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Growth analysis of Mombaça grass in silvopastoral and monoculture systems managed under different canopy heights

Análise de crescimento do capim-Mombaça em sistema silvipastoril e monocultura manejados sob diferentes alturas do dossel

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ABSTRACT

The purpose of this study was to evaluate growth characteristics of Mombaça grass in silvopastoral and monoculture systems under different canopy heights. Monoculture and silvopastoral systems were evaluated under different height management strategies which were: 70, 80, 90 and 100 cm, in two seasons of the year: rainy and rainy / dry transition seasons. The variables evaluated were LAR (Leaf area ratio), SLA (Specific Leaf Area), LWR (Leaf Weight Ratio), RGR (Relative Growth Rate), CGR (Crop Growth Rate), NAR (Net Assimilation Rate) and LAI (Leaf Area Index). The experimental design adopted was randomized blocks with five replications. Data were subjected to analysis of variance and F test, and the Duncan test was used to compare the systems. The effect of the cutting height was assessed through linear and quadratic regression equations (p> 0.05). The shade cast by the trees affects most of the growth characteristics of Mombaça grass, such as SLA and LWR, which increased to compensate for the lower light intensity reaching the understory. Growth characteristics linked to the efficiency of light assimilation tend to be greater in the silvopastoral system. Characteristics related to production such as CGR and LAI were superior in the monoculture system. The strategy of cutting the forage at a height of 70 cm with residue of 40 cm showed the best growth rates in comparison to the other cutting strategies in the silvopastoral system.
KEYWORDS: consortium; *Megathyrsus maximus*; integrated systems; shading.

RESUMO

O presente trabalho teve como objetivo avaliar as características de crescimento do capim-Mombaça em sistemas silvipastoril e monocultura sob diferentes alturas do dossel. Os sistemas avaliados foram de monocultura e silvipastoril com diferentes estratégias de manejo de corte que foram 70, 80, 90 e 100 cm, respectivamente em dois períodos do ano, chuvoso e transição chuva/seca as variáveis avaliadas foram RAF (Razão de Área Foliar), AFE (Área Foliar Específica), RPF (Razão de Peso Foliar), TCR (Taxa de Crescimento Relativo), TCC (Taxa de Crescimento Cultura), TAL (Taxa Assimilatória Liquida) e IAF (Índice de Área Foliar). O delineamento utilizado foi em blocos casualizados com cinco repetições. Os dados foram submetidos à análise de variância e teste F, teste de média de Duncan para comparar os sistemas entre si, o efeito das alturas de corte fora comparado por meio de equações de regressão linear e quadrática (p > 0,05). O sombreamento provocado pelo bosque afeta grande parte das características de crescimento do capim-Mombaça, como AFE e RPF, provocando um aumento nessas características como compensação pela menor intensidade luminosa que chega no sub-bosque. Características de crescimento ligadas à eficiência de assimilação de luz tendem a ser superiores em sistema silvipastoril. As características ligadas à produção como TCC e IAF foram superiores para o sistema de monocultura. A estratégia de colheita de forragem na altura de 70 cm apresentou as melhores taxas de crescimento em relação às demais estratégias de corte, para o sistema silvipastoril.

PALAVRAS-CHAVE: consórcio; *Megathyrsus maximus*; sistemas integrados; sombreamento.

INTRODUCTION

Management strategies for grasses grown in monoculture or under full sunlight systems already present a range of information that allows us to understand their development under different management conditions. The use of canopy height has been a great ally in understanding the dynamics of growth and changes in plant structure, serving as a tool to aid in the correct management of grasses in order to maximize the level of light interception (PEDREIRA et al. 2007).

Evaluating data on integrated production systems, such as silvopastoral systems, it is observed that there is still a lack of information on appropriate management strategies in shaded environments, due to the different arrangements of the tree component, resulting in variation in the interception of photosynthetic active radiation (PAR). However, the evolution of pasture management in integrated systems must be linked to knowledge on the growth dynamics of the forage grass, since its development is directly affected by the tree component, which forces the plant to adjust to its development process (SOUSA et al. 2023). Studies show that the influence of the understory modifies the rate of tiller emergence, growth speed and specific leaf area as an adaptive mechanism to the reduction in PAR interception (OLIVEIRA et al. 2020, PEREIRA et al. 2021).

