Australian Journal of Crop Science
AJCS

AJCS 16(03):381-388 (2022) ISSN:1835-2707
doi: 10.21475/ajcs.22.16.03.p3413

Production, forage quality and cattle performance in Paiaguas palisadegrass and Tamani grasses in different forms of animal supplementation in crop-livestock integration

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Abstract

Crop-livestock integration is the production strategy that consists of the diversification and integration of the different productive, agricultural and livestock systems, within the same area. Thus, the goal was to evaluate the production, forage quality and cattle performance in Paiaguas palisadegrass and Tamani grasses in different forms of animal supplementation in crop-livestock integration. The study was set up a randomized block experimental design, with four replicates, in a 2 x 2 factorial arrangement of two forages (BRS Tamani and BRS Paiaguas) and two animal supplementation strategies (mineral and protein-energy supplementation), in a crop-livestock integration system. Paiaguas palisadegrass showed higher forage production in all grazing cycles. Both forages showed satisfactory results in terms of average daily weight gain and total weight. The provision of protein supplementation to animals did not interfere with animal performance. Paiaguas palisadegrass and Tamani guinea grass showed potential in crop-livestock integration in succession to soybean and may be an alternative of quality food to be offered in the dry season. The system contributed to maintaining the sustainability of animal production on pasture.

Keywords: Animal performance; *Brachiaria brizantha*; forage production; nutritional value; *Panicum maximum*.

Introduction

Currently, the biggest global challenge comprises the balance between the production of energy, food and the use of water. Brazil, characterized by large arable areas, is under international pressure regarding deforestation, land use, water resources and climate change (Mercure et al., 2019). In this sense, the country had to find alternatives that would meet world requirements and make it competitive in the foreign market, since being the second largest producer of beef in the world, there was a need to intensify production systems, such as the crop-livestock integration system, which promotes increased production, restoration of degraded pastures and mitigates greenhouse gas emissions (Cortner et al. 2019). Moreover, this system collaborates with greater food production in increasingly smaller areas, contributing to environmental preservation (Costa et al., 2018). Among the crop-livestock integration systems, forage succession in the second crop after soybean harvest stands out, which is used in farms specialized in grain crops, which adopt forage grasses to improve the soil cover for the no-till system and, in the off-season, there is an opportunity to use this forage to feed cattle in the period of low rainfall, influencing forage production (Andrade et al. 2020).

To ensure the expected productivity in the system, it is necessary to choose forages more adapted to the soil and climatic conditions of the region, presenting a balance between forage quality and productivity. Forage grasses most used in crop-livestock integration systems are those of the genus *Brachiaria*. However, the new *Panicum maximum* cultivars have stood out with positive results (Dias et al. 2020; Dias et al. 2021).

Forage seasonality may interfere with the animal weight gain, because they lose quality in the absence of rainfall, so energy-protein supplementation can be an alternative to boost the performance of cattle in this period, promoting weight gain and early finishing of these animals. Furthermore, the nutritional value of forages is the key to the use and success of supplementation (Oliveira et al. 2019). For each genus there are several cultivars with different nutritional characteristics. As a result, it is necessary to know the potential of each species within the crop-livestock integration system. In this sense, the goal was to evaluate the production, forage quality and cattle performance in Paiaguas palisadegrass and Tamani grasses in different forms of animal supplementation in crop-livestock integration.

Results

Production and forage quality

When evaluating canopy height and forage production in all grazing cycles, Paiaguas palisadegrass showed higher values ($p < 0.05$) compared to tamani grass (Table 1), with an increase of 35, 28 and 30% dry matter production, for the first, second and third grazing cycles, respectively. However, when comparing height and production between forms of supplementation in all grazing cycles, the results were similar ($p > 0.05$) between forage crops.

As for the leaf: stem ratio, Tamani guinea grass showed a higher value than Paiaguas palisadegrass in both supplementation strategies, in the first and second cycles. In the third grazing cycle, the values were similar. When comparing the leaf: stem ratio of forage crops, there was no difference between forms of supplementation in all grazing cycles.

As for forage quality, in all grazing cycles, CP contents were similar ($p > 0.05$) between Tamani guinea grass and Paiaguas palisadegrass and between forms of supplementation (Table 2). For the NDF and ADF of the first grazing cycle, Paiaguas palisadegrass showed a lower value ($p < 0.05$) in both forms of supplementation (Table 2). In relation to the second and third grazing cycle, ADF and NDF contents were similar ($p > 0.05$) between forage crops and forms of supplementation.

