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Pre-defoliation canopy height for signal grass 'Basilisk' in silvopastoral systems

Alturas pré-desfolhação para o capim-braquiária 'Basilisk' em sistema silvipastoril

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Highlights

Shading the signal grass reduces forage production and tiller density.
Silvopastoral cultivation do not alter the chemical composition of the forage.
Signal grass must be defoliated between 40 and 50 cm in a silvopastoral system.

Abstract

The objective of this study was to compare the response of *Urochloa decumbens* cv. Basilisk pastures in monoculture and silvopastoral systems (SPS), and to determine the most suitable pre-defoliation canopy height for managing this species in SPS. Four pre-defoliation canopy heights (20, 30, 40, and 50 cm) were tested for signal grass in SPS, alongside a control treatment involving defoliation at 20 cm in full sun. The experiment was conducted using a randomized block design with four replicates. The forage accumulation rate was higher in monoculture (36.5 kg ha^{-1} day^{-1} of DM) compared to the silvopastoral system (22.0 kg ha^{-1} day^{-1} of DM), and there was no significant effect of pre-defoliation canopy height within the SPS. The density of tillers in monoculture was comparable to that observed in canopies managed at a height of 50 cm within the SPS. Leaf mass and leaf percentage were maximized at heights of 40 cm and 50 cm, respectively. Neither the cultivation system nor the pre-defoliation canopy heights in the SPS influenced the fiber and protein content. Leaf accumulation and mass were higher in

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monoculture, but the cultivation system did not affect the chemical composition of the forage. Heights between 40 cm and 50 cm in the SPS should be used to maximize tillering, mass, and leaf percentage of signal grass 'Basilisk'. The chemical composition of the produced forage did not undergo significant changes, neither between systems nor across pre-defoliation heights.
Key words: Canopy structure. Chemical composition. Forage production. Shading. Urochloa decumbens.

Resumo

O objetivo foi comparar a resposta de pastos de *Urochloa decumbens* cv. Basilisk em monocultivo e sistemas silvipastoris (SPS) e determinar a altura pré-desfolha mais adequada para o manejo desta planta em SPS. Quatro alturas pré-desfolha (20, 30, 40 e 50 cm) foram testadas para essa forrageira no SPS, além do tratamento de controle com desfolha a 20 cm ao sol pleno. O experimento foi conduzido em delineamento de blocos ao acaso com quatro repetições. A taxa de acúmulo de forragem foi maior no monocultivo (36,5 kg/ha.dia de MS) do que no sistema silvipastoril (22,0 kg/ha.dia de MS) e não houve diferença entre as alturas pré-desfolhação dentro do SPS. A densidade de perfilhos dos dosséis desfolhados com 50 cm no SPS foi semelhante ao monocultivo. A massa de lâminas foliares e a porcentagem de folhas foram maximizadas em alturas de 40 cm e 50 cm, respectivamente. O sistema de cultivo e as alturas pré-desfolha no SPS não influenciaram o conteúdo de fibras e proteína. O acúmulo e a massa foliar foram maiores em monocultura, mas o sistema de cultivo não afetou a composição bromatológica da forragem. Alturas pré-desfolhação entre 40 cm e 50 cm no SPS devem ser adotadas para maximizar o perfilhamento, a massa e a porcentagem de folhas da *U. decumbens* 'Basilisk'. A composição química da forragem produzida não sofreu alterações significativas, nem entre sistemas, nem entre diferentes alturas de pré-desfolha.
Palavras-chave: Composição bromatológica. Estrutura do dossel. Produção de forragem. Sombreamento. Urochloa decumbens.

Introduction

Considerable progress in pasture-based livestock production can be attributed to scientific research on tropical forage plants. These studies have led to the development of efficient management strategies for various species, significantly expanding forage production and enhancing its nutritional quality (Euclides et al., 2014).

Silvopastoral systems (SPS) have gained popularity among farmers as a technology to diversify and sustainably increase livestock production. However, tropical grasses like *Urochloa decumbens* (Stapf) R.D. Webster require specific defoliation targets in the understory of SPS. In monoculture grazing, pre-grazing strategies under an intermittent grazing regime are well-defined, based on light interception (LI) and critical leaf area index (Braga et al., 2009; Silva et al., 2015).