Pasture-forest integration systems have been the subject of studies, mainly in the recovery of degraded areas aiming to add production to sustainable management by maintaining part of the trees present in the pasture areas (CÁRDENAS et al. 2019). Animal production in this type of system is characterized as medium-term production while tree production as long-term, with this period being determined by the purpose of the tree introduced in this type of system, also considering the possibility of choosing fruit species (BATISTA et al. 2021).

Applying growth analysis in silvopastoral environments is an important tool to help selecting the best cultivars or management strategies based on the changes caused by competition with the tree component, aiming to determine the management that may be more efficient in maintaining the production and longevity of the pasture in shaded environments (BENICASA 1988). Grasses of the genus Megathyrsus maximus develop well when intercropped with forestry crops, due to their capacity of morphophysiological adjustment, which favors high production rates (MATTA et al. 2009).

It is therefore essential to carry out studies to evaluate the growth characteristics of tropical grasses in silvopastoral environments, and thus optimize and enhance the use of forage intercropped with native trees or forestry crops through the use of appropriate pasture management techniques. Thus, we hypothesized that grasses subjected to different cutting height managements in shaded environments had an influence on growth compared to those subjected to fully sunny environments. This study was therefore carried out in a silvopastoral area, integrating native trees and Megathyrsus maximus cv. Mombaça pasture, aiming to evaluate the grass growth patterns under different cutting management strategies.

MATERIAL AND METHODS

The experiment was conducted in the School of Veterinary Medicine and Animal Science of the Federal University of Northern Tocantins (EMVZ-UFNT), Araguaína Campus, Tocantins, Brazil, from December 2014 to June 2015. The climate of the region is classified as Aw, hot and humid (ALVARES et al. 2013), with average annual temperature and rainfall of 28 ºC and 1,800 mm, respectively. The evaluation periods were divided into rainy season, which began on December 21, 2014, and ended on March 20, 2015, and rainy/dry transition season, which lasted from March 21 to June 21. The rainfall data during the experimental period is shown in Figure 1, which was recorded by the Araguaína weather station, located at EMVZ-UFNT.

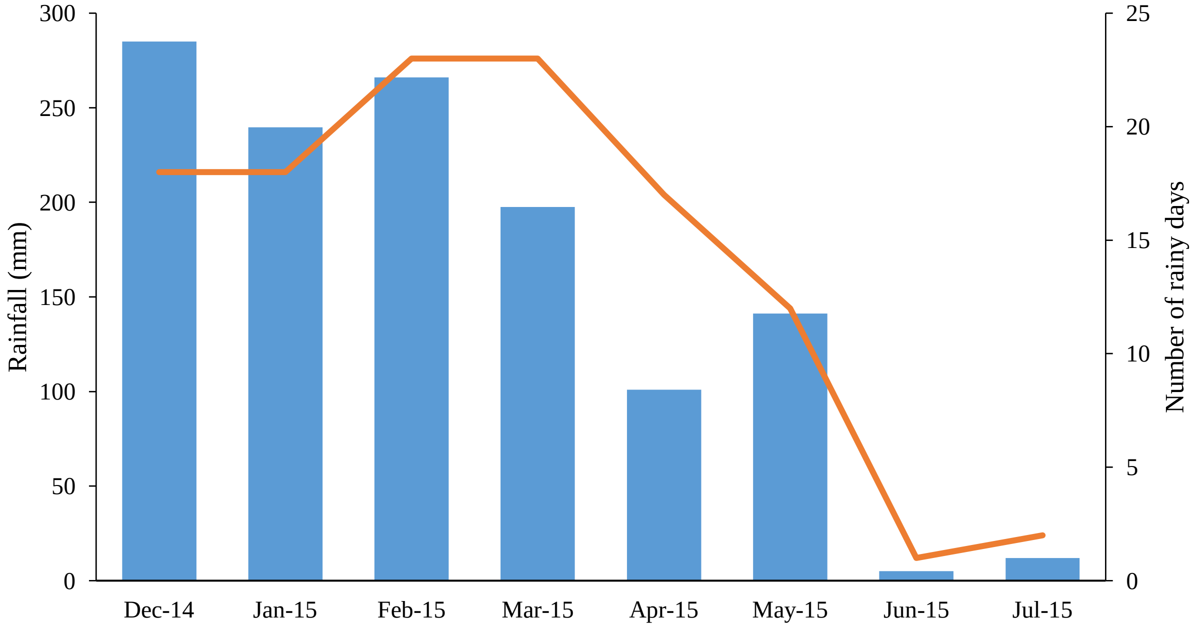

Figure 1. Rainfall (mm) and number of rainy days in the experimental area, in the city of Araguaína, Tocantins, Brazil.