Lignin and IVDMD showed no difference ($p > 0.05$) between forages and forms of supplementation, in all cycles (Table 2). However, there was an increase in lignin with advancing grazing cycles, from 17.59 to 19.53 g kg^{-1} DM in the first cycle to 22.76 to 23.64 g kg^{-1} DM in the third cycle. This result reflected lower values of in vitro dry matter digestibility with grazing cycles, from 684.65 to 693.86 g kg^{-1} DM in the first cycle to 601.11 to 619.88 g kg^{-1} DM in the third cycle. For the potassium concentrations of forages, in all cycles there was no significant effect ($p>0.05$) between forages and forms of supplementation (Table 3). As for phosphorus concentration, Tamani guinea grass was 17.69%, 11.90%, 12.96% and 8.18% higher than Paiaguas palisadegrass, in protein-energy and mineral supplementation, in the first and second cycles, respectively. In the third cycle, the concentration was similar ($p > 0.05$) between forages.

Cattle performance

For animal performance (Table 4), there was no influence ($p>0.05$) of forages and forms supplementation on the average daily weight gain (DWG) and total average weight gain (TWG) of the animals.

Discussion

The greater canopy height and forage production of Paiaguas palisadegrass in both forms of supplementation and in all grazing cycles, are due to the vigorous and rapid regrowth of this forage, even in periods of low rainfall and temperature as already demonstrated by Epifanio et al. (2019). It is worth mentioning the forage dry matter production in a crop-livestock integration system in the dry season, which is generally quite challenging in a conventional system. The third grazing cycle occurred from July to August, a critical period of drought for the Cerrado region in Central Brazil, where there is low forage availability due to climatic conditions. Even in this period of water scarcity, Paiaguas palisadegrass showed dry matter production of 2,087 kg ha^{-1} in protein-energy supplementation and 2,320 kg ha^{-1} in mineral supplementation. Satisfactory forage production in the off-season is due to benefits that the integrated system provides to the system, as the forage uses the nutrients of the soil from annual crop residues, promoting nutrition for the forage, resulting in greater forage availability even in periods of water deficit. Due to this characteristic, Paiaguas palisadegrass is among the most suitable forages for the crop-livestock integration system (Costa et al. 2016; Santos et al. 2016; Guarnieri et al. 2019; Santos et al. 2020).

Higher values of leaf: stem ratio of Tamani guinea grass in the two supplementation strategies, in the first and second grazing cycles, can be explained by the morphological characteristics of the forage, which presents thin and short stem, with a large proportion of leaves (Tesk et al. 2020). Similar results were reported by Machado et al. (2017), who evaluated different forages intercropped with soybean, and observed that Tamani guinea grass stood out for the large number of leaves and thin stems.

The reduction in plant height, dry matter production and leaf: stem ratio with advancing of grazing cycles, was already expected. This behavior is natural for tropical forages, because with the absence of rain, these plants physiologically increase the elongation of the stem at the expense of the production of new leaves.

Similar values regarding the crude protein content of the Tamani guinea grass and Paiaguas palisadegrass can be explained by the quality of both forages and the regrowth capacity in the dry period of the year. Therefore, it is possible to observe the importance of using crop-livestock integration to supply quality forage in the off-season, a time when there is usually low forage quality, due to production seasonality. Another positive aspect is saving supplementation, quality pastures reduce the use of protein supplementation to animals, as we can see in the present study, as there was no significant difference between groups with mineral and protein supplementation.

The results of CP obtained in this study corroborate studies on crop-livestock integration, where Maia et al. (2014), after the corn harvest, found average CP levels from 90 g kg^{-1} to 134 g kg^{-1}, for the months of September and October, respectively, and Costa et al. (2016) found CP levels varying from 117 to 128 g kg^{-1} and from 132 to 144 g kg^{-1} for Paiaguas palisadegrass in two sowing times, respectively.

