Rev. Bras. Saúde Prod. Anim., Salvador, v.23, 01 - 18, e202220200062, 2022
http://dx.doi.org/10.1590/S1519-9940202220200062

Forestry and Grassland
Received on: 17/12/2020
Accepted on: 27/07/2021

Gas exchanges, chemical composition and productive characteristics of tropical grasses deferred I: cultivars BRS Massai and BRS Tamani

Trocas gasosas, características produtivas e composição química de gramíneas tropicais diferidas I: cultivares BRS Massai e BRS Tamani

FONTINELE, Renato Gomes[1]
https://orcid.org/0000-0003-0251-9220

ARAÚJO, Ricardo Alves de[2]*(in memoriam)*
https://orcid.org/0000-0001-9696-5680

CÂNDIDO, Magno José Duarte[1]
https://orcid.org/0000-0003-3573-6053

ROGÉRIO, Marcos Cláudio Pinheiro[4]
https://orcid.org/ 0000-0003-3567-5211

COSTA, Clésio dos Santos[1]
https://orcid.org/0000-0003-0451-7157

SOUZA, Henrique Antunes de[4]
https://orcid.org/0000-0002-2209-4285

FURTADO, Rafael Nogueira[5]
https://orcid.org/0000-0002-4502-786X

POMPEU, Roberto Cláudio Fernandes Franco[3*]
https://orcid.org/0000-0002-4099-3575

[1] Universidade Federal do Ceará - UFC, Centro de Ciências Agrárias, Av. Mister Hull, 2977 - Bloco 808 - Campus do Pici - CEP 60356-000 - Fortaleza – CE, Brasil
[2] Universidade Estadual do Maranhão - UEMA, Tecnologia em Agronegócio R. Hernani Pereira, 458, CEP 65485-000, Itapecuru Mirim - MA, Brasil
[3] Pesquisadores, Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA, Centro Nacional de Pesquisa de Caprinos, Sobral, CE, Brasil
[4] Empresa Brasileira de Pesquisa Agropecuária - Embrapa Meio-Norte, Avenida Duque de Caxias, 5650 C.P 001 - Buenos Aires, Teresina - PI, 64008-780, Brasil
[5] Docente do Instituto Federal de Educação, Ciência e Tecnologia do Piauí - IFPI, Rodovia BR 407, KM 5, s/n - Lagoa dos Canudos, CEP 64750-000, Paulistana - PI, Brasil
*Corresponding author: roberto.pompeu@embrapa.br

ABSTRACT

This study aimed to evaluate the physiological parameters, the productive characteristics, structural and chemical composition of *Megathyrsus maximus (*syn. *Panicum maximum)* cultivars BRS Massai and BRS Tamani submitted to different periods of deferment and moments of use. The experimental design was randomized complete block design in a factorial scheme 2 x 2 x 3, being two grass cultivars (Massai grass and Tamani grass), two deferment periods (rainy season and dry-rainy transition) and three sealing times (40, 80 and 120 days). Both cultivars had higher leaf transpiration rate when used for 40 days of deferment (0.63 μmol/m^2/s). It was observed that the cultivar BRS Massai presented higher photosynthetic rate ($P<0.05$) to 40 days of deferment (1.10 μmol/m^2/s), higher rate of production and forage accumulation when used for 40 days. On another side, there was a greater efficiency in the use of water during the period of transition in the pastures sealed

Rev. Bras. Saúde Prod. Anim., Salvador, v.23, 01 - 18, e202220200062, 2022
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for 80 and 120 days (64.60 and 62.30 kg DM/ha/mm, respectively). A reduction ($P<0.05$) of total digestible nutrients (TDN) and crude protein (CP) was observed with the increase in pasture sealing time. In general, the deferment in the transition period allows the use of forage without greater productive and nutrient losses up to 80 days of sealing for the cultivar BRS Tamani and up to 40 days for BRS Massai.
Keywords: Forage accumulation, falling index, *Megathyrsus maximus*, photosynthetic rate

RESUMO

Objetivou-se avaliar os parâmetros fisiológicos, as características produtivas, estruturais e composição química de *Megathyrsus maximus* (syn. *Panicum maximum*) cultivares BRS Massai e BRS Tamani submetidas à diferentes períodos de diferimento e momentos de utilização. Utilizou-se o delineamento de blocos completos casualizados, em esquema fatorial 2 x 2 x 3, sendo duas cultivares de gramíneas (capim-massai e capim-tamani), dois períodos de diferimento (período chuvoso e transição chuvoso-seco) e três tempos de vedação (40, 80 e 120 dias). Ambas as cultivares tiveram maior taxa de transpiração foliar quando utilizadas aos 40 dias de diferimento (0,63 µmol/m^2/s). Observou-se que a cultivar BRS Massai apresentou a maior taxa fotossintética (1,10 µmol/m^2/s), taxa de produção e acúmulo de forragem quando utilizada aos 40 dias de diferimento ($P<0,05$). Por outo lado, houve maior eficiência no uso da água durante o período de transição nos pastos vedados por 80 e 120 dias (64,60 e 62,30 kg de MS/ha/mm, respectivamente). Observou-se redução ($P<0,05$) dos nutrientes digestíveis totais (NDT) e proteína bruta (PB) com o aumento no tempo de vedação das pastagens. De modo geral o diferimento no período de transição possibilita a utilização da forragem sem maiores perdas produtivas e nutritivas até os 80 dias de vedação para a cultivar BRS Tamani e até os 40 dias para a BRS Massai.
Palavras-chave: acúmulo de forragem, índice de tombamento, *Megathyrsus maximus*, taxa fotossintética

INTRODUCTION

Pastures are the basis for sustaining livestock activity in tropical regions. Despite the low cost of grazing production, this is strongly affected by the statehood of production, which limits the performance of herds in certain periods of the year, such as in the semiarid region of northeastern Brazil (ARAÚJO et al., 2017). In these regions, the maximum forage production, both in quantity and quality, occurs during the period in which the highest rainfall indices are concentrated, being reduced in the dry season, mainly due to drought (MARANHÃO et al., 2019).

