Dry matter allocation and chemical composition of brachiaria brizantha and decumbens 45 days after emergence

Alocação da matéria seca e composição química das braquiárias brizantha e decumbens, aos 45 dias após emergência

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ABSTRACT

This study evaluated dry matter allocation and chemical composition of brachiaria brizantha and decumbens under conditions of good nutrient supply. The study was

conducted in the city of Coruripe, East Mesoregion of the state of Alagoas, in a medium-textured dystrophic red-yellow latosol. The experimental design was randomized blocks with five replications, and the plots consisted of five furrows of five meters in length, spaced 0.60 meters apart. Phosphorus was applied at the bottom the open furrows at a dose equivalent to 50 kg of P ha^{-1}. Nitrogen and potassium fertilizers were applied at doses equivalent to 150 ha^{-1} when plants were approximately 5 cm tall. Evaluations of dry matter accumulation and allocation were carried out 45 days after plant emergence, when light interception by leaves was approximately 90%. Both species showed high growth rates, with an average shoot dry matter accumulation of 5.64 t ha^{-1}, but brachiaria decumbens was about 25% more productive than brachiaria brizantha. There was no effect of the species on the percentage of dry matter allocation and about 50% of it was allocated to in the leaves. There was also no species effect on shoot crude protein content, which had an average of 106 g kg^{-1}, enough to ensure good ruminal fermentation. Brachiaria decumbens had higher calcium, magnesium and sulfur contents compared to brachiaria brizantha, although adequate contents of these three nutrients were also found in brachiaria brizantha.

Keywords: production system, sustainability, agricultural management.

RESUMO

No presente trabalho, avaliou-se a alocação da matéria seca e a composição química das braquiárias brizantha e decumbens, em condições de bom suprimento de nutrientes. O estudo foi conduzido em Coruripe, região leste de Alagoas, em um Latossolo Vermelho-Amarelo distrófico, de textura média. O delineamento experimental foi o de blocos ao acaso, com cinco repetições, sendo as parcelas constituídas de cinco sulcos de cinco metros de comprimento, espaçados de 0,60 metro. No fundo do sulco aberto para a semeadura foi aplicado fósforo, na dose equivalente a 50 kg de P ha^{-1}. As adubações nitrogenada e potássica, em doses equivalentes a 150 ha^{-1}, foram realizadas em cobertura quando as plantas apresentaram cerca de 5 cm de altura. As avaliações do acúmulo e partição da matéria seca foram realizadas aos 45 dias após a emergência das plantas, quando a interceptação foliar era de aproximadamente 90% da luz solar. As braquiárias tiveram alta taxa de crescimento, com valor médio de acúmulo de matéria seca na parte aérea de 5,64 t ha^{-1}, contudo, a braquiária decumbens foi cerca de 25% mais produtiva que a braquiária brizantha. Não houve efeito de espécie de braquiária na alocação percentual da matéria seca e, cerca de 50% desta matéria seca, estava alocada nas folhas. Para os teores de proteína bruta da parte aérea das braquiárias também não foi constatado efeito de espécie de braquiária, tendo-se obtido valor médio de 106 g kg^{-1}, suficiente para assegurar uma boa fermentação ruminal. A braquiária decumbens teve maior teor de cálcio, magnésio e enxofre que a braquiária brizantha, mas, mesmo na braquiária brizantha os teores desses três nutrientes estavam em concentrações adequadas.

Palavras-chave: sistema de produção, sustentabilidade, gerenciamento agrícola.

1 INTRODUCTION

Pastures are the main source of roughage for ruminants, and extensive areas in the state of Alagoas are used for beef cattle and dairy farming. In sown pastures, there is a predominance of the genus *Urochloa* (formerly *Brachiaria*). Farmers have shown a

preference for plants of this genus because of their robustness, wide adaptability to different edaphoclimatic environments, associated with high yield potential and good nutritional value of plants (BRAZ, 2003; PACHECO et al., 2013; OLIVEIRA et al., 2017; OLIVEIRA et al., 2021). Studies conducted by Souza (2010) showed that *Urochloa brizantha* (brachiaria brizantha) cv. *Marandú* and *Xaraés*, as well as *Panicum maximum* cv. *Massai* and *Tanzania* had the highest yields.