It can be seen in Table 3 that the CP contents in all grazing cycles met the protein requirements (equal to or greater than 70 g kg^{-1} DM), of the animals evaluated, without impairing performance (Van Soest, 1994). The water deficit period corresponds to the time of great nutritional challenge for cattle, as performance can be reduced due to the decrease in forage availability and quality (Oliveira et al. 2019). Nitrogen is the main limitation for the degradation of forage fiber (Oliveira et al. 2020). The lower contents of NDF and ADF in Paiaguas palisadegrass in relation to Tamani guinea grass in the first cycle, demonstrated that the high stocking rate promoted effective control of stem growth of Paiaguas palisadegrass by animal grazing. Anjos et al. (2016) reported that the stem elongation restriction through grazing is the most appropriate management to promote better structure to the canopy and decrease the loss of

Table 1. Productive characteristics of forages, in different supplementation strategies, according to grazing cycles.

Productive characteristics	Forages		Supp.	P value F	P value S	P value F : S
	Tamani guinea grass	Paiaguas palisadegrass				
		First grazing cycle				
Sward height (cm)	38.85 Ba	46.08 Aa	PE	0.016	0.852	0.093
	41.94 Ba	45.56 Aa	M			
Dry matter (kg ha^{-1})	2490 Ba	3325 Aa	PE	0.037	0.547	0.070
	2307 Ba	3150 Aa	M			
Leaf:stem ratio	3.75 Aa	2.40 Ba	PE	<0.001	0.525	0.192
	3.52 Aa	2.29 Ba	M			
		Second grazing cycle				
Sward height (cm)	29.70 Ba	34.70 Ab	PE	<0.001	0.009	0.193
	31.72 Ba	39.88 Aa	M			
Dry matter (kg ha^{-1})	2227 Ba	2810 Aa	PE	0.002	0.522	0.260
	2125 Ba	2767 Aa	M			
Leaf:stem ratio	2.80 Aa	2.17 Ba	PE	0.049	0.900	0.957
	2.85 Aa	2.19 Ba	M			
		Third grazing cycle				
Sward height (cm)	22.30 Bb	32.50 Ab	PE	<0.001	<0.001	0.281
	27.56 Ba	35.80 Aa	M			
Dry matter (kg ha^{-1})	1727 Bb	2287 Aa	PE	<0.001	0.029	0.383
	1815 Ba	2320 Aa	M			
Leaf:stem ratio	1.46 Aa	1.24 Aa	PE	0.192	0.464	0.955
	1.35 Aa	1.11 Aa	M			

Means followed by different letters, uppercases in the same row (forage) and lowercases in the same column (supplementation), are significantly different by Tukey's test at 5% probability. Suppl.: Supplementation; PE: protein-energy supplementation; M: mineral supplementation; F: Forage; S: supplementation; DM: Dry matter

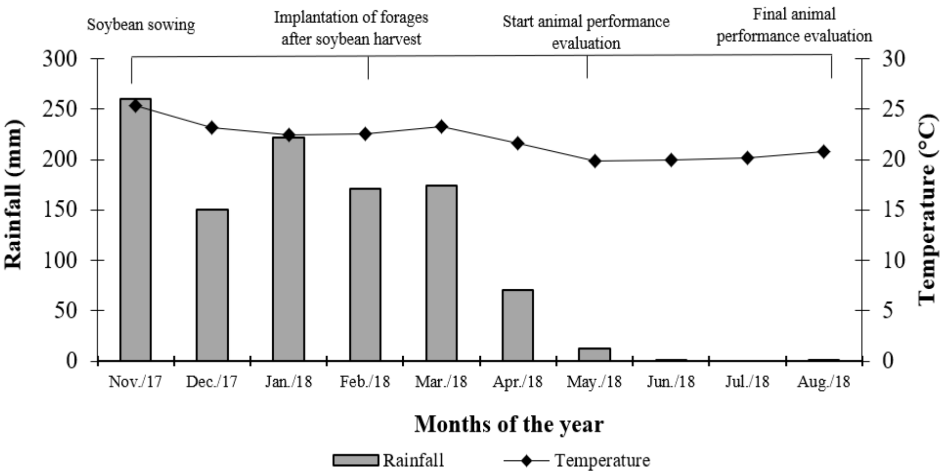

Fig 1. Monthly rainfall and average temperatures recorded from November 2017 to August 2018, Rio Verde - GO, Brazil.

Table 2. Chemical characteristics of forages, in different supplementation strategies, according to grazing cycles.