Although the production and nutritive value of forage vary according to the seasons and the management technique adopted (CARDOSO et al., 2017), the feeding demand of grazing animals remains constant throughout the year. Thus, to obtain a stock of bulking that guarantees the feeding of the herd in the dry season, some strategies can be adopted, such as the use of silage, hay or deferment of the surplus forage accumulated in the rainy season. It is emphasized that the latter consists of excluding from grazing a certain area at the end of the forage plant growing season, thus enabling fodder to be accumulated to be used during the off-season (SANTOS et al., 2009).

The main difficulty of this technique is to combine high production with the quality of forage in deferred pastures. Because, in general, pastures deferred for a longer period produce more forage mass, but with higher percentages of stem, dead forage and reproductive byes, which causes lower nutritional value (SANTOS et al., 2010) and reduced grazing efficiency. On other hand, a short deferment period improves the nutritional value and grazing efficiency, due to the higher percentage of green leaves, lower plant tipping and a higher number of vegetative bystanders in the deferred pasture; however, it produces a smaller amount of forage (SANTOS et al., 2010), which may be insufficient for feeding the herd in the off-season.

As for forage, it is recommended that those with low accumulation of stems and high leaf blade production are recommended to maintain good nutritional value throughout the pasture sealing period (EUCLIDES et al, 2007). Besides, Martuscello et al. (2019) highlighted the forage quality of *Megathyrsus maximus* cultivars, due to the high dry matter production (DM) and adaptability to different climatic conditions, in addition to good acceptability by animals (ANDRADE et al., 2013). The cultivar BRS Tamani that was launched by the Brazilian Agricultural Research Company (EMBRAPA, 2015), for example, stands out for its low size, abundance of leaves productivity, vigor, nutritional value (high levels of crude protein and digestibility), resistance to pasture squeal and ease of management (EMBRAPA, 2015). These characteristics are interesting to the deferment technique, thus requiring studies comparing to other cultivars that are on the market for the longest time, such as BRS Massai.

In view of the above, the present study was conducted with the objective of evaluating the influence of two deferment periods, with three pasture sealing times on gas exchange, canopy structure, biomass components and chemical composition of cultivars BRS Massai and BRS Tamani in the climatic conditions of northeastern Brazil.

MATERIAL AND METHODS

The experiment was conducted in the municipality of Sobral, Ceará, Brazil, at Fazenda Três Lagoas (3°45'00.77" South and 40°20'38.55" West), belonging Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), in Centro de Pesquisa com Caprinos e Ovinos, from march to october 2016. The climate is BSh type, semi-arid hot, with rains between december and may. Rainfall, air humidity, average temperature, and wind speed data (Inmet, 2016) are shown in Figure 1.

