STRUCTURAL AND PRODUCTIVE FEATURES OF *Panicum* CULTIVARS SUBMITTED TO DIFFERENT REST PERIODS IN THE IRRIGATED SEMIARID REGION OF BRAZIL

CARACTERÍSTICAS ESTRUTURAIS E PRODUTIVAS EM CULTIVARES DE Panicum SUBMETIDAS A INTERVALOS DE CORTE SOB IRRIGAÇÃO NO SEMIÁRIDO

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ABSTRACT: The objective of this study was to evaluate the structural and productive features of *Panicum maximum* cultivars (Tanzânia, Mombaça, Massai, and Zuri) in three rest periods (30, 45 and 60 days), in the semiarid region of Brazil. The experiment was carried out in a completely randomized design with three replicates. The length of the leaf blade and the diameter of the stem increased as a function of the cut intervals. Leaf blade width and number of live leaves (3.86 leaves tiller^{-1}) were not affected by cut intervals. The height of the canopy increased with the ages, with effect in the mass of forage, being the cv. Zuri the most productive with 148,75 cm e 18.297,49 kg ha^{-1} DM at 60 days. The highest masses of leaves and stems were obtained in the longest rest period, while the leaf/stem ratio decreased. In the cut-off interval of 45 days, the cultivars of *Panicum maximum* have shown satisfactory yield, and the smaller cut interval provides a reduction in canopy height and stem thickness.

KEYWORDS: Accumulation rate. Forage mass. Morphological composition.

INTRODUCTION

Pastures, the food base of beef and milk cattle, are of great importance for Brazilian cattle growth, since it has made the country the main meat exporter in the world (VALLE et al., 2009), where more than 83% of slaughter cattle are bred on pasture (FERRAZ; FELÍCIO, 2010). Despite the importance of forage plants, it is estimated that more than 70% of cultivated pastures are at some stage of degradation (MACEDO et al., 2014), and inadequate management of grazing is one of the leading causes of this process (DIAS-FILHO, 2011).

The practice of defoliation requires adequate monitoring through grazing management to ensure an optimal balance between growth, senescence and consumption processes, to allow high-quality forage production and pasture persistence (SILVA, 2004). The equilibrium of the defoliation can be adjusted using combinations between interval and intensity (SANTOS et al., 2010a). According to Lara et al. (2012), in spite of the growing number of studies that use light canopy interception as a criterion for grazing management, for modeling purposes and/or growth potential and morphological composition dynamics, the traditional methods based on fixed periods of rest are valuable in the construction of databases for a given environment. As using the methods based on fixed rest periods, the differences in growth potential and morphological composition dynamics can be attributed to the evaluated treatments.

Among the forage crops, the *Panicum* genus has been outstanding for use in irrigated areas (VOLTOLINI et al., 2011), since they are widely known for their productivity, quality and adaptation to different soil and climatic conditions. It is considered the most productive species among tropical forage propagated by seeds and has been widely used for its abundant production of long leaves, high growth form, and high acceptability by the animals (JANK et al., 2010). However, there is a lack of information in the literature on the grazing

Received: 15/03/18
Accepted: 05/10/18

http://dx.doi.org/10.14393/BJ-v35n3a2019-36402

management of these grasses in the semiarid environment.

In this context, we aimed to evaluate the effect of the rest periods on the structural and productive features in cultivars of *Panicum maximum* in the semiarid environment, and under irrigation.

MATERIAL AND METHODS

The experiment was performed between August/2016 and June/2017 in the agronomic field of the Agricultural Sciences Campus, of the Federal University of the São Francisco Valley, located in the municipality of Petrolina-PE (09º 19' 24" South and 40º 33' 34" West, at an altitude of 391 m (1282,81 ft)). The climate, according to the Köppen classification, is of BSh type, with an average annual temperature of 26ºC (78,8ºF) and average annual precipitation of 435 mm (14,709.1 oz). Precipitation and temperature data (Figure 1) were collected at a meteorological station located 50 m from the experimental area.