When considering pastures grown in SPS, there is no consensus on the best defoliation strategy. This is because trees alter environmental factors such as temperature, water availability, and particularly the quantity and quality of light

(Rodrigues et al., 2014). Previous research has shown that shading of tropical grasses such as *Urochloa decumbens* 'Basilisk' leads to changes in the morphogenetic, structural, and morphological patterns of the forage (Coelho et al., 2014; Gobbi et al., 2011; Lopes et al., 2016; Paciullo et al., 2011). These alterations can significantly affect forage production and quality, and the height at which the plant reaches 95% LI.

The stem elongation is an example of the growth pattern of shaded plants (Panigrahay et al., 2020). This response induces a series of structural changes in herbaceous grass that allow the plant to grow taller to compete with surrounding vegetation. So, with a taller structure, taller stems and a different leaf dispose the plant can reach 95% LI at taller sward heights. Hence, it is important to test different pre-defoliation canopy heights in forage grass canopies in SPS to identify the optimal defoliation strategy. The most effective management will maximize the accumulation of forage, as well as its chemical and structural composition in the shade.

Urochloa decumbens 'Basilisk' was once one of the most widely cultivated grasses (Valle et al., 2010), and continues to cover a large part of the pasture areas in Brazil. This grass has also been extensively studied in systems intercropped with trees (Lopes et al., 2016, 2017; Paciullo et al., 2007, 2011). Thus, defining pre-defoliation canopy height goals for *U. decumbens* 'Basilisk' in SPS, under intermittent grazing, has the potential to optimize its forage production.

Therefore, this study aims to compare the productive and chemical response of *U. decumbens* 'Basilisk' in both monoculture and silvopastoral systems and to determine the most suitable pre-defoliation canopy height for managing this forage grass in a silvopastoral system.

Materials and Methods

The experiment was conducted from December 18, 2017, to April 26, 2018, in a silvopastoral system covering approximately 6,900 m². Established for 10 years, this system is in Montes Claros, Minas Gerais, Brazil, at coordinates 16°40'3.17" South latitude and 43°50'40.97" West longitude, 598 m above sea level. The local climate is classified as Aw (tropical savanna), characterized by high annual temperatures, summer rainfall, and a dry winter (Alvares et al., 2013). Precipitation and average temperature data were collected throughout the experimental period (Figure 1).