ISSN 1519 9940

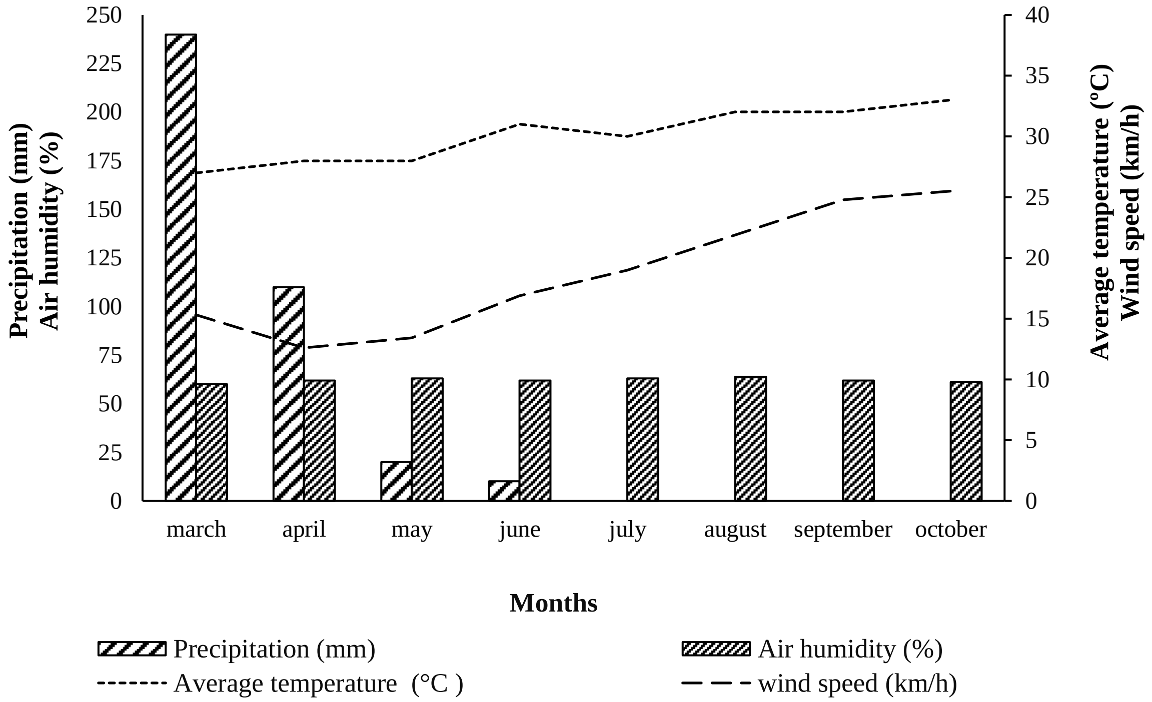

Figure 1. Precipitation, air humidity, average temperature, and wind speed during the trial period (March to October 2016)

The soil of the experimental area is classified as Chromic Luvissol (SANTOS et al., 2018). The tillage consisted of a plowing and two gradations. Before the implementation of the experiment, soil samples were collected to evaluate its fertility, which presented the following chemical characteristics: pH (in H_2O) = 6.75; Organic matter (g/dm^3) = 12.50; Phosphorus (mg/dm^3) = 21.5; Potassium (mg/dm^3) = 39; Calcium (mmolc/dm^3) = 44.50; Magnesium (mmolc/dm^3) = 28.50; H+Al (mmolc/dm^3) = 16; Aluminum (mmolc/dm^3) = 0; Sodium (mg/dm^3) = 101; Boron (mg/dm^3) = 0.21; Copper (mg/dm^3) = 1.30; Iron (mg/dm^3) = 30; Manganese (mg/dm^3) = 24.60; Zinc (mg/dm^3) = 2.35. After cleaning, the soil was fertilized with phosphorus (15 mg/dm^3) and potassium (10 mg/dm^3), base saturation = 48%.

Sowing was performed manually for both cultivars, using a viable pure seed rate equivalent to 6.0 kg/ha in grooves with 5 cm depth and spacing between rows of 40 cm. Fertilization was carried out with phosphorus, potassium, and micronutrients, with simple superphosphate (60 kg of P/ha), potassium chloride (20 kg of KCl/ha) and micronutrients (20 kg/ha of FTE BR-12) as sources of these nutrients. When soil moisture conditions were favorable, nitrogen fertilization (urea source) was applied in two doses. The first occurred ten days after seedling emergence and the second ten days after the first dose. After complete establishment (32 days after sowing), the plants were submitted to a uniformity cut, with a height of 35 cm above the soil surface, corresponding to a residual leaf area index (LAIr) equal to 2.0, determined with the aid of the PAR/LAI analyzer in agriculture

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DECAGON LP-80 (DECAGON Devices, Inc., Pullman, Washington-USA).

The experiment was conducted in a randomized block design, in a factorial scheme 2 × 2 × 3, of *Megathyrsus maximus* cultivars BRS Massai and BRS Tamani, in two periods of deferment (rainy season and transition) and three times of grassland sealing (40, 80 and 120 days), with four replications. Totaling 48 experimental plots of 20 m² each (5 × 4 m). For the conditioning of the treatments evaluated, two deferment periods were used, the first in the rainy season, where the pastures were managed undercut simulating a grazing, after 14 days of deferment, while the second deferment period, performed in the transition to drought, the pastures were used after 40 days of established. After the periods of use (rainy and transition period), the pastures were sealed to be evaluated at 40, 80 and 120 days after the date of pasture sealing (Figure 2).