Forage plant adaptation and growth can be evaluated by several variables, the most common being dry matter production and allocation in the plant throughout the biological cycle (OLIVEIRA et al., 2000; PORTES et al., 2000; OLIVEIRA et al., 2017). The chemical composition of pastures (especially protein, phosphorus and sulfur contents) greatly influences forage digestibility and intake by ruminants, thus having a significant effect on animal productivity. Other factors that interfere in the persistence, production and bromatological quality of forage are nutrient availability in the soil, chemical fertilization, weather conditions and pasture management (DE BONA, 2008; VIANA et al., 2011; FRANCISCO et al., 2017; DIAVÃO, 2022).

To improve the low productivity of land and animals, some producers have chosen to replace one forage with another, but this alternative has not been effective. Therefore, it is essential to reconstruct soil fertility with lime and gypsum application, chemical fertilization, in addition to decompressing the surface layer of the soil, usually compacted by intense animal trampling (PORTES et al., 2000; OLIVEIRA et al., 2018; FIGUEIREDO et al., 2020). In chemically and physically depleted soils, the nutritional value of forage is low, characterized by high levels of cell wall constituents and low levels of protein, calcium and phosphorus (STROZZI, 2014; OLIVEIRA et al., 2017; KOZLOSKI, 2019; DIAVÃO, 2022).

Thus, this study aimed to evaluate, under conditions of good nutrient supply, dry matter production and allocation, in addition to the chemical composition of brachiaria brizantha and decumbens 45 days after plant emergence.

2 MATERIAL AND METHODS

The study was conducted in the city of Coruripe, state of Alagoas (Latitude: 10° 8' 1" S, Longitude: 36° 10' 34" W) (Figure 1). According to Köppen classification, the entire eastern half of the state has a tropical and warm climate (As'), with autumn/winter rainfall between 1,000 mm and 1,500 mm. There is an increasing variation in rainfall from January to December 2020 (Figure 2). The region does not show large fluctuations

in average temperature, varying between 23°C and 28°C on the coast. The soil was classified as medium-textured dystrophic red-yellow latosol.

Figure 1 - Location of the study site, city of Coruripe, state of Alagoas.

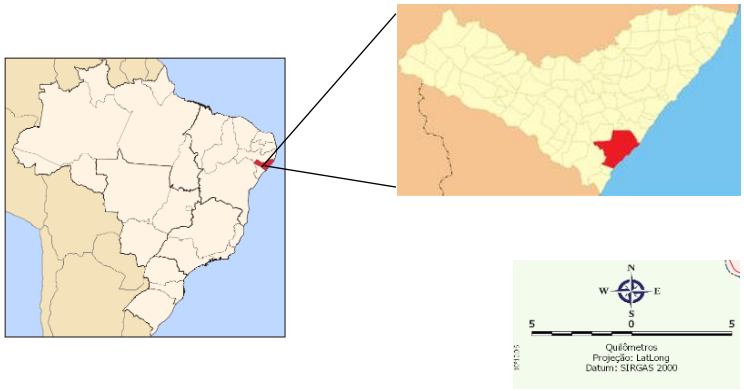
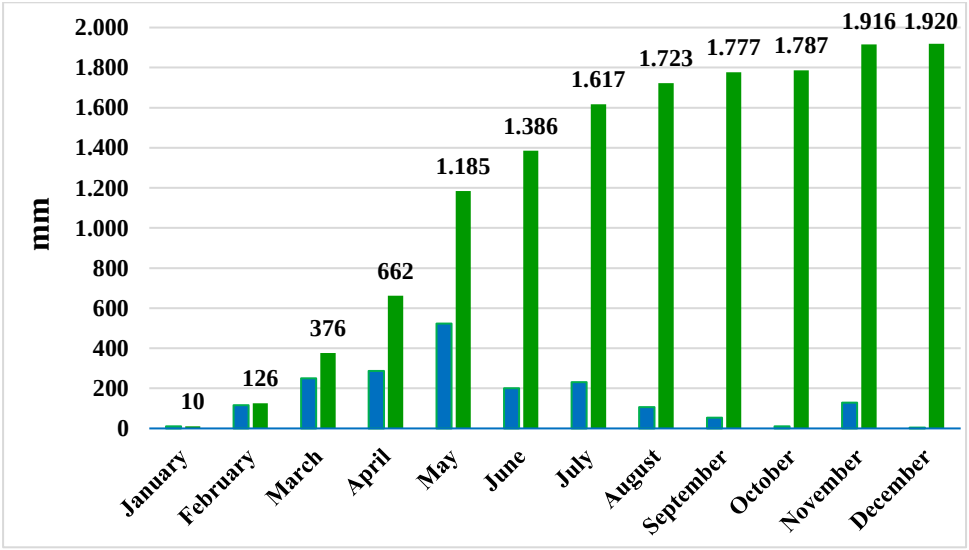