Chemical characteristics	Forages		Supp.	P value F	P value S	P value F : S
	Tamani guinea grass	Paiaguas palisadegrass				
		First grazing cycle				
CP (g kg^{-1} DM)	135.08 Aa	142.20 Aa	PE	0.806	0.246	0.066
	147.98 Aa	138.91 Aa	M			
NDF (g kg^{-1} DM)	676.63 Aa	649.80 Ba	PE	0.004	0.550	0.803
	683.35 Aa	652.59 Ba	M			
ADF (g kg^{-1} DM)	388.57 Aa	365.61 Ba	PE	0.003	0.028	0.180
	382.23 Aa	343.27 Ba	M			
Lignin (g kg^{-1} MS)	19.53 Aa	18.18 Aa	PE	0.903	0.492	0.253

	18.70 Aa	17.59 Aa	M			
IVDMD (g kg^{-1} DM)	686.80 Aa	693.86 Aa	PE	0.238	0.671	0.539
	684.65 Aa	685.36 Aa	M			
Second grazing cycle						
CP (g kg^{-1} DM)	123.47 Aa	118.60 Aa	PE	0.303	0.961	0.784
	124.87 Aa	116.60 Aa	M			
NDF (g kg^{-1} DM)	719.42 Aa	707.62 Aa	PE	0.183	0.121	0.693
	705.92 Aa	699.32 Aa	M			
ADF (g kg^{-1} DM)	394.72 Aa	409.10 Aa	PE	0.998	0.131	0.041
	399.05 Aa	384.65 Aa	M			
Lignin (g kg^{-1} MS)	20.45 Aa	20.65 Aa	PE	0.500	0.679	0.526
	22.19 Aa	22.15 Aa	M			
IVDMD (g kg^{-1} DM)	660.36 Aa	647.61 Aa	PE	0.685	0.813	0.685
	657.69 Aa	657.68 Aa	M			
Third grazing cycle						
CP (g kg^{-1} DM)	96.47 Aa	109.55 Aa	PE	0.4676	0.610	0.132
	102.57 Aa	97.72 Aa	M			
NDF (g kg^{-1} DM)	726.85 Aa	723.47 Aa	PE	0.3968	0.600	0.816
	725.27 Aa	719.42 Aa	M			
ADF (g kg^{-1} DM)	418.97 Aa	414.70 Aa	PE	0.2974	0.467	0.795
	416.47 Aa	409.47 Aa	M			
Lignin (g kg^{-1} MS)	22.93 Aa	22.76 Aa	PE	0.456	0.578	0.723
	23.64 Aa	23.38 Aa	M			
IVDMD (g kg^{-1} DM)	614.88 Aa	601.11 Aa	PE	0.373	0.638	0.919
	619.88 Aa	608.82 Aa	M			

Averages followed by different letters, upper case in the line (forage) and lower case in the column (supplementation), differ from each other by Tukey's 5% probability test. Supp.: supplementation, PE: protein-energy supplementation; M: mineral supplementation; F: forage; S: supplementation; DM: dry matter. CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; IVDMD: in vitro digestibility of matter dry.

Table 3. Phosphorus and potassium concentration of forages in different supplementation strategies, according to grazing cycles.

Nutrients	Forages		Supp.	P value F	P value S	P value F:S
	Tamani guinea grass	Paiaguas palisadegrass				
First grazing cycle						
Potassium (g kg^{-1})	14.64 Aa	15.20 Aa	PE	0.177	0.146	0.570
	13.30 Aa	14.56 Aa	M			
Phosphorus (g kg^{-1})	1.33 Aa	1.13 Bb	PE	0.002	<0.001	0.017
	1.41 Aa	1.26 Bb	M			
Second grazing cycle						
Potassium (g kg^{-1})	13.40 Aa	12.71 Aa	PE	0.436	0.385	0.699
	12.66 Aa	12.42 Aa	M			
Phosphorus (g kg^{-1})	1.22 Aa	1.08 Ba	PE	0.046	0.745	0.409
	1.19 Aa	1.10 Ba	M			
Third grazing cycle						
Potassium (g kg^{-1})	11.95 Aa	11.28 Aa	PE	0.1065	0.5232	0.6305
	11.87 Aa	10.73 Aa	M			
Phosphorus (g kg^{-1})	0.96 Aa	0.82 Aa	PE	0.3210	0.0921	0.0677
	1.00 Aa	0.95 Aa	M			

Averages followed by different letters, upper case in the line (forage) and lower case in the column (supplementation), differ from each other by Tukey's 5% probability test. Supp.: supplementation; PE: protein-energy supplementation; M: mineral supplementation; F: forage; S: supplementation.