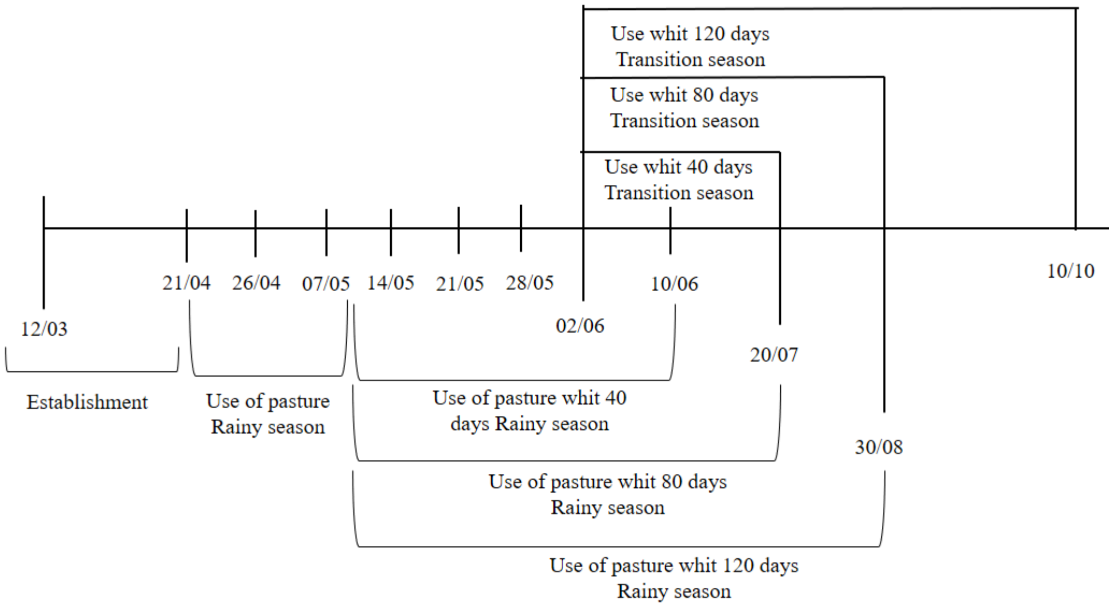

Figure 2. Chronological representation of the experiment

For gas exchange evaluations, the infrared CO_2 analyzer, IRGA model LCpro-SD (ADC Bioscientific Ltd. Hoddesdon, Hertfordshire, UK), was used, where at the time of each use after the pasture seal, newly expanded leaves of six tillers were chosen in each experimental unit. The measurements were performed in the median part of the last expanded leaf, always at the times of 9:00 a.m. to 11:00 a.m. The variables, leaf temperature (°C), internal leaf CO_2 concentration (ppm), leaf transpiration rate (mol/m^2/s) and leaf photosynthesis rate (mol/m^2/s) were analyzed. The relative chlorophyll index (Unid. SPAD), was measured with the aid of chlorophyll meter (Chlorophyll Meter-SPAD-502) for indirect measurement of chlorophyll content in newly expanded leaves.

Gravimetric indices were determined for stem elongation, leaf blade and leaf blade senescence. Therefore, at the end

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of each period, approximately 10 tillers per sampling unit were collected, taking them to the laboratory and parting them into stems, expanded leaf blades and emerging leaf blades. Each of these fractions had its total length recorded, being then submitted to drying in a forced ventilation oven at 55 °C for 72 hours and weighed, obtaining the weight index per unit length of the emerging leaf blade (α1), expanded leaf blade (α2) and stems (β). Thus, the rate of production and accumulation of forage was estimated during the growth period, from the elongation rate, and leaf blade senescence, and the rate of stem elongation and the population density, according to the following equations, adapted from Davies (1993): FPR = [(LBER x α1) + (SER x β)] x PDT; FARn = [(LBER x α1) + (SER x β) – (LBSR x α2)] x PDT. where: FPR: Forage production rate (kg dm/ha/day); LBER: Leaf blade elongation rate (cm/tiller/day); α1: Weight index/unit length of emergent leaf blade (g/cm); SER: Stem elongation rate (cm/tiller/day); β: Weight index per unit of stem length (g/cm); PDT: Population density of tillers (tillers/m²); FARn: Net forage accumulation rate (kg/ha/day); LBSR: Leaf blade senescence rate (cm/day); α2: Weight index/unit length of expanded leaf blade (g/cm).

At the time of each use after deferment, the samples were randomly collected in 0.50 x 0.50 m frames, with manual cuts at ground level. The samples were weighed and separated into leaf blades, stems (stems + sheaths) and senescent material. After fractionation, the samples were placed in a forced air ventilation oven, regulated to 55 ºC, for 72 hours and weighed. The biomass of the components was used to calculate the percentage of leaf blades, stems and senescent material. The sum of biomass of the different morphological components was used to determine the total forage biomass (kg of DM/ha), dead forage biomass (kg DM/ha), leaf blade/stem. The efficiency of water use (kg DM/mm) was estimated by dividing the total forage biomass by the amount of accumulated precipitation (mm) during the sealing period of each deferment.

Canopy height was determined by measuring eight points in each experimental plot, with the aid of a graduated ruler and taking as criterion the distance between the part of the plant located highest in the canopy and the soil level. The tipping index was obtained by dividing the height of the extended plant and the height of the non-extended canopy. The population density of tillers was determined by counting the number of tillers that contained inside the frame.

After pre-drying, the samples of morphological fractions were crushed in knife mills (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA) with a 1.0 mm sieve. In the ground samples, the levels of DM (method no. 934.01) and CP (method no. 954.01) were determined according to AOAC (2003). For neutral detergent fiber (NDF) analyses, the samples were treated with thermostable alpha-amylase, without the use of sodium sulphite and corrected for residual ash (MERTENS, 2002), which was analyzed according to Van Soest et al. (1991). The TDN content was calculated using the equation proposed by Capelle et al. (2001).

Statistical analyses were performed using the MIXED procedure of the SAS® (EdSAS Inst. Inc., Cary, NC, USA, 2015). The data were submitted to

ISSN 1519 9940

Rev. Bras. Saúde Prod. Anim., Salvador, v.23, 01 - 18, e202220200062, 2022
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normality (Shapiro-Wilks) and homoscedasticity tests (Levene) and, after the assumptions, were submitted to analysis of variance by F test. The analyses were performed from the following model: Yijkm = μ + ∝i + βj + γk + (αβγ)ijk + δm + eijkm. Where Yijkm is the dependent variable corresponding to the experimental observation; μ is the general average; αi is the fixed effect of cultivars; βj is the fixed effect of the deferment period; γk is the fixed effect of the moment of use; (αβγ)ij is the interaction effect between cultivar, period, and time of use; δm is the random block effect; and eijk is the random error, assuming a normal distribution. The interaction between the factors was deployed only when significant to 5% probability. To evaluate the effects of each factor, the means were compared by the Tukey test, at 5% probability.