Table 1. Chemical characteristics of the soil of the experimental areas from the 0-20-cm-deep layer.

System	pH	MO	P	K	Ca	Mg	Al	H +Al	SB	V
	$CaCl_2$	-----g kg-1-----		-------mg dm^{-3}-------			--------$cmol_c$ dm^{-3}---------			
Silvopastoral	4,5	2,04	0,82	2	0,004	0,003	0,0018	0,45	2,0	2,6
Monoculture	4,7	4,76	0,79	1	0,004	0,003	0,0063	0,46	1,0	2,03

Phosphorus (P, Mehlich-1); potassium (K, Mehlich-1); calcium (Ca, extraction with KCl 1 mol L-1); magnesium (Mg, extraction with KCl 1 mol L-1); aluminum (Al, extraction with KCl 1 mol L-1); H + Al (potential acidity); SB - sum of bases and V - base saturation.

According to the chemical analysis of the soil (Table 1), it was determined a fertilization and correction program in order to provide adequate nutrients for the development of the grass. In October 2014, the soil pH was corrected by applying 2 t ha-1 of dolomitic limestone in both production systems, aiming to raise the calcium content to 2 cmolc dm3 in the 0-20-cm-deep layer, by correcting aluminum saturation and increasing calcium and magnesium. The soil was fertilized in November 2014. Nitrogen fertilization (300 kg ha-1 year-1 of N) was split into applications, the first application (50 kg ha-1 of N) was made in the beginning of the evaluation period and the rest over the harvest cycles, using ammonium sulphate as source of N. Phosphorus was applied in the amount of 57.48 and 57.63 kg ha-1 of P2O5, in the form of single superphosphate in the monoculture and SPS systems, respectively. Potassium fertilization (240 kg ha-1 year-1 of K2O) was also divided, and distributed over the harvest cycles in the form of potassium chloride.

The silvopastoral system (SPS) was established with the consortium of native Babaçú trees (Attalea speciosa Mart.) and Mombaça grass (Megathyrsus maximus cv Mombaça). The monoculture or Fully Sunny (FS) system consisted of a single pasture of Mombaça grass. For both systems, the experimental area totaled 0.4 ha. The area had been previously used for experiments related to forage production since 2009 (Santos et al. 2018; Silveira Junior et al. 2017).

The experimental design used a 4 x 2 factorial scheme, with four canopy heights (70, 80, 90 and 100 cm) and two production systems (silvopastoral and monoculture), allocated in randomized blocks, with 5 replications, totaling 40 experimental units. The production systems were allocated independently and then were compared.

Prior to the beginning of the experimental period, the area of the silvopastoral system was thinned to adjust the shading. The shading level was close to 25%, determined by a lux meter (Model LD 200). These measurements were taken at 50 points within the SPS on an equidistant and representative grid (8 x 8). The light readings were taken between 6am and 1pm and compared with the readings at full sun, according to the equation:

$$100 - \{\frac{readingSPS}{readingFS} * 100\}$$

In November 2014, , the production cycle period was used to standardize the grass at the canopy height to be analyzed (70, 80, 90 and 100 cm) for both systems. After the first evaluation cycle, all variables were evaluated between December 2014 and June 2015.

To determine the average canopy height of each treatment, 20 spots were measured in each plot, allowing a maximum variation of 5% between the measured and specified height for each treatment, using a graduated ruler (PALHANO et al. 2005). To increase the effectiveness of measuring the heights in both systems, a crossbar was placed at the end of each plot and a master line was passed through to guide the harvest height, allowing control of the desired heights to be maintained.

After reaching the canopy height preconized in each growth cycle, mechanical cuts were made with a cleaver, leaving a post-cut residue of 40 cm from the ground. An area of 1.0 m² (1 x 1 m) was sampled at these sites, where the biomass of harvestable green forage was quantified. All the material was then taken to the laboratory to determine the indicators of Mombaça grass growth.