Table 4. Values of initial and final weight (kg), average daily weight gain (DWG) in kg, average total weight gain (TWG) in kg arrobas animal^{-1} ha^{-1} in each forage system with different supplementation strategies for cattle on pasture.

Animal performance	Forage		Supl.	P value F	P value S	P value F:S
	Tamani guinea grass	Paiaguas palisadegrass				
Initial weight (kg)	240.30	238.60	PE	0.916	0.099	0.991
	240.10	238.70	M			
Final weight (kg)	293.70	285.60	PE	0.948	0.881	0.696
	284.10	289.90	M			
DWG (kg)	0.83	0.67	PE	0.911	0.291	0.076
	0.59	0.73	M			
TWG (kg)	53.40	47.00	PE	0.837	0.741	0.190
	44.00	52.70	M			
Arroba animal^{-1*}	1.78	1.57	PE	0.834	0.736	0.190
	1.47	1.76	M			

Means followed by different letters, uppercases in the same column (forage) and lowercases in the same row (supplementation), are significantly different by Tukey's test at 5% probability. Suppl.: Supplementation, PE: protein-energy supplementation; M: mineral supplementation; F: Forage; S: supplementation. *Considering 1 arroba equal to 30 kg body weight with estimated carcass yield of 50%.

Table 5. Initial and final stocking rate (animal unit - AU ha^{-1}) in each forage system with different supplementation strategies for pasture cattle.

Variables	Tamani guinea grass	Paiaguas palisadegrass	Supplementation^{1}
Initial stocking rate (UA ha^{-1})	3.22	3.90	PE
	2.38	2.37	M
Final stocking rate (UA ha^{-1})	1.62	2.21	PE
	1.80	2.39	M

^{1}PE: protein-energy supplementation; M: mineral supplementation; AU - equivalent to 450 kg live weight.

material and accumulation of dead material, consequently improving the nutritional value. Even in the third grazing cycle, considered as a critical period of water scarcity in the region of Central Brazil, the contents of NDF and ADF remained stable for both forages. This result is due to the development of forage crops even in the dry season, favoring better quality of forage to be supplied to the animals. It is worth mentioning that this is possible in pastures formed in the first year in the crop-livestock integration, where there is the use of the residue from the previous crop, reflecting in a higher quality forage production. Higher contents of NDF and ADF result in lower intake and digestibility of forage, impairing animal performance (Garcia et al. 2016).

The lack of significant differences in lignin and digestibility in relation to the animals receiving protein-energy supplementation was because the animals were grazing on pastures with high forage quality, as shown by the results of chemical composition, with average CP during the total grazing cycle, 121.67 and 120.58 g kg^{-1} DM for Tamani guinea grass and Paiaguás grasses, respectively (Table 3). The high proportion of leaves of these forages and smaller amounts of fiber fractions contributed to this result, facilitating the consumption of animals, since larger fiber portions have a negative correlation with intake and digestibility (Epifanio et al. 2019).

Knowing the nutritional requirements in relation to the minerals (phosphorus and potassium) of forage plants is a key factor for management because they interfere with the production and quality of the forage to be provided to the animals, reducing the cost of acquiring feed for the animals (Moreira et al. 2013).

The lack of a significant effect for potassium may be related to the high capacity that forage plants have in extracting this nutrient through leaves (Khan et al. 2010). In all cycles evaluated, both forages met the animal requirement regarding potassium, which according to Khan et al. (2009), in forage plants, potassium should be above 8 g kg^{-1} DM, while for growing cattle the need for this mineral is above 10 g kg^{-1} DM, showing that all animals received the amounts of potassium necessary for development.

The higher concentrations of phosphorus in Tamani guinea grass in the first and second cycles in the two forms of supplementation compared to Paiaguas palisadegrass may be related to greater phosphorus uptake, extracting a greater amount, since Tamani guinea grass has a higher soil fertility requirement. The two forages in the two forms of supplementation met the requirements of growing beef cattle for phosphorus, where ideal amounts can vary between 0.5 and 2.5 g kg^{-1} DM (NRC 2001). High concentrations of phosphorus in the soil demonstrate the effect of the crop-livestock integration system in relation to its benefits, is quite relevant since a large part of the beef cattle herd is found on pastures located in the Central-West region of the Brazilian Cerrado, where most of the time the soil is deficient in important nutrients, such as magnesium, calcium and phosphorus (Euclides et al., 2019). It is worth remembering that adequate concentrations of phosphorus in soil promote the increase of roots and tillering of forages (Rezende et al., 2011).