RESULTS

Interaction (P<0.05) was observed between the deferment periods and time of use for the gas exchange of the grasses (Table 1). It was observed that, within the rainy season, the grasses had a higher rate of leaf transpiration when used at 40 days of deferment (0.63 μmol/m^2/s). On the other hand, when comparing with the transition time, the grasses reduced leaf transpiration rate by 0.24 mol/m^2/s for the same time of use. During the rainy season, the internal CO_2 concentration was higher in grasses with longer sealing time, 80 and 120 days, with an average of 375.35 ppm of CO_2. On the other hand, in the transition period the concentration increased at 80 days, but at 120 days of use no CO_2 concentration was detected in the plants.

Table 1. Unfolding of interaction between deferment periods and moments of use on gas exchange, leaf temperature and relative chlorophyll index of cultivars BRS Tamani and BRS Massai

Deferment periods	Moments of use (days) 40	80	120	SEM[1]
	Leaf transpiration rate (μmol/m^2/s)			
Rainy	0.63Aa	0.38Ab	0.38Ab	0.05
Transition	0.39Ba	0.43Aa	0.41Aa	
	Internal CO_2 concentration (ppm)			
Rainy	224.40Bb	365.30Aa	385.40a	2.50
Transition	305.20Ab	387.10Aa	0.00	
	Leaf temperature (°C)			
Rainy	37.25Ba	36.25Ba	36.45Aa	2.00
Transition	38.10Aa	37.65Aa	37.50Aa	
	Relative Chlorophyll index (SPAD unit)			
Rainy	25.00Aa	22.00Ab	16.00Ac	0.80
Transition	20.00Aa	10.00Bb	8.00Bb	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

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Regarding leaf temperature, there was no effect (P>0.05) of the moments of use within each season, but when comparing the periods, the periods observed higher leaf temperature in the transition period, at 40 and 80 days of use. While the relative chlorophyll index decreased with the increase in time of use, presenting lower value (16 SPAD unit) at 120 days during the rainy season, while in the transition period the lowest index was observed at 80 and 120 days, with an average value of 9 SPAD unit. When comparing both periods, they observed a higher chlorophyll index in deferred pastures at 80 and 120 days (22.00 and 16.00 SPAD unit, respectively) in the rainy season.

The higher rate of leaf transpiration and, as well as the lower internal concentration of CO_2 recorded in the pasture used after 40 days of sealing during the rainy season are related to intense photosynthetic capacity of these plants.

Interaction (P<0.05) was observed between both factors (Table 2) on photosynthesis rate and internal CO_2 concentration. The cultivar BRS Massai presented the highest photosynthetic rate at 40 days of deferment (1.10 μmol/m^2/s), with the increase in the sealing time of the pastures to 80 and 120 days, there was a reduction in the photosynthesis rate 0.40 and 0.16 mol/m^2/s. On the other hand, for the cultivar BRS Tamani, only at 120 days of deferment there was a reduction in the photosynthetic rate (0.05 μmol/m^2/s). While the internal CO_2 concentration differed (P<0.05) between both cultivars only the deferment after 40 days, with lower CO_2 concentration for the cultivar BRS Massai compared to BRS Tamani. It is also noteworthy that in both the CO_2 concentration was higher at 80 days of deferment, with values of 385.30 and 367.10 ppm for Tamani and Massai, respectively.

Table 2. Unfolding of interaction between cultivars and moments of use on gas exchange of cultivars BRS Tamani and BRS Massai

Cultivars	Moments of use (days)			SEM[1]
	40	80	120	
	Photosynthesis rate (μmol/m^2/s)			
BRS Tamani	0.26Ba	0.22Aa	0.05Ab	0.08
BRS Massai	1.10Aa	0.40Ab	0.16Ac	
	Internal CO_2 concentration (ppm)			
BRS Tamani	322.50Ab	385.30Aa	194.00Ac	2.50
BRS Massai	207.20Bb	367.10Aa	191.50Ac	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

Regarding the photosynthetic rate, it was observed that the reduction was less abrupt in the cultivar BRS Tamani, over time, because the reduction of photosynthetic capacity only occurred in the deferred pasture at 120 days, reaching low values (0.05 μmol/m^2/s). On the other hand, the cultivar BRS Massai, even with a higher photosynthetic rate, decreased 0.70 μmol/m^2/s when the deferment was increased to 80 days.

There was interaction (P<0.05) between cultivars and time of use on forage production rate and forage accumulation rate. The cultivar BRS Massai showed higher forage production rate and forage accumulation rate when used at 40 days, and this cultivar also showed higher rate of forage accumulation at 80 days when compared to BRS Tamani (Table 3).

Table 3. Unfolding of interaction between cultivars and moments of use on the rate of production and accumulation of forage of cultivars BRS Tamani and BRS Massai

Cultivars	Moments of use (days)			SEM[1]
	40	80	120	
	Forage production rate (kg DM/ha/day)			
BRS Tamani	105.60Ba	41.80Ab	25.60Ab	0.01
BRS Massai	116.70Aa	51.30Ab	27.60Ab	
	Forage accumulation rate (kg DM/ha/day)			
BRS Tamani	78.80Ba	28.30Bb	17.10Ac	0.01
BRS Massai	88.70Aa	35.10Ab	17.80Ac	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

When comparing the moments of use, it can be observed that both cultivars presented a higher rate of forage production at 40 days of deferment, with reduction at 80 and 120 days of sealing, which did not differ from each other. In general, the shorter sealing time led to the highest biomass production in both cultivars. This response provided increases of 50% of forage biomass in relation to the pastures deferred for longer, which in turn showed decreases in the daily accumulation rate of 50 and 61 kg DM/ha/day for the BRS Tamani pasture used at 80 and 120 days, respectively. For the cultivar BRS Massai, the decrease was even greater, with a reduction of 53 and 71 kg DM/ha/day in the pastures used at 80 and 120 days, respectively.