A representative sub-sample was taken from the samples, and the morphological components were separated into leaf blade, stem + leaf sheath, and dead material to determine the growth indices. These components were then taken to a forced air circulation oven to dry at 65 ºC until reaching constant mass for subsequent analysis.

The following growth parameters were evaluated according to Beadle (1993): LAR (Leaf Area Ratio), SLA (Specific Leaf Area), LWR (Leaf Weight Ratio), RGR (Relative Growth Rate), CGR (Crop Growth Rate), NAR (Net Assimilation Rate) and LAI (Leaf Area Index), using the equations below.

$$RGR \text{ (g g}^{-1}\text{ dia}^{-1}\text{)} = (\ln W2 - \ln W1) / (T2 - T1)$$

Where: ln is the Neperian logarithm; WI and W2 represent the mass of dry matter at times T1 and T2:

$$LAR(cm^2 or\ dm^2 g^{-1}) = \frac{L}{W} or \frac{L1 + L2}{W1 + w2}$$

Where: L = leaf area; W = dry mass

The specific leaf area relates the surface area to the mass of dry matter of the leaf itself (LA/LDM):

$$SLA = \left(\frac{LA}{LDM}\right)$$

$$LWR(gdm^{-2}day^{-1}) = (LDM/PDM)$$

$$NAR = \frac{(W2 - W1) * (InL2 - InL1)}{L2 - L1} * LAI = LA/S$$

Where: W: Dry mass; T: Time; LA: Leaf area; LAI: Leaf area index; LDM: Leaf dry mass; PDM: Plant dry mass; S: Soil or substrate area.

Data were subjected to normality (Shapiro-Wilk) and homoscedasticity (Bartlett) tests to verify distribution and homogeneity, respectively. When necessary, data were transformed into Log (x) and again subjected to the statistical assumptions. Variables with a normal distribution were subjected to analysis of variance and F-test, then the Duncan test was used to compare the systems together using the SAS statistical program, and regression analysis was applied using quadratic or linear regression equations (P > 0.05) to assess the effect of cutting heights on the growth characteristics of Mombaça grass.

RESULTS AND DISCUSSION

LAR was affected by the production system, showing higher values in the SPS in comparison to the monoculture, with increases of 38.10 and 25.53% in the rainy and rainy/dry transition seasons, respectively (Table 2).

Table 2. Leaf area ratio (LAR), specific leaf area (SFA) and leaf weight ratio (LWR) of Mombaça grass managed under different cutting heights in silvopastoral system and monoculture in two seasons, in the city of Araguaína, Tocantins.

Variable	System	Mean	Regression	R²	CV	Significance	
						System	Height
LAR (cm²g-1)	Rainy						
	SPS	0.029a	Y= 0.04 - 0.00012x	0.24	12.07	0.001	0.110
	Monoculture	0.021b	Y= 0.021	0.35			
	Rainy/dry transition						
	SPS	0.0295a	Y= 0.0295	0.53	19.39	0.001	0.068
	Monoculture	0.0235b	Y= 0.0456 – 0.0026x	0.37			
SLA (cm²g-1)	Rainy						
	SPS	0.03a	Y= 0.030		9.92	0.001	0.001
	Monoculture	0.024b	Y= 0.05 - 0.0003x	0.46			
	Rainy/dry transition						
	SPS	0.031a	Y= 0.031	0.71	21.67	0.032	0.185
	Monoculture	0.027b	Y= 0.027	0.52			
LWR (dm^{-2} day^{-1})	Rainy						
	SPS	0.920a	Y= 1.082 - 0.0019x	0.39	2.9	0.010	0.002
	Monoculture	0.892b	Y= 1.18 - 0.00334x	0.62			
	Rainy/dry transition						
	SPS	0.906a	Y= 2.496 – 0.035x + 0.00019x²	0.62	4.08	0.010	0.001
	Monoculture	0.811b	Y= 1.4524 – 0.00754x	0.80			

Lowercase letters compare systems in the columns according to the Duncan test at 5% probability. Coefficient of variation (CV).