Normally, tropical forages do not meet the requirements of nitrogen, phosphorus and potassium for animals on pasture in the off-season, which is why supplementation in the dry season is used as a way to supply these nutrients to animals (Fardous et al. 2010). On the other hand, it is observed in the present study that the three nutrients met the requirements for the animals to show their normal development and to express their genetic load for weight gain, showing the savings in costs with supplementation, with adoption of the integration system. The increase in soil fertility is also one of the great advantages of adopting the system, reducing the costs with fertilization and taking advantage of the nutrients for the pasture, collaborating with its restoration, since the fertilization constitutes the biggest expense for restoration (Dias et al., 2021).

There was a reduction in the stocking rate from the first to the third grazing cycle (May to August) (Table 5), due to the lower production of dry matter available to animals in the third grazing cycle (Table 1). This stocking rate adjustment was already expected due to the seasonality in forage production, reducing forage regrowth under conditions of low rainfall, temperature and light, factors that determine the development and productivity of the forage (Costa et al., 2016).

There was a considerable increase in the average body weight of the animals, even with stocking rates above the reality of the Brazilian herd (Table 7), which under normal pasture conditions, the stocking rate is below 1 animal unit ha^{-1} - equivalent to 450 kg live weight (Gléria et al., 2017). The integration systems provide quality forage in the middle of the dry or winter season, being the big advantage of using of the system.

Evaluating cattle performance with *Brachiaria* and *Panicum maximum* forages in an integrated crop-livestock system, Dias et al. (2021) found that Tamani guinea grass showed higher quality of forage, which resulted in better animal performance in the off-season. In addition, it was concluded that the establishment of pastures through soybean over sowing proved to be an efficient technique for providing feed in the off-season and promoting good animal performance, and this approach reduces the environmental impact of livestock, because of a more efficient use of soil nutrients and is associated with greater sustainability.

Crop-livestock integration systems have been gaining ground in recent years, as they are a promising alternative to meet the demand for quality forage and for use during the dry period, due to their high annual production per area. Given the many advantages that the crop-livestock integration system provides, the use of land in a sustainable and intensive way, without the need to explore native areas (Peterson et al. 2020), coupled with the provision of food for a growing population (Allaoui et al., 2018), makes this system an important survival tool for the next few years. This is only possible by the combination of agriculture with livestock, which together provide complex synergism between soil, plants and animals, increasing the productivity of areas without expanding them and increasing profitability with sustainability (Carvalho et al., 2018).

Materials and Methods

Site description

This study was conducted at the Institute of Science and Technology Comigo, in Rio Verde, state of Goias, Brazil. The area used has a history of use of integrated crop–livestock systems in the last three years.

The soil of the experimental area was classified as a typical Dystrophic Red Latosol (Santos et al. 2018). The soil in the 0-20 cm layer was physically and chemically characterized before starting the experiment. It had 351 g kg^{-1} of clay; 539 g kg^{-1} of sand; 110 g kg^{-1} of silt; pH in CaCl: 4.90; Ca: 2.58 cmol$_c$ dm^{-3}; Mg: 0.74 cmol$_c$ dm^{-3}; Al: 0.11 cmol$_c$ dm^{-3}; H + Al: 5.05 cmol$_c$ dm^{-3}; K: 0.21 cmol$_c$ dm^{-3}; cation exchange capacity: 8.59 cmol$_c$ dm^{-3}; V: 41.14%; P (Mehlich): 33.70 mg dm^{-3} and OM: 27.18 g kg^{-1}. During the experiment, the monthly rainfall and average temperature data were recorded (Figure 1).

Experimental design, treatments and crop establishment

The experimental design was in randomized blocks, with four replicates, in a 2 x 2 factorial arrangement, being two forages (Tamani guinea grass and Paiaguas palisadegrass), and two animal supplementation strategies: protein-energy (PE) and mineral supplementation (M).