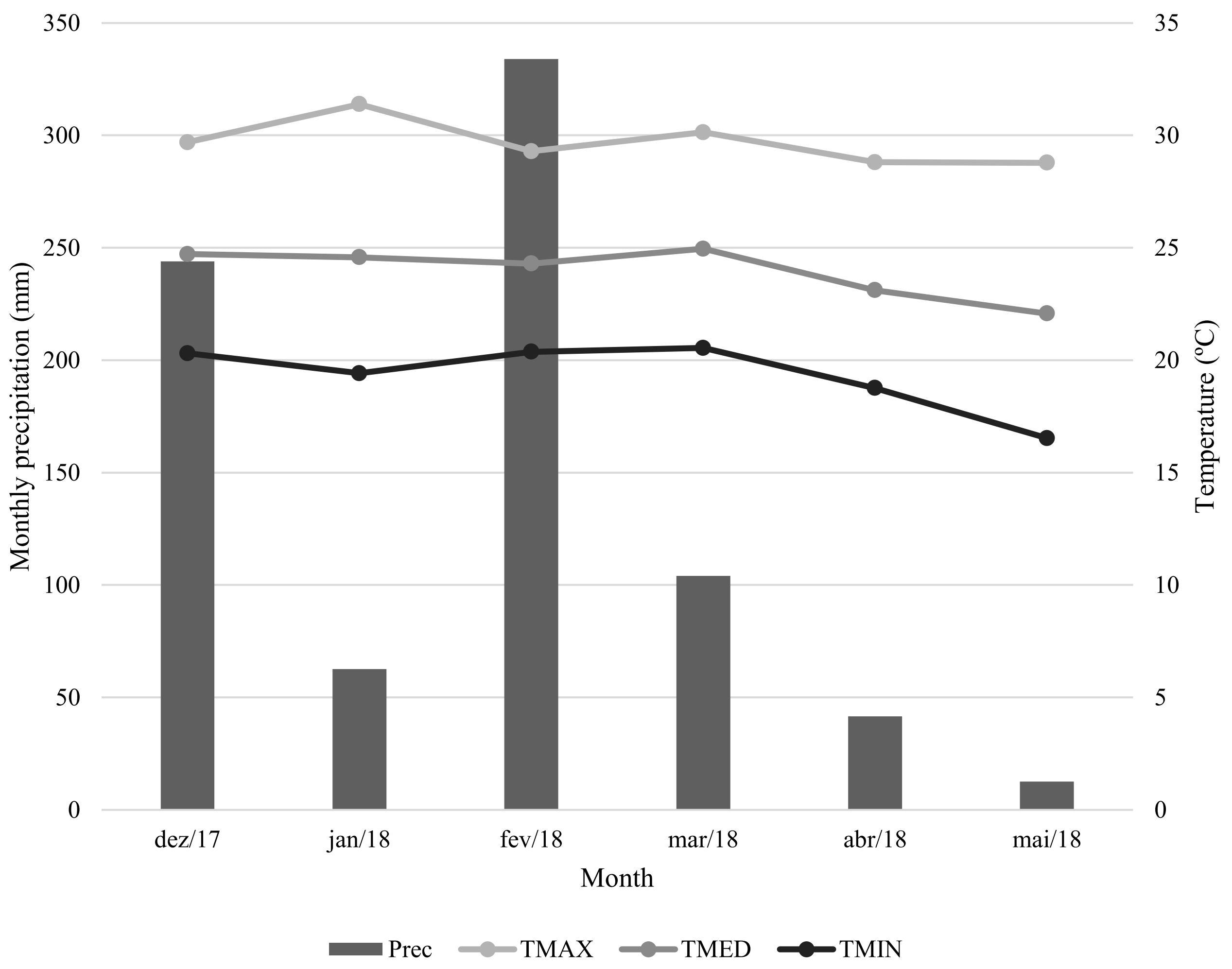

Figure 1. Monthly temperature and precipitation in Montes Claros, MG, during the experimental period.
Source: Instituto Nacional de Meteorologia [INMET] (2018).

The treatments consisted of four pre-defoliation canopy heights (20, 30, 40, and 50 cm) of *U. decumbens* 'Basilisk' in the silvopastoral system. These were compared to a control pasture in monoculture (without trees), which maintained a pre-defoliation canopy height of 20 cm, corresponding to 95% LI by the canopy (Braga et al., 2009). The experiment was laid out in a randomized block design with four replicates. In all defoliation strategies, the stubble height was set to 50% of the pre-defoliation canopy height. We use the 50% reference as it aligns with studies suggesting the defoliation of tropical grasses at 40 to 60% of their 95% LI pre-grazing height (Silva et al., 2015).

The forage plant was established one year prior in plots measuring 9 x 4 m, situated between rows of eucalyptus. The longer dimension of the plot, 9 m, spanned the inter-row space of eucalyptus, maintaining 50 cm from the tree trunks. During the establishment period until the start of the experiment, the pasture was mechanically harvested every 30 days during the rainy season and every 60 days during the dry season. Control treatment plots were set up in an adjacent area.

The tree species used in the silvopastoral system was eucalyptus (*Eucalyptus* spp., clone I144), planted with a spacing of 10 m between rows and 4 m between trees within a row. At the beginning of the experimental period, the trees were pruned in the lower branches to reduce shading in the understory. The trees had an average height of 20 m.

Light characterization in full sun and within the SPS was conducted using a portable ceptometer (model AccuPAR, LP-80, Decagon Devices, Pullman, USA). In the SPS, the device was positioned at the center of the rows (5 m from the tree row), and 1 m from the tree row. Measurements in full sun were taken at the center of each plot. The photosynthetically active radiation was measured hourly from 08h00 to 16h00 for ten days at the beginning of the experimental period, revealing an average of 50.0% shading in the SPS compared to full sun.

In December 2017, the grass canopy was uniformly harvested at 10 cm from the soil level, and the grass canopy of each plot was managed according to pre-established heights (20, 30, 40, or 50 cm). To determine the harvest timing, plant height was monitored every two days by measuring 10 random points in each plot.

The soil in the 0-20 cm layer was chemically characterized as follows: water pH = 5.1; Mehlich P = 10.58 mg dm^{-3}; K = 203 mg dm^{-3}; Ca^{2+} = 7.62 mg dm^{-3}; Mg^{2+} = 2.27 $cmol_c$ dm^{-3}; Al^{3+} = 0 $cmol_c$ dm^{-3}; H + Al = 2.45 $cmol_c$ dm^{-3}; base saturation = 81%; and organic matter = 6.28 dag kg^{-1}. The plots were fertilized with 80 kg ha^{-1} of P_2O_5 using single superphosphate, 100 kg ha^{-1} of K_2O using potassium chloride, and 100 kg ha^{-1} of nitrogen using urea. Nitrogen and potassium fertilization were applied twice, initially right after canopy the uniformity cut and again 60 days later. Phosphorus fertilization was applied immediately after the uniformity cut. The entire area was irrigated during critical periods using a sprinkler system at a rate of 730 L h^{-1} for four hours per day.