In a silvopastoral system, grasses are expected to reduce LAR to the detriment of the reduction in forage dry matter, but the opposite has been reported, where the grass manages to adjust through phenotypic plasticity (SILVEIRA JUNIOR et al. 2017). Therefore, the higher LAR in the SPS may be associated with the plants' ability to adapt to shading and competition between crops for light in the system (SILVA et al. 2007), causing greater final length and higher leaf elongation rates when compared to pastures cultivated in fully sunny environment (PACIULLO et al. 2008), aiming for greater useful leaf area for photosynthesis and growth.

In the rainy season and in the SPS, LAR had a decreasing linear effect, decreasing by 0.0012 cm² g-1 as canopy height increased every 10 cm, while in the monoculture, canopy height influenced this characteristic in the rainy/dry transition period, with a decreasing linear response, causing it to decrease by 0.0026 cm² g-1 as canopy height increased every 10 cm (Table 2). LAR is one of the grass's characteristics that decreases as the grass develops and is mainly affected by shading (BARBERO et al. 2001). Despite the increase in LAI as plant height increases, LAR tends to decrease due to the leaves overlapping each other, causing shading of the lower leaves, which accelerates the process of leaf senescence, reducing the photosynthetically active area (CUTRIM JÚNIOR et al. 2014).

SLA was affected by the system in the seasons evaluated, showing higher values in the SPS, with an average increase of 2.5% and 14.81% in the rainy season and rainy/dry transition, respectively (Table 2). The increase in grass SLA in shaded environments as an adaptive response has also been reported by other studies (GOMES et al. 2019, PEREIRA et al. 2021). The stress caused by shading in grasses stimulates changes in the plant's photosynthetic apparatus, resulting in adjustments in the grass's photosynthetically active leaf area due to changes in the spectrum of light entering the forest (PACIULLO et al. 2007), which is most evident during the rainy/dry transition season. According to Gonçalves et al. (2012), the milder microclimate in shaded environments ensures lower leaf temperature and transpiration rate, which can lead to a greater allocation of carbon to increase the leaf surface, which was observed during the rainy/dry transition season in the SPS.

The effect of canopy height on SLA was only observed during the rainy season in the monoculture system, with a decreasing linear response, decreasing by 0.003 cm² g-1 as canopy height increased every 10 cm. Cutting height management does not seem to be the determining factor in modulating grass's SLA, which shows that this characteristic is linked to the adjustment of the photosynthetic apparatus, especially under shading conditions, as an alternative to increasing the photosynthetically active area linked to light capture.

LWR proved to be a growth characteristic directly influenced by the production system and canopy height management (Table 2). Higher LWR values were found in the SPS when compared to the monoculture, showing an increase of 3.14% and 11.71% in the rainy season and rainy/dry transition season, respectively. These results are due to the effect of shading in affecting forage biomass production, which modifies the distribution of biomass between the shoot and the root of the grass, which tends to have a greater flow of biomass allocation in the shoot, with greater investment in the efficiency of the grass's photosynthetic apparatus (SOUTO et al. 2009), resulting in higher LWR and SLA.

In the SPS, LWR had a linear decreasing effect in the rainy season, decreasing by 0.019 g-1 g-1 for each 10 cm increase in the grass cutting height, while in the rainy/dry transition season, it had a quadratic effect with a minimum point at 92 cm. In the monoculture, for both seasons studied, there was a decreasing linear response, decreasing by 0.0334 and 0.0754 g-1 g-1 for each 10 cm increase in cutting height, respectively. Studies conducted in this same experimental area show that the leaf:stem ratio decreased with increasing canopy height (RODRIGUES et al. 2019). Therefore, as the plant gets taller, the greater the fraction of photoassimilates exports to the stem will be, and this way, variations in LWR reflect the qualitative aspects of the grasses (OLIVEIRA et al. 2020).

RGR is directly linked to the accumulation of DM in a given time interval, which is influenced by the amount of initial DM present at the initial evaluation point (PEIXOTO et al. 2011). In the monoculture system and in the rainy season RGR was higher (18.66%) than in the SPS for both management strategies. However, it was noted that as rainfall decreased, RGR fell by 5.05% in the monoculture system, showing the efficiency of the silvopastoral system in maintaining productivity, minimizing the seasonality of the rainy/dry transition season (Table 3). There was a significant effect of canopy height on RGR, with similar patterns between seasons of the year and production system, with a decreasing linear response.