Figure 2 - Rainfall in 2020 in the city of Coruripe, state of Alagoas. Monthly and accumulated volume of rain.



In March 2020, soil samples were collected in the 0-20 cm layer. The soil showed 46.59% base saturation, without the presence of exchangeable aluminum (Table 1). Plowing and harrowing were carried out to improve the physical properties of the soil before the sowing of the brachiaria species. In April 2020, brachiaria brizantha (*Urochloa brizantha* cv. *Marandu)* and brachiaria decumbens (*Urochloa decumbens* cv. IPEAN) were sown at a rate of 15 kg of pure viable seeds per hectare (Figure 3).

Table 1 - Analytical results of the soil sample in the 0-20cm layer collected of the study area in March.

Layer	pH in	P	K	Ca	Mg	Al^{+3}	H + Al	BS	CEC (t)	CEC (T)	V	m
	H20	.-- mg dm^{-3}--- .		.---------- $cmol_c$ dm^{-3}----------.							.------%-----.	
0 to 20 cm	5.2	18	98	2.6	0.9	0.0	4.3	3.75	3.75	8.05	46.59	0.00

pH in water (1:2.5 ratio). Ca^{2+}, Mg^{2+} and Al^{3+} extracted by $^{1\ mol\ L\text{-}1}$ KCl. P, K and Na extracted by Mehlich-1. H^{+} + Al^{3+} extracted by 0.5 $^{mol\ L\text{-}1}$ calcium acetate at pH 7.0.

Figure 3 - Plant emergence and nitrogen and potassium fertilization between the rows of brachiaria.

The experimental design was randomized blocks with five replications, and the plots consisted of five furrows of five meters in length, spaced 0.60 meters apart. Phosphorus was applied at the bottom of the open furrows at a dose equivalent to 50 kg of P ha^{-1} (equivalent to 114.5 kg of P_2O_5) using simple superphosphate as a P source to increase efficiency in nitrogen metabolism and protein synthesis, as there is a strong interaction of N, P and S in biochemical routes (MALAVOLTA et al., 1997; OLIVEIRA et al., 2018). The phosphate fertilizer was covered with a layer of earth of approximately 5 cm. Brachiaria seeds were distributed by hand in the furrows and covered with a thin layer of earth (approximately 1 cm). There was no need for pest and weed control.

Nitrogen and potassium fertilizers were broadcast (Figure 3) when the plants were around 5 cm tall. The fertilization doses were equivalent to 150 ha^{-1}, using ammonium sulfate and potassium chloride as nutrient sources. Ammonium sulfate is used to eliminate

N losses by volatilization (OLIVEIRA et al., 2018) and increase N metabolism efficiency, as previously mentioned.

Dry matter accumulation and allocation were evaluated 45 days after emergence (DAE), sampling areas of 1.0 m^2 in the central rows of the plots. This sampling was defined by estimating light interception of 90%. The brachiaria plants were cut close to the soil surface, weighed, and subsampled to quantify dry matter allocation in stems + petioles and leaves. In the subsamples, the green leaves were separated from the rest of the plant, and each fraction was weighed again. These subsamples were dried in a forced ventilation oven at 50 °C to constant mass and weighed, following procedures described by Malavolta et al. (1997) and Silva and Queiroz (2006). Based on these values, dry matter accumulation was calculated in stems + petioles and leaves. Shoot dry matter accumulation in brachiaria brizantha and decumbens was the sum of the dry matter of the stems + petioles and leaves of each species.