Each forage system was divided into four paddocks (replicates). The systems with Tamani guinea grass and Paiaguas palisadegrass in protein-energy supplementation were 0.83 ha each and the systems with Tamani guinea grass and Paiaguas palisadegrass in mineral supplementation were 1.17 and 1.12 ha, respectively.

Forages were implanted in succession to soybeans (2017/2018) on February 28, 2018. For establishment of forages, 5.0 kg of pure viable seeds were used for Paiaguas palisadegrass and 3.5 kg for Tamani guinea grass with 60% nd 40% of cultural value, respectively. The seeds were mixed with P_2O_5 fertilizer at a dosage of 150 kg ha^{-1} and distributed by broadcasting in the respective areas with aid of the pneumatic fertilizer-sowing machine.

Animal performance

After the development of forages, at 84 days of sowing (may), twenty uncastrated total of 20 Nellore steers were used, with a mean age of 13.25±0.77 months and with initial average body weight of 239.43±29.98 kg.

On May 24, 2018, the cattle were vaccinated against clostridiosis and cleared, according to the prophylactic calendar. Initially, the animals were weighed for standardization and randomly distributed among the four forage systems. The rate was calculated based on the forage supply available at that time. For this purpose, six percent of the forage supply in relation to the animals' body weight was used, estimating a grazing efficiency of 50%.

The grazing system methodology recommended was intermittent, with a seven-day occupancy period, a 21-day rest period, and a variable stocking rate, which was adjusted whenever necessary throughout the experiment, according to forage availability (Table 5). The experiment lasted 91 days, being 84 days in evaluations, with three grazing cycles of 28 days each and seven days of adaptation of the animals to diets and management. The animals remained in the area until 08/23/2018. Later the forages stayed in rest to re-grow, for formation of biomass coverage for the no-tillage system of the next crop of soybean (Muniz et al., 2021).

The animals remained in the pastures with good quality water and with the mineral or protein-energy supplements ad libitum. The animals were weighed every 28 days, always with previous fasting of solids of at least 12 hours. The daily average weight gain values were measured at 56 and 84 days using the final body weight value, minus the initial body weight value and divided by the period under experimentation. To obtain the values of arrobas production (1 arroba at the equivalent of 15 kg), the value of the total weight gain divided by 30 was used, considering carcass yield of 50%. These values were adjusted to the specific size of the area of each forage system, obtaining the values of arrobas per ha.

Evaluation of forage production and nutritional value

The productive characteristics and nutritional value of the forages were evaluated from May to August 2018, always before the animals entered the paddocks. Sward height measurements were obtained using a ruler for systematic readings, measuring 20 random points from each paddock.

To evaluate forage production, eight samples measuring 0.25 m^2 were collected per paddock, and the forage was cut to 20 cm high for the ground surface. The collected material was placed in plastic bags, and a representative sample of approximately 200 g was placed in paper bags. The samples were placed in a forced-air oven at 55°C to determine the partial dry matter. Lastly, the material was ground in a mill with a 1-mm sieve and subjected to chemical analysis.

After each cut, evaluated the leaf:stem ratio, the samples were manually separated, divided into leaf blade and pseudostem (stem + sheath), and placed in paper bags, weighed, and then dried in a forced-air oven (55°C) until reaching constant weight.

Chemical composition analyzes were performed to determine for dry matter (DM), crude protein (CP), according to the methodologies described by the AOAC (1990). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were estimated by the method described by Mertens (2002). The in vitro dry matter digestibility (IVDMD) was analysed using the technique described by Tilley and Terry (1963). Nutrient concentrations (nitrogen, phosphorus and potassium) were determined according to the methods of Malavolta et al. (1997).

Statistical analysis

The variables were submitted to analysis of variance in R version R-3.1.1 (2014), using the ExpDes package (Ferreira et al. 2014). The means were compared by the Tukey test at 5% probability.

Conclusions

Paiaguas palisadegrass showed higher forage production during the three grazing cycles. Both forages showed satisfactory results in terms of average daily weight gain and total weight. The provision of protein supplementation to animals did not interfere with animal performance.

Paiaguas and Tamani guinea grass showed potential in crop-livestock integration in succession to soybean and may be an alternative of quality food to be offered in the dry season. The system contributed to maintaining the sustainability of animal production on pasture.

Acknowledgment

This work was supported by the Goiano Federal Institute and Fapeg for granting the scholarship.

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