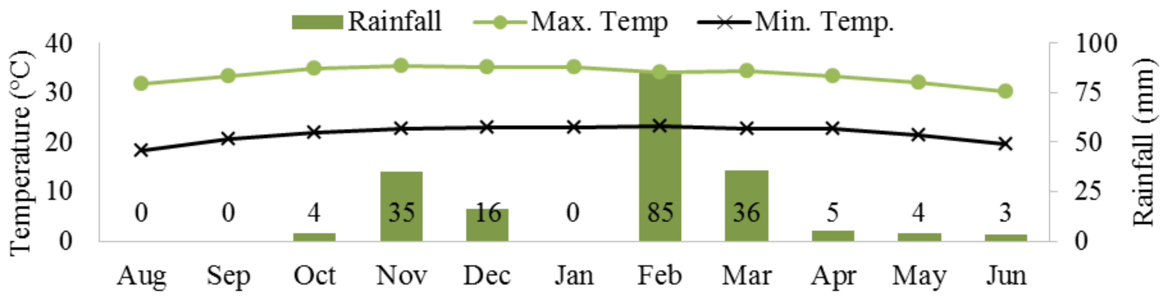

Figure 1. Rainfall, maximum and minimum temperatures from August 2016 to June 2017.

The soil in the area was classified as Yellow Argissoil, with medium/sandy texture (EMBRAPA, 2006). Before the beginning of the experiment, soil samples were collected in the 0-20 cm layer and submitted for chemical analysis (Table 1). There was no need for acidity and fertility correction; only fertilization was performed in the cover, applying 150 kg/ha/year of N, in the form of urea, which was divided into three applications, one every two cycles of evaluation.

Table 1. Soil chemical characteristics in the 0-20 cm layer.

pH	P (mg dm^{-3})	Ca	Mg	K	Na	H+Al	Al	CEC	BS (%)
		- - - - - - - - - - - -	- - - - - -	- - - - - -	cmol$_c$ dm^{-3}	- - - - - -	- - - - - -		
5.7	20.22	1.5	0.8	0.36	2.17	1.16	0.0	5.98	81

CEC: cation exchange capacity; BS: Base saturation

The experimental design was completely randomized, with a scheme of measures repeated in the time (cuts), being the treatments four cultivars of *Panicum maximum* Jacq. (Tanzânia, Mombaça, Massai and Zuri) submitted to three cut intervals based on fixed rest periods (30, 45 and 60 days). The cut intensity for all treatments was 25 cm of the height of the residue, as recommended by Difante et al. (2010). The experimental area used was 30 m², subdivided into 12 experimental units of 2.5 m² (2.5 x 1.0 m), three for each cultivar (replicates).

The cultivars were established in September 2015. Before the beginning of the experiment, the plants were managed with 30-day cut intervals, and the area weed-free was maintained through manual weeding. Irrigation was done daily by a micro-sprinkler system (3 h day^{-1}), using two micro-sprinklers per plot, with a flow rate of 50 L h^{-1} each. Before the beginning of the evaluations, a standardization cut in the plants was performed at a height of 25 cm of the level of the ground in all the experimental units. Excluding the standardization cut, the cuts performed for each interval were at 30, 45 and 60 days.

Before each cut, the height of the canopy was measured with a rod, graduated in centimeters, at three representative points of each plot. Canopy height was considered from the ground level to the average curvature of the leaves. The plants were then cut to 25 cm from the soil and taken to the laboratory where the fresh mass was determined. Soon afterward, subsamples were collected and separated manually in leaf blades and stems (stem + sheath). These samples were conditioned separately in paper bags, weighed and placed in a greenhouse with forced air circulation, at 55ºC for 72 hours, in order to determine the dry matter (DM) content and to estimate the forage mass and of each of the components morphological (kg ha^{-1} DM). From this, the mass of leaf blades and stems were calculated, and the leaf blade/stem ratio was determined by the ratio between the dry mass of leaves and the dry mass of stems. The morphological components accumulation rates were determined by the ratio between the mass of each component, and the rest period, expressed as kg ha day^{-1} DM.

The evaluation of the structural features was performed by three representative tillers, from other subsamples. In these, the length and width of the leaf blade, stem diameter, and the number of live leaves were measured. The dimensions of the leaf blade were measured in the last expanded leaf of the tiller, with the aid of a digital caliper. The length of the leaf blade was given by the distance between the leaf tip and its ligule. The width of the leaf blade was measured in the central part of the leaf and the diameter of the stem was obtained in the middle of this organ. The number of live leaves consisted of the number of expanding and expanded leaves of each tiller, disregarding the leaves that had more than 50% of the senescent leaf blade, being classified as dead.