Subsubsamples of stems + petioles and leaves were ground in a stainless-steel mill and submitted to sulfuric and nitric-perchloric digestions. Crude protein, phosphorus, potassium, calcium, magnesium and sulfur contents were determined in the dry and ground material, following methods described by Malavolta et al. (1997) and Silva and Queiroz (2006). Crude protein contents were obtained by the Kjeldahl method, phosphorus by spectrocolorimetry and potassium by flame photometry. Calcium and magnesium were determined by atomic absorption spectrophotometry and sulfur by turbidimetry. The results were submitted to analysis of variance and the means compared by the Scott-Knott test at 5% probability (FERREIRA, 2011).

3 RESULTS AND DISCUSSION

Based on the mean squares of the analysis of variance and the coefficient of variation for dry matter accumulation and allocation in leaves, stems + petioles and shoot dry matter accumulation, we found there was a significant effect of brachiaria species for dry matter accumulation in stems + petioles and shoot dry matter accumulation (Table 2). For dry matter accumulation in stems + petioles, average values of 2.46 and 3.25 t ha^{-1} were found for brachiaria brizantha and decumbens, respectively.

Table 2 - Mean squares of variance and coefficient of variation (CV) of dry matter accumulation in stems + petioles (Ac. S+P); dry matter accumulation in leaves (Ac. L); dry matter accumulation in shoots (Ac. S); and the percentage allocation of dry matter in stems + petioles (Alloc. % S+P) and leaves (Alloc. % L) of Brachiaria brizantha and decumbens 45 DAE.

Source of Variation	DF	Mean Square				
		Ac. S+P ($t\ ha^{-1}$)	Ac. L ($t\ ha^{-1}$)	Ac. S ($t\ ha^{-1}$)	Alloc. % S+P	Alloc. % L
Brachiaria (B)	1	1,548.88**	6,161.5ns	4,109.1*	14.93 ns	14.95 ns
Block	4	91.41	93.46	338.1	1.93	1.94
Residue	4	85.7	166.91	452.1	3.66	3.65
Mean value		2.85	2.78	5.64	50.56	49.44
CV (%)		10.26	14.69	11.93	3.78	3.87

**, *, ns significant at 1.0%, 5.0% or not significant, respectively, by the F test.

The greater accumulation of dry matter in stems + petioles of brachiaria decumbens resulted in an increased dry matter accumulation in the entire plant shoot compared to brachiaria brizantha. The accumulation of dry matter in the entire shoot of brachiaria decumbens was 6.27 t ha^{-1}, approximately 25% higher than that of brachiaria brizantha (5.00 t ha^{-1}). However, shoot dry matter accumulation was also considered high for brachiaria brizantha. Growth rate and dry matter accumulation are influenced by several factors, especially water and nutrient availability in the soil, temperature, luminosity, plant yield potential and time (STROZZI, 2014; DIAS et al., 2021; OLIVEIRA et al., 2021). In a similar study to this one, Portes et al. (2000) reported shoot dry matter of brachiaria brizantha of 2.5 t per hectare 45 days after emergence.

One of the factors that may have contributed to the greater accumulation of dry matter in this study compared to that of Portes et al. (2000) was nutrient availability, a consequence of the higher fertilization used in sowing and broadcasting. Portes et al. (2000) applied 300 kg per hectare of 04-30-16 at sowing and 40 kg of N per hectare at 40 DAE. Oliveira et al. (2018) stated that grasses have a high response to fertilization, especially to nitrogen. Oliveira et al. (2021) conducted studies with brachiaria brizantha in soil of good fertility and reported an average rate of shoot dry matter accumulation of 120 kg per hectare per day, up to 45 DAE. In this study, average shoot dry matter accumulation of brachiaria brizantha and decumbens was 110 and 139 kg per hectare per day, up to 45 DAE, respectively.