There was a triple interaction (P<0.05) on the phyllochron of both cultivars (Table 4). A lower phyllochron was observed when using BRS Tamani grass pasture after 40 days of deferment (7.80 days) during the rainy season. On the other hand, the highest phyllochron was observed in the cultivar BRS Massai when used after 120 days of deferment at the transition time (26 days).

Table 4. Unfolding of interaction between cultivars, deferment periods and moments of use on the phyllochron of cultivars BRS Tamani and BRS Massai

Cultivars	Deferment periods	Moments of use (days)			SEM[1]
		40	80	120	
		Phyllochron (days)			
BRS Tamani	Rainy	7.80Bc	14.70Bb	18.60Ba	0.90
	Transition	8.60Ac	15.70Ab	20.60Ba	
BRS Massai	Rainy	8.80Ac	16.50Ab	24.40Ba	

	Transition	8.90Ac	16.80Ab	26.00Aa

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

Interaction (P<0.05) was observed between the deferment periods and time of use on total forage biomass, dead forage biomass, leaf/stem ratio and water use efficiency (Table 5). In relation to total forage biomass, higher yields were observed during the rainy season for both cultivars. However, within each season, there was variation between the moments of pasture use, and in the rainy season the pasture differed and used after 120 days presented lower total forage biomass (3,760 kg/ha). In the transition season, the pasture with the longest deferment time also presented lower total forage biomass (2,633 kg/ha) but did not differ from the pasture used after 80 days of sealing (2,851 kg/ha).

Table 5. Unfolding of the interaction between the deferment periods and moments of use on biomass, morphological components of forage and water use efficiency of cultivars BRS Massai and BRS Tamani

Deferment periods	Moments of use (days)			SEM[1]
	40	80	120	
	Total forage biomass (kg DM/ha)			
Rainy	5,720Aa	4,601Ab	3,760Ac	170.30
Transition	3,169Ba	2,851Bb	2,633Bb	
	Dead forage biomass (kg DM/ha)			
Rainy	1,105Ab	1,343Ab	1,647Aa	53.40
Transition	1,080Aa	1,030Ba	557Bb	
	Leaf/stem ratio			
Rainy	2.16Aa	1.60Ab	1.46Ac	0.10
Transition	0.91Ba	0.90Ba	0.77Bb	
	Water use efficiency (kg DM/mm)			
Rainy	76.00Aa	37.50Bb	21.60Bc	3.90
Transition	70.50Aa	64.60Aa	62.30Aa	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

Higher dead forage biomass (1,647 kg DM/ha) was observed in the open pasture after a 120-day deferment in the rainy season. The leaf/stem ratio was higher in the deferred pasture at 40 days during the rainy season (2.16), and at all times of use, the relationship was higher at that time. On the other hand, although the greater relationship between leaf blade and stems produced was at the time of the waters, there was greater efficiency for water use in the transition period to the pastures sealed for 80 and 120 days of sealing, respectively.

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There was an effect (P<0.05) of the cultivars at different times of grass use on pasture height and population density of tillers (Table 6). In general, both cultivars had the same pasture height at all times of use after sealing (38.02, 30.50 and 28.35 cm for 40, 80 and 120 days, respectively). Thus, it can be observed that the pastures with longer sealing time had lower height of the forage canopy. A similar result was observed for the population density of tillers, where in the highest sealing times there was a decrease of 47.33% for the cultivar BRS Massai deferred, while in the pasture of the cultivar BRS Tamani there was a reduction of 63.96%.

Table 6. Unfolding of the interaction between cultivars and moments of use on the structural characteristics of cultivars BRS Massai and BRS Tamani

Cultivars	Moments of use (days)			SEM[1]
	40	80	120	
	Pasture height (cm)			
BRS Tamani	38.05Aa	29.40Ab	26.20Ac	0.70
BRS Massai	38.00Aa	31.60Ab	30.50Ac	
	Population density of tillers (Tillers/m^2)			
BRS Tamani	1,084Ba	724Ab	552Ac	37.00
BRS Massai	.1,426Aa	708Ab	514Ac	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

There was interaction (P<0.05) between cultivars, deferment time and moment of use on the falling index of grasses (Table 7). It was observed that in both cultivars the falling index was higher during the deferment performed in the rainy season, where in turn there was greater falling of pastures with the increase of the sealing time (1.91, 2.45 and 3.20 for 40, 80 and 120 days of use after sealing, respectively).

Table 7. Unfolding of the interaction between cultivars, deferment periods and moments of use on the tipping index of cultivars BRS Massai and BRS Tamani

Cultivars	Deferment periods	Moments of use (days)			SEM[1]
		40	80	120	
		Falling index			
BRS Tamani	Rainy	1.91Ac	2.45Ab	3.20Aa	0.10
	Transition	1.50Ca	1.20Cb	1.27Cb	
BRS Massai	Rainy	1.74Bc	2.30Bb	2.40Ba	
	Transition	1.30Da	1.23Cb	1.24Cb	

Averages followed by different lowercase letters in the line and different uppercase letters in the column differ by Tukey test (P<0.05). [1] Standard error mean.