Table 3. Relative growth rate (RGR), crop growth rate (CGR) and net assimilation rate (NAR) of Mombaça grass managed under different cutting heights in silvopastoral system and monoculture in two seasons of the year, in the city of Araguaína, Tocantins.

Variable	System	Mean	Regression	R^2	CV	Significance	
						System	Height
	Rainy						
RGR ($g\ g^{-1}\ day^{-1}$)	SPS	0.284b	Y= 0.776 - 0.0058x	0.98	1.33	0.001	0.001
	Monoculture	0.337a	Y= 0.935 - 0.00704x	0.97			
	Rainy/dry transition						
	SPS	0.229a	Y= 0.6426 – 0.00486	0.98	2.27	0.001	0.001
	Monoculture	0.218b	Y= 0.588 – 0.00436x	0.89			
	Rainy						
CGR ($kg\ ha^{-1}\ day^{-1}$)	SPS	53.92b	Y= 53.92		13.68	0.001	0.817
	Monoculture	122.92a	Y= 122.92				
	Rainy/dry transition						
	SPS	62.96b	Y= 62.96	0.71	19.5	0.001	0.185
	Monoculture	102.92a	Y= 556.67 – 11.757 x 0.0742x²	0.55			
	Rainy						
NAR ($g\ cm^2\ day^{-1}$)	SPS	7.46b	Y= 17.43 - 0.1172x	0.72	7.77	0.0001	0.0001
	Monoculture	11.37a	Y= 24.28 - 0.1518x	0.62			
	Rainy/dry transition						
	SSP	6.4b	Y= 45.967 – 0.862 x 0.00474x²	0.63	4.08	0.031	0.0009

Lowercase letters compare systems according to the Duncan test at 5% probability. Coefficient of variation (CV).

In the SPS system, a decrease of 0.058 and 0.0486 g g-1 day-1 was observed for every 10 cm increase in canopy height in the rainy season and rainy/dry transition season, respectively. In the monoculture system, a decrease of 0.0704 and 0.0436 g g-1 day-1 was observed for every 10 cm increase in canopy height, in the rainy and rainy/dry transition seasons, respectively. RGR decreases as the plant ages, and is influenced by the management height and rainfall during the period and the pasture growing environment (ALEXANDRINO et al. 2005). In addition, grass growth will depend on the total DM accumulated in the residue and the height of the canopy, since as the plant grows its metabolic rates tend to decrease (BENICASA 1988).

CGR was affected by the production system (Table 3). In shaded environments (SPS), reductions of 127.97 and 63.47% were observed in CGR in comparison to the monoculture in the rainy and rainy/dry transition seasons, respectively (Table 3). In addition, CGR was not influenced by the cutting strategies in the two systems evaluated, except for the rainy/dry transition season in the monoculture. CGR represents the balance of physiological processes and is related to the accumulation of DM per day (SILVA et al. 2016). This growth variable is influenced by the population density of tillers and LAI (ALEXANDRINO et al. 2005) and is therefore affected by management characteristics and the pastoral environment, which explains the lower CGR in the SPS. A study conducted in this same experimental area showed that the population density of tillers decreased when the Mombaça grass was managed in shaded environments (RODRIGUES et al. 2019). Therefore, competition between the tree component and the grass for light, water and nutrients affects forage growth rates (CARVALHO et al. 2002).

On the other hand, the reductions in the difference between monoculture and SPS on CGR as rainfall is reduced, recorded in the rainy/dry transition season (Figure 1), reinforces the idea that shading in the SPS system reduces evapotranspiration, allowing plants to maintain forage production during long periods of water scarcity (ARAÚJO et al. 2020).

There was a significant difference between the systems evaluated for the seasons studied, with the highest NAR in the monoculture system, which is an increase of 52.41 and 16.09% in the rainy season and rainy/dry transition, respectively. The higher NAR in the monoculture system is linked to a greater incidence of light that stimulates tillering (RODRIGUES et al. 2019), which associated with the higher LAI (Table 4) increases the rates of DM accumulation in this environment, while in a silvopastoral system the tree component competes with the grass for light, water and nutrients (SANTOS et al. 2020). Light intensity is one of the limiting factors in the accumulation of DM in this environment due to changes in the light spectrum that directly affects the tillering rate (ARAÚJO et al. 2020). The decrease in NAR as cutting height increases is due to the longer regrowth time, which can be influenced by the time of forage accumulation (ALEXANDRINO et al. 2005).