Harvests occurred when each plot reached its pre-established height. At these times, a 1 m^2 random sample of grass forage was harvested within the usable area (1 m away from the plot sides), and the stubble height was maintained at 50% of the pre-defoliation canopy height. All forage within the 1 x 1 m frame was weighed to determine the fresh mass production (FMP). The forage sample was analyzed to determine its dry matter content (% DM), chemical composition, and plant-part composition (leaf, stem, and dead material).

The FMP and % DM were used to estimate the average forage yield per harvest (kg ha^{-1}). The leaf/stem ratio was calculated as the quotient between the dry weight of leaves and stems. The dry mass measured in the frames was converted to kg ha^{-1} of dry forage mass, and the plant-part composition was expressed as a percentage (%). The forage accumulation rate (kg ha^{-1} day of DM) was calculated as the amount of green forage (leaves and stems) accumulated above the stubble height, divided by the number of growth days. The total dry mass production for the experimental period resulted from the sum of all harvests.

Tiller density was measured the day before each harvest by counting all live tillers (aerial and basal) in a randomly positioned 0.5 x 0.5 m frame. At the end of the period, the average number of tillers was calculated based on the counts from each harvest. The forage bulk density, expressed in mg cm^{-3} of DM, was obtained by dividing the dry mass harvested above the stubble height by the volume occupied by the harvested forage, estimated by multiplying the frame area by the vertical stratum height cut (difference between pre- and post-cut heights). Following the collection, the entire plot was uniformly mowed to the specified stubble height using a backpack brush cutter.

In the laboratory, samples designated for pre-dry matter determination were placed in a forced ventilation oven at 55 °C for 72 h and then processed in a Wiley mill with a 1-mm sieve. Following this, the samples were analyzed for dry matter (DM) content at 105 °C, mineral matter (MM), and crude protein (CP) in accordance with the Association of Official Analytical Chemists [AOAC] (2006) standards. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined using the methodology outlined by Van Soest et al. (1991). The ether extract (EE) content was quantified using the procedure Am 5-04 from the American Oil Chemists' Society [AOCS] (2005) with a Marconi extractor. Non-fiber carbohydrates (NFC) were calculated using the formula NFC = 100% - (% NDF + % MM + % CP + % EE).

When treatments showed significant differences in the ANOVA, they were compared to the control using the Dunnett test at a 5% significance level. The impact of varying canopy heights within the silvopastoral system was analyzed using regression analysis. Model selection was based on the significance of the parameters, the coefficient of determination (R^2), and the biological interpretation of the results. These analyses were conducted using GENES software, a computational tool for genetics and statistics, version 1990.2017.43 (Cruz, 2013).

Results and Discussion

Significant differences (P<0.05) were observed among the pre-defoliation canopy heights within the silvopastoral system (SPS; i.e., common treatments) compared to the signal grass in monoculture (control) for total dry mass (TDM), leaf dry mass (LDM), forage accumulation rate (FAR), percentage of dead material (%DeM), tiller density (TD), and forage bulk density (FBD). However, no significant differences (P>0.05) were found between the common treatments and the control regarding the percentage of leaves (%L), percentage of stems (%S), and leaf/stem ratio (L/S) (Table 1).

The TDM of the control was significantly higher than that of the treatments in the SPS, with the control TDM being 66.85% greater than the average of different pre-defoliation canopy heights in the SPS. Furthermore, no effects (P>0.05) or fitting to regression models were noted when comparing the management heights within the SPS. Hence, the diverse management goals adopted for *U. decumbens* 'Basilisk' in the SPS did not yield differences in forage production. The presence of eucalyptus trees (~20 m in height) and reduced row spacing (10 m) shaded the grass in the understory, which limited the plant growth and rendered it less responsive to the pre-defoliation canopy heights in the SPS.

Leaf dry matter followed the same trend as TDM, where the monoculture canopy was superior ($P<0.05$) to the mean of canopies under different heights in the SPS. Within the SPS, LDM fits a quadratic regression model as the pre-defoliation height increases. The peak of LDM was at the estimated height of 39.8 cm, reaching a total of 2040 kg ha^{-1}. Therefore, defoliations at 20 cm were severe for *U. decumbens* cv. Basilisk in the SPS, reducing its production and FAR. Additionally, the reduction in LDM at greater heights could be attributed to interspecific and intraspecific competition, shading, and prolonged growth periods.