There was interaction (P<0.05) between cultivars, deferment time and moment of use on the chemical-bromatological composition of grasses (Table 8). In general, both cultivars showed higher dry matter content at 120 deferment days in the transition period. It was observed that the crude protein content was higher for the cultivar BRS Tamani deferred for 40 days in the rainy season. On the other hand, the cultivar BRS Tamani used after 120 days of sealing in the transition period reached lower crude protein content (5.60%).

Table 8. Unfolding of the interaction between cultivars, deferment periods and moments of use on the chemical composition of cultivars BRS Massai and BRS Tamani

Cultivars	Deferment periods	Moments of use (days) 40	80	120	SEM[1]
		Dry matter[2] (%)			
BRS Tamani	Rainy	43.30Bc	51.31Bb	55.61Ca	1.64
	Transition	54.61Ac	58.70Ab	78.00Aa	
BRS Massai	Rainy	39.11Cb	42.80Ca	43.40Da	
	Transition	53.94Ac	58.43Ab	68.70Aa	
		Crude protein[3] (%)			
BRS Tamani	Rainy	11.53Aa	9.42Ab	7.11Ac	0.32
	Transition	7.00Ca	5.90Cb	4.90Cc	
BRS Massai	Rainy	7.70Ba	6.40Bb	5.60Bc	
	Transition	5.00Da	4.44Db	3.71Dc	
		Neutral detergent fibre[3] (%)			
BRS Tamani	Rainy	67.83Cc	78.70Ab	81.40Ba	0.86
	Transition	76.43Ac	82.30Bb	83.40Ca	
BRS Massai	Rainy	72.95Bc	79.20Ab	90.60Aa	
	Transition	75.10Ac	76.50Cb	81.41Ba	
		Total digestible nutrients[3] (%)			
BRS Tamani	Rainy	55.50Aa	51.00Ab	49.90Ab	0.35
	Transition	51.90Ca	49.50Cb	49.01Cb	
BRS Massai	Rainy	53.40Ba	50.80Bb	46.00Bc	
	Transition	52.50Ca	51.90Ab	49.83Cb	

[1]Standard error mean. [2]Values in relation to the natural matter content. [3]Values in relation to dry matter content. Averages followed by different lowercase letters in the row and different uppercase letters in the column differ by Tukey test (P<0.05).

Regarding the neutral detergent fiber content of the cultivars, there was even greater variation between the periods and times of use, where the cultivar BRS Tamani, deferred for 40 days, had lower neutral detergent fiber content during the rainy season and regardless of the cultivar or season of use, the pastures used after 120 days of fence had the highest levels of neutral detergent fiber, especially the cultivar BRS Massai used in the rainy season, where the neutral detergent fiber had an average of 90.60% of dry matter. The levels of total digestible nutrients were higher for cultivars with shorter deferment time, especially for cultivar BRS Massai during the rainy season. A reduction in total digestible nutrient content was observed over time when the pastures were deferred, but in all situations, the use at 80 or 120 days provided the same value, except for the cultivar BRS Massai with use at 120 days during the rainy season, which drastically reduced the levels of total digestible nutrients.

DISCUSSION

When comparing both evaluation periods, only at 40 days of use, the internal CO_2 concentration was influenced, being higher in the transition period. This higher concentration is the result of higher uptake by carboxylative enzymes, resulting in higher photosynthetic rate, something common in C4 metabolism plants (LEAKEY et al., 2006). On the other hand, cultivar BRS Tamani has greater resilience in the transition period, which may be related to some mechanism of resistance to lower water availability, because even with the reduction of photosynthetic activity, it was able to perform escape mechanisms through of shoot-root osmotic adjustment, through the inhibition of shoot growth and mobilizing photo-assimilates for expansion of the root system, resulting in a reduction in forage biomass (SEKI et al., 2007).

The reduction in the daily accumulation rate in both cultivars (Table 3) occurs due to the decrease in the activity of carboxylative enzymes at older ages, disfavoring the carboxylation of organic molecules and reducing the concentration of free CO_2 in mesophilic cells (PAN et al., 2004). In addition, pastures deferred for a longer time had lower relative chlorophyll indices, which reduces their nutritional value and, simultaneously, when subjected to high temperatures (Table 1), result in stomatal closure (MONTEIRO et al., 2014), which consequently, it leads to a decrease in the photosynthetic rate (SANTOS et al., 2013) and water loss by transpiration (MARANHÃO et al., 2019), resulting in lower dry matter production (TAIZ & ZEIGER, 2017), which confirms the higher transpiration rate and lower internal CO_2 concentration.

The greater amount of dead forage biomass in the pasture deferred at 120 days in the rainy season (Table 5) is due to the high falling index of grasses (Table 7), since, during the rainy season, the falling index was higher in pasture fenced for longer, leading to a lower incidence of light radiation at the base of the canopy (SOUSA et al., 2012; VILELA et al., 2012), inhibiting tillering (Table 6) and inducing leaf and tiller mortality (SOUSA et al., 2019), especially in the cultivar BRS Massai. Such behavior is typical in deferred pastures since there is greater accumulation of dead fodder in long-term deferred. All these effects can be confirmed by phyllochron (Table 4), since the increase in deferment time provided older tillers, leading to an increase in phyllochron (PAIVA et al., 2011), so the leaves of the tillers begin to senesce reducing the height of the pasture.