Data were submitted to analysis of variance and the means of the treatments and the effect of the interaction compared by the Tukey test to 5% of significance, through the statistical program SISVAR 5.6 (FERREIRA, 2011). The following statistical model was used: Yijk = μ + Ci + αij + Fk + (CF) ij + βijk, where: Yijk = value observed in cultivar i, interval k, repetition j; μ = general mean effect; Ci = effect of cultivar i (Tanzânia, Mombaça, Massai and Zuri); αij = effect of the random error attributed to the plot; Fk = effect of cut interval k (30, 45 and 60 days); (CF) ij = effect of interaction between cultivar i and interval k; βijk = random error attributed to the sub-plot.

RESULTS AND DISCUSSION

The interaction between rest periods and cultivars was not significant (P> 0.05) for leaf blade length and width, stem diameter and number of live leaves. When comparing the cultivars, we observed a significant difference (P <0.05) for leaf blade length, leaf blade width and stem diameter. Cvs. Mombaça, Tanzânia, and Zuri presented values similar to each other and higher than cv. Massai. This latter cultivar obtained the lowest values for these parameters (Table 2). These results are related to the features inherent to each cultivar. Some of them have thicker stems, larger leaves, and larger ones, as in the case of Tanzânia, Mombaça, and Zuri, while others are smaller, presenting thinner stems and narrower leaves, such as Massai (JANK et al., 2010).

Table 2. Structural features of *Panicum maximum* cultivars submitted to rest periods.

Variable	Massai	Mombaça	Tanzânia	Zuri	SEM
Length of leaf blade (cm)	57.45b	97.61a	86.06a	93.24a	4.35
Width of leaf blade (cm)	1.08b	3.64a	3.42a	3.34a	0.08
Diameter of the stem (cm)	0.32b	0.93a	0.94a	1.02a	0.03
Number of live leave (leave $tiller^{-1}$)	3.53a	3.93a	3.90a	4.13a	0.16

SEM, Standard error mean. Averages followed by distinct letters on the line differ from one another by the Tukey test (P<0.05).

Gomes et al. (2011), evaluating 23 genotypes of *P. maximum*, found much lower values than those of the present study for length (54.56, 68.26 and 48.97 cm) and leaf blade width (0.84, 2.12 and 1.78 cm) in the cultivars Massai, Mombaça and Tanzânia, respectively. These lower values can be due to the absence of cover fertilization, variation in rainfall and lower cut interval adopted by the authors.

Working with Zuri grass under salinity and irrigation slides, Camilo (2017) found maximum values of 62.68 and 3.04 cm for leaf length and width, respectively, under high water availability (120% of evapotranspiration). This lower length observed by the author may be associated with the height (10 cm of the soil) and frequency of cut (28 days) adopted, which resulted in a lower sprout capacity and, consequently, lower leaf growth. According to Gomide et al. (2002), the residual leaf area after cutting or grazing plays a fundamental role in promoting new growth, as it influences the photosynthetic capacity and speed of recovery of pasture.

The number of live leaves (NLL) was not affected by any of the sources of variation (P> 0.05), with a mean of 3.86 leaves $tiller^{-1}$ (Tables 2 and 3). The absence of a cut-off effect may be due to the low variations in climatic conditions throughout the experiment, which may have been insufficient to modify this variable. Fagundes et al. (2006), evaluating morphogenetic and structural features of tropical pastures, reported that variations in the number of live leaves occurred due to changes in environmental conditions when they observed higher values during rainy season for this parameter.

Santos et al. (2011) also did not verify plant height effects on the number of live leaves in *B. decumbens* cv. Basilisk. The authors suggest that these results are due, in part, to the phenotypic plasticity of the grass, which allows the alteration of its morphogenesis to maintain a stable number of leaves alive. The values obtained in the present study for the number of live leaves are similar to those found by Gomide and Gomide (2000) for cvs. Tanzânia and Mombaça (3.5 leave tiller^{-1}), by Luna et al. (2014) for cv. Massai (4.11 leave tiller^{-1}) and by Camilo (2017) to the Zuri grass (3.4 leave tiller^{-1}).