There was no significant effect of species on the percentage allocation of dry matter in stems + petioles (Table 2). The average allocation of dry matter in stems + petioles was 50.56% and, therefore, 49.44% was allocated in leaves. Both for the percentage allocation of dry matter in stems + petioles and leaves, there was a coefficient of variation of 3.78 and 3.87%, respectively. Thus, there was practically equal

participation of stems + petioles and leaves in the forage of these brachiaria collected at 45 DAE. Strozzi (2014) conducted a study in the state of São Paulo with brachiaria brizantha (cv. *Marandú*) using a fertilization dose of 250 kg of N per hectare and found that the percentage allocation of dry matter in leaves was 52%, a value close to that found in this study.

Table 3 shows the average values of crude protein and P, K, Ca, Mg and S contents in stems + petioles, leaves and the entire shoots of brachiaria brizantha and decumbens. Plant shoot protein has been one of the variables most used in competition studies or for the evaluation of forage yield potential (SNIFFEN et al., 1993; DE BONA, 2008; VIANA et al. 2011; MORAIS et al., 2013). In this study, there was no effect of species on crude protein content in stems + petioles, and an average value of 66.2 g per kg of dry matter (or 6.6%) was found. On the other hand, there was a significant species effect on crude protein contents in leaves. The average leaf crude protein content of brachiaria decumbens was 156 g kg^{-1}, approximately 10% higher than that of brachiaria brizantha. However, there was no difference in shoot crude protein content of the brachiaria, which was 106.5 g per kg of dry matter, a value close to that reported by Figueiredo et al. (2020) and Silva et al. (2020).

There may be grazing selectivity by animals even at 45 DAE, usually for softer plant parts with higher nutritional value. Even without this consideration, we found the protein content of the entire shoot of the brachiaria to be enough for good fermentation and digestibility of dry matter in the rumen. Sniffen et al. (1993) and Morais et al. (2013) believe food consumption in cattle is mainly controlled by ruminal activity. A crude protein content of 70 g kg^{-1} (or 7.0 %) in the total diet would be considered the critical minimum for a good ruminal fermentation condition. Still, according to Morais et al. (2013), lower crude protein levels lead to a decrease in consumption and, consequently, maintenance requirements are not met, resulting in weight loss (PAULINO et al., 2003). For this reason, the lower intake and digestibility of tropical grasses in advanced maturity are related to low crude protein content and the lower supply of ammonia in the rumen for cellulolytic bacteria (KOZLOSKI, 2019).

Table 3 - Average values of crude protein, phosphorus, potassium, calcium, magnesium and sulfur contents in dry matter of stems + petioles (S+P), leaves (L) and shoot (S); and coefficient of variation (CV) for

Brachiaria	.------- Crude protein -----.			.---------- Phosphorus ----------			.---------- Potassium ---------		
	S+P	Leaves	Shoots	S+P	Leaves	Shoots	S+P	Leaves	Shoots
	.---------- g kg^{-1} de Dry matter ----------.								
brizantha	67 a	140 a	104 a	2.6 a	3.1 a	2.8 b	37 a	27a	32 a
decumbens	65 a	156 b	109 a	2.4 a	3.0 a	2.7 a	37 a	28 a	32 a
C V (%)	10.2	2.8	3.19	3.79	2.98	1.75	1.54	3.81	2.16
Brachiaria	.---------- Calcium ----------			.--------- Magnesium --------.			.--------- Sulfur --------.		
	S+P	Leaves	Shoots	S+P	Leaves	Shoots	S+P	Leaves	Shoots
	.---------- g kg^{-1} de Dry matter ----------.								
brizantha	4.0 a	5.7 a	4.8 a	1.1 a	2.5 a	1.8 a	2.9 a	2.8 a	2.9 a
decumbens	4.9 b	7.4 b	6.1 b	1.1 a	3.7 b	2.4 b	3.9 b	3.8 b	3.8 b
C V (%)	3.19	7.33	7.13	9.75	1.93	3.74	11.13	8.46	9.77

sampling carried out at 45 days after emergence of brachiaria brizantha and decumbens.
Means followed by the same letter in the column do not differ from one another by the Scott Knott test at 5.0% probability.