In the SPS, NAR had a decreasing linear effect, decreasing by 1.172 g cm² day-1 for each 10 cm increase in grass cutting height, while a quadratic effect was observed in the rainy/dry transition season, with a minimum point at 90.92 cm height. In the monoculture system, NAR decreased by 1.518 and 0.0754 g cm² day-1 for each 10 cm increase in management height in the rainy and rainy/dry transition seasons, respectively. The strategy imposed on the grass has a major influence on NAR, because as the cutting height increases, NAR decreases, regardless of the type of system, whether it is an integrated system or a monoculture pasture (Table 3). Characteristics such as NAR and LAR are influenced by the height management, where greater cutting heights result in a decrease in these characteristics, due to a reduction in the leaf/stem ratio, dropping the proportion of assimilative organs in relation to non-assimilative organs, such as stems (CÂNDIDO et al. 2005).

There was a significant difference in LAI between the production systems during the seasons evaluated, with higher LAI values found in the monoculture system when compared to the SPS, an increase of 57.78 and 36.10% in the rainy season and the rainy/dry transition season, respectively (Table 4).

Table 4. Leaf area index (LAI) of Mombaça grass managed under different cutting heights in silvopastoral system and monoculture in two seasons, in the city of Araguaína, Tocantins.

Variable	System	Mean	Regression	R²	CV	Significance	
						System	Height
LAI	Rainy						
	SPS	3,34b	Y= - 0.306 + 1.2107x	0.4	14.46	0.001	0.0001
	Monoculture	5,27a	Y= - 0.89 + 0.0726x	0.42			
	Rainy/transition period						
	SPS	4,93b	Y= - 2.966 + 0.093x	0.3	23.78	0.0004	0.001
	Monoculture	6,71a	Y= - 3.715 + 0.122x	0.71			

Lowercase letters compare systems in the rows according to the Duncan test at 5% probability.

Shading affects the rate of tiller emergence and DM production (RODRIGUES et al. 2019), contributing to reductions in LAI (Table 4). The association between different plant species tends to modify the characteristics associated with growth such as LAI and CGR, due to the grass suffering inhibition in the consortium (ROSA et al. 2007).

In the rainy season and monoculture system, LAI reduced by 0.817 in the leaf area/soil area ratio for each cm increase in cutting height, while in the SPS, there was an increase of 0.905 in the leaf area/soil area ratio for each cm increase in height. In the rainy/dry transition season, there were reductions of 3.593 and 2.873 in the leaf area/soil area ratio for each cm added in the monoculture and SPS systems, respectively. The management strategy that provides the grass with greater height tends to increase LAI to the point where the leaves located in the lower part of the plant begin to self-shade (FAGUNDES et al. 1999), which is the main factor that can increase or decrease the leaf area depending on the height adopted. Therefore, LAI can vary with climatic conditions, but also with the region, due to the variation in light intensity that occurs according to the geographical location of the pasture, which causes changes in growth characteristics (FAGUNDES et al. 2005).

Based on the joint analysis of the data, the 70 and 80 cm cutting heights in the monoculture system were superior to the other heights in the two seasons evaluated, showing greater efficiency in adjusting to the management imposed. In the SPS, the 70 cm cutting height was superior. The intercropping of Mombaça grass with native trees directly affects the characteristics linked to light capture efficiency, such as LAR, SLA and LWR, with an increase in these characteristics due to shading, which causes the grass to adjust them in order to optimize light absorption.

Characteristics such as CGR and LAI tend to be higher in monoculture pasture system, as they are directly linked to the number of plants per area, which always tends to be higher in fully sunny systems. The silvopastoral system showed good adaptability to changes in the season of year, which shows that pastures cultivated in consortium with trees reduce the variation in production and the effect of seasonality on growth characteristics.

CONCLUSION

The production system and the height of the forage canopy affect the growth of the Mombaça grass, regardless of the time of year. The silvopastoral system provides greater leaf weight ratio, specific leaf area and leaf area ratio when compared to the monoculture system. However, higher growth rates are not reflected in a significant increase in leaf area index, net assimilation rate and crop growth rate.

The height of 70 cm is the most suitable for harvesting forage in the silvopastoral system, as it causes the best growth rates in Mombaça grass.

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