The leaf length was affected by the cut intervals (P <0.05), with an increase in length as the cut interval increased, with the highest values obtained at 45 and 60 days of rest (Table 3). This result can be due to the longer shoots observed in the plants harvested at larger intervals have longer shoots. According to Casagrande et al. (2010), the length of the stem has a direct influence on the growth of the leaf, since it determines the space to be covered by it for its emergence and expansion.

Table 3. Effect of rest period on the structural characteristics of *Panicum maximum* cultivars.

Variable	30	45	60	SEM
Length of leaf blade (cm)	70.51b	91.34a	92.80a	3.97
Width of leaf blade (cm)	2.91a	2.82a	2.86a	0.08
Diameter of the stem (cm)	0.70c	0.81b	1.00a	0.03
Number of live leave (leave tiller^{-1})	3.87a	3.75a	3.94a	0.15

SEM, Standard error mean. Averages followed by distinct letters on the line differ from one another by the Tukey test (P<0.05).

The leaf blade width was not influenced by the cut intervals (P> 0.05), with a mean of 2.86 cm. According to Silva et al. (2010), leaf length and width are related to leaf area index (LAI), which indicates the ability of the canopy to intercept sunlight for photosynthesis and generate energy for plant maintenance and growth. In this way, these variables are determinant for obtaining higher dry matter yields (COSTA et al., 2009), since larger leaf blades have a more considerable amount of tissue, which contributes to the higher total forage mass (SANTOS et al., 2010b).

The stem diameter varied according to the cut intervals (P <0.05), with a lower value at 35 days and greater at 60 days of rest (Table 3). Castagnara et al. (2011), evaluating the structural features of tropical grasses under nitrogen fertilization, found an average value of 1.17 cm in diameter at 42 days of rest in *Panicum maximum* cultivars, greater than the results observed even at 60 days. According to the authors, the development of the stem occurs as a consequence of the growth of the canopy, in order to give the plant greater sustentation.

The effect of the interaction between cultivars and cut intervals was significant (P <0.05) for canopy height and forage mass. In all cultivars, a positive correlation was observed between canopy height and cut intervals, with the highest values at 60 days of rest (Table 4). This result was expectable since plants submitted to more extended rest periods have their heights increased. The cvs which obtained the highest heights were Zuri and Tanzânia at 30 days, and cvs. Zuri, Tanzânia, and Mombaça at 45 days compared to the Massai grass, which presented the lowest values for this parameter at all intervals. At 60 days of rest, Zuri grass had the highest height (148.75 cm).

Table 4. Height of forage canopy and forage mass in *Panicum maximum* cultivars submitted to rest periods.

Rest period (day)	Massai	Mombaça	Tanzânia	Zuri
		Canopy height (cm) (SEM = 2.02)		
30	57.33Bc	67.38Abc	74.17Ac	77.56Ac
45	76.67Bb	109.17Ab	98.67Ab	105.50Ab
60	102.17Ca	143.00Aba	130.58Ba	148.75Aa
		Forage Mass (kg ha^{-1} DM) (SEM = 944.28)		
30	2653.48Ab	2618.05Ab	3163.39Ab	5613.30Ab
45	6186.87Aab	5776.78Ab	6250.86Ab	10026.06Ab
60	8687.24Ba	10273.48Ba	11736.09Ba	18297.49Aa

SEM, Standard error mean. Averages followed by distinct letters on the line differ from one another by the Tukey test (P<0.05).

These results suggest that pastures harvested at intervals of 45 and 60 days showed greater interception of light (IL) than recommended (95% IL), corresponding to pre-grazing heights: 70 cm for Tanzânia grass (BARBOSA et al., 2007), 90 cm for the Mombaça grass (CARNEVALLI et al., 2006), 55 cm for the Massai grass (BARBOSA et al., 2010) and 70 to 75 cm for Zuri grass (EMBRAPA, 2014). Light interception is challenging to assess, but its correspondence with pasture height allows this parameter to be used in practical conditions to guide grazing management. Thus, the shorter cut interval (30 days) provided a reduction in the canopy height, besides the possibility of using the pasture in a higher number of grazing cycles.

