, non-suckling calves and without supplementation, according to Malafaia et al. (2004). Data on animal performance in silvipastoral systems are scarce in the literature, notably referring to the tree component densities mainly in SPS in which tree are native components, as in the case of babassu palm tree.

In work carried out in pastures of *B. brizantha* CV. Marandu, established in silvipastoral system with eucalyptus, body weight gain of Nellore steers of ages similar to those used in this work ranged from 392 and 892 $g.steer^{-1}$ day (Bernardino et al., 2011). These authors considered moderate weight gains for animals grazing Marandu grass, when faced with results obtained in monoculture and highlighted the potential use of silvo-pastoral systems in the production of beef cattle.

The largest ADG observed in animals maintained in LD palms is due to the intake of high amount of leaves allowed by the structure of the canopy. As showed in Figure 3, the forage production on LD palms was superior to other systems in both periods, with an average of 4,945 $kg.ha^{-1}$. Moreover, the leaf fraction, which is the favorite part of ruminants, was the highest in this system.

Average daily gainof over 500 g for animals raised exclusively on pastures, as observed in this work, showed reasonable performance of crossbred steers during the growing phase. The gain per area shows the same tendency as the ADG, with the higher value in the LD palms system presenting the best values, with gain of 84.37 $kg.ha^{-1}$, followed by monoculture, AD and HD palms, which did not differ among them (P>0.05). The system with 80 palm trees showed the highest stocking rate over time, and then animal production by area was bigger. Bernardino et al. (2007) evaluated the performance of steers on SPS of eucalyptus and *B. brizantha* and observed gain of 57 $kg.ha^{-1}$, lower than the obtained value in the present study.

Based on forage production (Figures 3 and 4) and the data of the relation of forage mass over the months, it can be considered that in all the pastoral systems, there was a moderate grazing intensity, because the use of grazing has allowed the maintenance of plants considered palatable. However, it did not allow the increase in its production, except in the monoculture in which there was an increase of 3.22%. As discussed earlier, it was an increase considered undesirable because there was only an increase of stems.

The stocking rate throughout the experimental period varied depending on the monthly availability of forage, in which in the beginning of the experiment there was the need for a large stocking rate, because the effect of fertilization in single dose caused the a significant production. The average stocking rate throughout the experimental period were 2.11, 2.35, 2.26 and 2.15 $AU.ha^{-1}$ for monoculture, LD, AD and HD palms, respectively (Figure 5).

In monoculture and HD palm systems stocking rate declined significantly throughout the experiment. On monoculture, for example, even with an increase in the production of forage, the availability of leaves was critical during the dry season. On HD palms the forage availability was the most affected, in which from one period to another there was a decrease of 25.06%. This was probably influenced by shading, since 160 palm trees/ha at random provides a higher shade, interfering with photosynthetic capacity of the grass. As a way to get light, there was a greater increase of stems, about 17.41% greater than the leaves component.

Babassu palm trees of the experiment were adults, with overall average of 7.5 m shaft height (base of the cup). The architecture (a form of inverted pyramid) causes the degree of shading to be much larger than other tree species used in SPS as the eucalyptus, for example, in which much higher density is used. This great shading provided by babassu palms can compromise the diffused light penetration in the pasture. However, in the system with LD palms, forage production remained steadily, and then the stocking rate in this pastoral environment was greater.

Conclusions

Palm trees density and the DMI affect the animal performance. The 80 palm trees system has better animal performance and forage production over time, which makes the stocking rate and livestock production

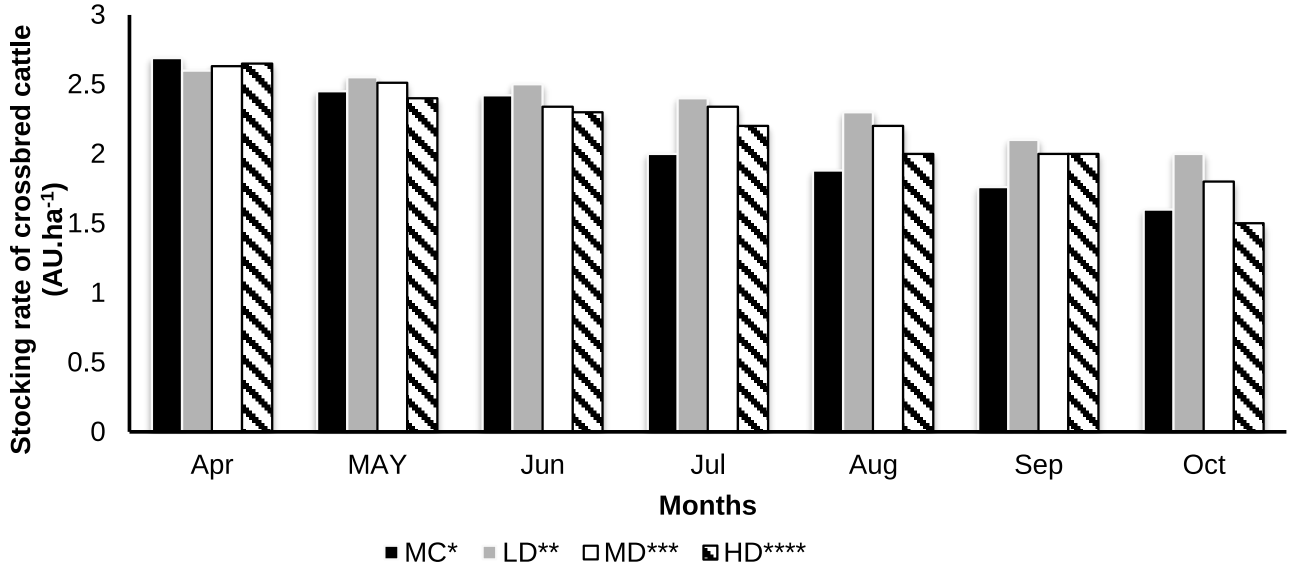

Figure 5. Stocking rate of crossbred cattle (Nellore x Guzerá) in AU.ha^{-1}, in silvo-pastoral and monoculture systems throughout the experimental period in the year, 2013. *Monoculture; **80 palm trees.ha^{-1}; ***131 palm trees.ha^{-1}; ****160 palm trees.ha^{-1}.

per area higher.

Conflict of Interests

The authors have not declared any conflict of interests.

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