Most tropical grasses have significant response to nitrogen fertilization which are influenced by other factors. For instance, base saturation, the balanced availability of other nutrients (especially phosphorus and sulfur), pasture management and weather conditions, especially when increased water availability is associated with increased temperature and luminosity (MALAVOLTA et al., 1997; FRANCISCO et al., 2017; OLIVEIRA et al., 2018; DIAVÃO, 2022). Viana et al. (2011) found quadratic effects of nitrogen fertilization on crude protein content in the entire shoot of brachiaria. In the control treatment, protein contents were 87 g kg^{-1}, rising to 108 g kg^{-1} at a dose of 200 kg of N per hectare.

Brachiaria brizantha had statistically higher phosphorus content in shoot dry matter than brachiaria decumbens, but for animal nutrition this effect should be of little bromatological importance, as the percentage difference in phosphorus content between the two species is only 3.7%. The statistical significance was probably due to the small coefficient of variation in P contents in shoot dry matter, only 1.75% (Table 3). For potassium, there was no species effect, and the average K content in the shoot dry matter of brachiaria was 32.02 g kg^{-1}. The average dry matter accumulation in brachiaria shoot dry matter was 5.64 t per hectare (Table 2). Thus, multiplying this value by K content resulted in 180 kg of potassium per hectare at 45 DAE. According to Oliveira et al. (2021), brachiaria are plants that absorb large amounts of potassium from the soil. For a comparative example, Oliveira et al. (2021) found in crops of hybrid corn variety

BM3066 with average forage production of 59.5 t of natural matter (about 20 t of dry matter ha^{-1}) an average potassium accumulation of 195 kg ha^{-1}.

Brachiaria decumbens had higher calcium, magnesium and sulfur contents than brachiaria brizantha. On average, the sulfur contents in shoot dry matter of brachiaria decumbens were about 30% higher than those of brachiaria brizantha. Sulfur greatly influences nitrogen metabolism and protein synthesis, as these nutrients have joint action on various metabolic routes. The common point of the metabolic routes of nitrogen and sulfur assimilation is the incorporation of sulfide in O-acetylserine by OAS-thiol-lyase in the formation of cysteine. In addition to cysteine, sulfur is also a constituent of cystine and methionine (MALAVOLTA et al., 1997; DE BONA, 2008; OLIVEIRA et al., 2018).

The nitrogen: sulfur (N:S) ratio has been used as a reference to evaluate whether the amount of sulfur in cattle diet is adequate. Thus, for the efficient use of food by cattle, the N:S ratio should be between 12:1 and 14:1. Fodder with smaller relationships can have an impact on improved nitrogen utilization, reducing ammonia levels in the rumen and increasing nitrogen retention. However, it is desirable that the S content in forage does not exceed 4.0 g kg^{-1} (RODRIGUES et al., 1998; DE BONA, 2008). The N:S ratios of brachiaria brizantha and brachiaria decumbens, calculated from the values mentioned in Table 3, were 5.73 and 4.58, respectively, without exceeding the value of 4.0 g kg^{-1}. Thus, both brachiaria brizantha and brachiaria decumbens, sulfur content and n:s ratio would be suitable for good ruminal fermentation.

4 CONCLUSION

In the conditions in which this study was conducted, both brachiaria species showed high growth rates. However, shoot dry matter accumulation in brachiaria decumbens was approximately 25% higher than brachiaria brizantha. Yet, there was no species effect on the percentage allocation of dry matter and about 50% of it was allocated in the leaves.

There was no difference in crude protein contents in the shoots of the brachiaria species, and we found an average value of 106 g kg^{-1}, enough to ensure good ruminal fermentation.

Brachiaria decumbens had higher calcium, magnesium and sulfur contents than brachiaria brizantha, although contents of these three nutrients were considered adequate in brachiaria brizantha.

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