The highest yields of forage mass were obtained at 60 days in comparison to the other cut intervals (P <0.05). Among the cultivars, there was a significant difference (P <0.05) only in the 60 days interval, when cv. Zuri was more productive (18,297.49 kg ha^{-1} DM) than the others (Table 4). We confirmed that the forage mass behaved in a similar form as observed for the canopy height, showing an increasing effect with the development of the plant, which provided greater forage accumulation with the increase of the cut interval. Stabile et al. (2010), when evaluating cvs. Massai, Mombaça, and Tanzânia observed lower values for dry matter production at 60 days of growth (7067, 4432 and 3734 kg ha^{-1} DM, respectively). The use of irrigation and cover fertilization carried out in this work can explain these results, contributing to higher yields.

The interaction between cut intervals and cultivars was significant (P <0.05) for the masses of the morphological components, as well as for the leaf/stem ratio (Table 5).

Table 5. Morphological composition and leaf blade/stem ratio in *Panicum maximum* cultivars submitted to rest periods.

Rest period (day)	Massai	Mombaça	Tanzânia	Zuri
	Leaf blade mass (kg ha^{-1} DM) (SEM = 635.47)			
30	1554.53Ba	1972.58ABb	2291.79ABb	4129.31Ab
45	4319.32Aa	4058.82Aab	4338.91Aab	6804.71Aab
60	3000.66Ba	5217.43ABa	7096.00Aa	8091.99Aa
	Stem mass (kg ha^{-1} DM) (SEM = 480.73)			
30	1098.95Ab	645.47Aa	871.60Ab	1483.99Ab
45	1867.55Ab	1717.97Aa	1911.95Ab	3221.35Ab
60	5686.59Ba	5056.04Ba	4640.09Ba	10205.49Aa
	Relation leaf blade/stem (SEM = 0.22)			
30	1.72Ba	2.70Aa	2.39ABa	2.57ABa
45	2.09Aa	2.17Aab	2.10Aa	2.02Aa
60	0.59Ab	1.18Ab	1.48Aa	0.79Ab

SEM, Standard error mean. Averages followed by distinct letters, upper case in the row and lowercase in the column, differ by Tukey test (P <0.05).

In general, the values observed for the masses of the morphological components (leaf blade and stem) were similar to those obtained for the forage mass, increasing with the extension of the cut interval (Table 5). At 30 days, the leaf blade mass was higher for cv. Zuri when compared to the Massai grass (P <0.05). There was no difference between cultivars for this parameter at 45 days (P> 0.05). On the other hand, within 60 days, cvs. Tanzânia and Zuri were more productive (P <0.05) than the Massai grass.

The stem mass did not differ (P> 0.05) between the cultivars in the intervals of 30 and 45 days. However, at 60 days of rest, the stem mass was higher (P <0.05) for Zuri grass, when compared to the other cultivars. This difference indicates that, after 45 days, the Zuri grass continues to grow intensely, producing more stem than leaves.

Barbosa et al. (2007), working with Tanzânia grass in Mato Grosso do Sul, found, for the same height of residue (25 cm of soil), leaf blades masses of 9,000 and 10,560 kg ha^{-1} DM, respectively, for canopies with 90 and 95% of interception of light, values that are well superior to those of the present work. These results can be due to the higher nitrogen dose used by the authors (200 kg ha^{-1} N), which may have led to the more significant development of pasture.

The leaf/stem ratio decreased as increasing the cutting age (P <0.05). The highest values for the leaf/stem ratio were obtained in the intervals of 30 and 45 days in all the cultivars, except for the Tanzânia grass, which presented no difference for this parameter as a function of the cut intervals. There was no significant difference (P> 0.05) between the cultivars for this characteristic at 45 and 60 days of age. On the other hand, within 30 days, cv. Mombaça obtained the highest value (P <0.05) for the blade/stem ratio when compared to the cv. Massai.

We considered these results satisfactory: the leaf blade ratio was, on average, twice as high as the stem, exceeding the threshold considered critical for this relationship (1.0). Only cvs. Massai and Zuri presented values below the critical level (at 60 days). According to Brâncio et al. (2003), leaf blade ratio lower than the critical values causes a reduction in quantity and quality of the forage produced, being able to negatively influence the structure of the pasture and the efficiency of the grazing animals.