Probably the water deficit in the higher ages of use (80 and 120 days after deferment) was one of the factors that affected the leaf/stem ratio (Table 5), the other factor was the free growth of the grasses itself, that is, the search for light, which in conditions like this increases the amount of stem (ARAÚJO et al., 2016), through the etiolation of the grass.

Water utilization efficiency is associated with nitrogen nutrition, thus, it is

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inferable that water availability influences nitrogen metabolism, as there is a positive correlation between increased size and, consequently, leaf weight with nitrogen concentration in plant leaf blades (LOPES et al., 2020) and soil water availability (MARANHÃO et al., 2019).

Taiz & Zeiger (2017) point out that when there is abundant water and nitrogen available, photosynthetic activity is favored and demand for CO_2 grows. As a response, the stomata open, decreasing the stomatic resistance to diffusion, and the opposite is observed with the increase of the deferment time (Table 2). Inevitably there is loss of water through transpiration, however, since the water supply is abundant, it is advantageous for the plant to "exchange" water for photosynthesis products, essential for growth and production, even though the efficiency of water use has decreased with the increase in the deferment time, the efficiency of water use, a variable that expresses the amount of dry matter produced by the amount of water applied, was higher in the transition period, when water availability was lower, thus showing that both cultivars have the potential to adapt to low water regimes (SOUZA & MARTUSCELLO, 2017).

This behavior probably stemmed from the partial closure of the stomata in response to the water vapor pressure deficit, causing the plants to remain only with maintenance breathing (MONTEIRO et al., 2014), ratified by the internal CO_2 concentration, which was virtually null after 120 days of deferment during the transition period (Table 1).

It should be noted that, for the falling index, the data show the need for a certain differentiation in the management of the two cultivars. For the grasses of the species *Megathyrsus maximus*, plants with falling index between 2.0 and 2.4 and with moderate falling, plants with tipping index ≥ 2.5, while plants with tipping index ≥ 3.0 are considered very layered (SOUZA & MARTUSCELLO, 2017). Thus, the highest falling index can be related to the lowest rates of forage accumulation at the age of use of 120 days in both periods of the year (Table 3). Wind speed (Figure 1) may have contributed to aggravate this effect, given that winds with a speed above 10 km/h can cause mechanical damage to cespitose forage grasses such as those of the species *Megathyrsus maximus*, causing stem breakage and leaf detachment, contributing to the loss of accumulated biomass (PEREIRA et al., 2002). It is noteworthy that the tipping index is a measure of paramount importance for deferred pastures, thinking about the side of the next rainy season. Pastures that have a high falling index end up resulting in a reduction in tillers, as observed in this study, which may compromise the perennity in the following production cycles, resulting in pasture degradation.

During the rainy season, the cultivar BRS Massai, unlike BRS Tamani, did not provide the minimum content of 7% crude protein required to meet the requirements of nitrogen compounds for the correct functioning of the ruminal microbiota at a normal pass-through rate (LAZARINI et al., 2009). This fact was not expected, because in the rainy season, the highest rainfall (Figure 1), combined with initial nitrogen fertilization, would provide up to 40 days of deferment, the minimum crude protein value, since grasses of this genus easily present a value above 7% (SOUZA & MARTUSCELLO, 2017). The lowest dry matter content observed in both cultivars during the rainy season was expected, considering that high moisture content is observed at the time of higher precipitation (ARAÚJO et al., 2016), to the detriment of the dry or transition period, decreasing humidity with the increase of the deferment period (COSTA et al., 2017). The decrease in humidity over time favors cell stiffness, which considerably increases neutral detergent fibrecontent (Table 8).

On the other hand, the higher presence of low digestibility material reduced total digestible nutrients (Table 8), both with increasing deferment time and in the transition period. The highest total digestible nutrients values were verified for BRS Tamani deferred in the rainy season. These results are justified due to the lower increase in cell wall components during this period and which may interfere with digestibility, such as higher leaf/stem ratio (Table 5). It is worth mentioning the importance of the deferment technique for regions with low forage availability, another point that should be emphasized is that the use of different times of use is a strategy that should be well planned to scale the distribution of forage mass over the dry period.

The cultivar BRS Massai stands out for the higher forage production under dry conditions and can be used up to 80 days after deferment, while the cultivar BRS Tamani has superior nutritional value, and can be used up to 120 days of deferment, if carried out in the rainy season. Deferred pasture in the rainy season has a higher nutritional value than the dry season. Deferred pasture in the rainy season has a higher nutritional value than the dry season. In general, the deferment of the cultivar BRS Massai at the time of transition allows the use of forage without major losses up to 40 days of deferment.

ACKNOWLEDGMENTS

The authors thank the Dr. Ricardo Alves de Araújo (*in memoriam*) for his indispensable dedication and collaboration for the successful publication of this article; to the Coordenação de Aperfeiçoamento de Pessoal do Nível Superior (CAPES) for postgraduate scholarships; to Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA for its financial support (Grant No. 02.13.06.007.00.05) and for all the technical, installation and infrastructure support.

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