We observed the higher rate of leaves blade accumulation (LBAR) in the cv. Zuri at 30 and 45 days of the aftermath. At 60 days of aftermath, cv. Massai displayed a lower rate than cvs. Zuri and Tanzânia (Table 6). All cvs., except Tanzânia, displayed lower LBAR at 60 days than at 45. These results highlight that from the 45 days of the aftermath on; the pasture already reached the maximum number of living leaves per tiller, and the equilibrium between the appearance and senescence of the leaves (SIMIONI et al., 2014). At this point, the aftermath period shall be interrupted by defoliation or cut, in order to avoid the excessive accumulation of stem and senescent material in the canopy (CUTRIM JUNIOR et al., 2011). The resemblance between the LBAR of the cv Massai at 60 days with 33.4 kg ha day^{-1} DM described by Emerenciano Neto et al. (2017) in grazing lands of this cultivar harvested by sheep with a 86 days interval confirms the equilibrium between the apparence and senescence of the leaves described previously.

Table 6. Morphological components accumulation rate in *Panicum maximum* cultivars submitted to rest periods.

Rest period (day)	Massai	Mombaça	Tanzânia	Zuri
	Leaf blade accumulation rate (kg ha day^{-1} DM) (SEM = 8.82)			
30	51,82Bb	65,75Bab	76.39Ba	137.64Aa
45	95,98Ba	90.19Ba	96.42Ba	151.21Aa
60	34,29Bb	48.65ABb	62.45Aa	70.27Ab
	Stem accumulation rate (kg ha day^{-1} DM) (SEM = 6.08)			
30	36.63ABb	21.51Bb	29.05ABb	49.46Ab
45	41.50Aab	38.18Aa	42.48Aa	71.58Aab
60	68.82ABa	47.63Ba	41.73Ba	96.83Aa

SEM, Standard error mean Averages followed by distinct letters, upper case in the row and lowercase in the column, differ by Tukey test (P <0.05).

At the 45th day of the aftermath we could not observe any difference among the different cvs. as refers to the stem accumulation rate (SAR). At the other intervals, the SAR of the cv. Zuri was higher than cv. Mombaça. We observed the highest SAR at 60 days of aftermath, as compared to 45 days aftermath interval. This result is associated with the height of the canopy (Table 4), as the is the structural component of the plant, and its growth depends on the growth of the plant itself.

The results obtained in this study suggest that the cutting or grazing of these cultivars should be done with shorter rest periods (30 or 45 days), providing greater leaf accumulation and less accumulation of stem and dead material, which, according to Difante et al. (2010), impair the nutritional quality of forage and make it difficult to apprehend animals grazing.

CONCLUSIONS

The cultivars of *Panicum* studied in this paper displayed adequated production rates in the irrigated semiarid region as harvested at intervals of up to 45 days. At these rest periods, the forage displayed high production of leaves blades.

Among the cultivars studied, cv. Zuri shall be highlighted for its higher productivity. For this reason, its use shall be suggested in intensive production systems, which require a higher mass of forage to sustain animal productivity.

RESUMO: Objetivou-se avaliar as características estruturais e produtivas de cultivares de *Panicum maximum* (Tanzânia, Mombaça, Massai e Zuri) em periodos de descanso (30, 45 e 60 dias) no semiárido brasileiro, sob irrigação. O experimento foi realizado em delineamento inteiramente ao acaso, com três repetições. O comprimento da lâmina foliar e o diâmetro do colmo aumentaram em função dos intervalos de corte. A largura da lâmina foliar e o número de folhas vivas (3,86 folhas/perfilho) não foram afetados pelos intervalos de corte. A altura do dossel aumentou com as idades, com efeito na massa de forragem, sendo a cv. Zuri superior com 148,75 cm e 18.297,49 kg/ha de MS, aos 60 dias. As maiores massas de lâminas e colmos foram obtidas no maior período de rebrotação, enquanto que a relação folha/colmo diminuiu. No intervalo de corte de 45 dias, as cultivares de *Panicum maximum* apresentaram produção satisfatória, sendo que o menor intervalo de corte proporciona redução na altura do dossel e na espessura do colmo.

PALAVRAS-CHAVE: Composição morfológica. Massa de forragem. Taxa de acúmulo.

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