Table 1
Productive and morphological aspects of *Urochloa decumbens* 'Basilisk' canopies in monoculture (CON) and silvopastoral system with varying pre-defoliation canopy heights

Variable	CON	Defoliation height (cm)				Regression equation	R^2	CV (%)
		20	30	40	50			
TDM (kg ha^{-1})	5223.0	2840.6*	3456.1*	3224.9*	2999.4*	$\hat{Y}$= 3130.3	-	13.77
LDM (kg ha^{-1})	3132.0	1450.2*	2030.2*	1914.8*	1938.5*	$\hat{Y}$=-168.9+110.9x - 1.391x^2	48.62	12.74
FAR (kg ha^{-1} day^{-1})	36.2	17.9*	24.5*	23.0*	22.7*	$\hat{Y}$= 22.0	-	12.98
%L	59.80	52.06	59.90	59.13	65.16	$\hat{Y}$=45.57 + 0.385x	85.39	8.16
%S	29.40	30.13	32.25	32.88	32.72	$\hat{Y}$= 32.00	-	6.92
%DeM	10.80	17.82	7.85	7.99	2.13*	$\hat{Y}$= 25.37 - 0.469x	86.49	40.81
TD (tillers m^{-2})	631.0	446.1*	504.2*	525.8*	563.4	$\hat{Y}$= 379.1 + 3.735x	96.64	7.15
L/S	2.1	1.8	2.1	2.1	2.3	$\hat{Y}$= 2.1	-	18.70
FBD (mg cm^{-3})	0.64	0.34*	0.33*	0.32*	0.28*	$\hat{Y}$ = 0.32	-	15.47

* Statistically different from the control according to Dunnett's test, at 5% probability. TDM: total dry mass; LDM: leaf dry mass; FAR: forage accumulation rate; %L: percentage of leaves; %S: percentage of stems; %DeM: percentage of dead material; TD: tiller density; L/S: leaf/stem ratio; FBD: forage bulk density.

A study indicated that *U. decumbens* is optimally managed at pre- and post-defoliation heights of 40 cm and 20 cm, respectively, in SPS (Machado et al., 2020). This alignment of current findings with existing literature supports the hypothesis that forage plants grown in the understory of SPS achieve a higher sward height at 95% LI than those grown in full sunlight. This suggests that *U. decumbens* 'Basilisk' should be defoliated at taller heights in SPS compared to a monoculture grass canopy.

The monoculture grass canopy exhibited a higher FAR than all the SPS management goals. However, varying pre-defoliation canopy heights within the SPS did not influence the FAR of *U. decumbens* 'Basilisk' (Table 1). In the SPS, the average FAR was 22 kg ha^{-1} day^{-1} of DM, which is 40% lower than that in grass monoculture. Lopes et al. (2016), who investigated the effects of three levels of shading (0%, 20%, and 70%) and two fertilization levels, found that the FAR under full sunlight was 42% greater than in shaded conditions for *U. decumbens.* They noted no variation in FAR until the highest level of shading, even with fertilization, suggesting that the significant shading from large trees could have prevented variations in FAR due to changes in pre-defoliation canopy height.

The %L in the canopies within the SPS did not differ significantly (P>0.05) from that found in the monoculture canopy. Analysis of heights in the SPS showed that %L fit a linear and positive regression model (Table 1). Increasing the pre-defoliation canopy height, and consequently the stubble height, likely led to the harvest of the upper parts of the canopy, where most leaves are concentrated. The linear response of %L to pre-defoliation canopy height indicates that shaded forage grasses require adjustments in defoliation management, necessitating greater pre- and post-defoliation heights for optimal forage production and plant-part composition.

Stem percentage in the canopies within the SPS did not differ (P>0.05) from the monoculture canopy (Table 1), and this variable did not fit any regression models (P>0.05) (Table 1). The %S in canopies within the SPS averaged 32.00%, compared to 29.44% in monoculture. These data contrast with findings by Martuscello et al. (2009) and Martins et al. (2014), who observed increased stem elongation rates with increased shading levels. It is likely that harvesting the upper half of the canopy reduced and standardized the %S across all evaluated forage canopies. Thus, shading response may have increased stem elongation in signal grass 'Basilisk', but %S did not increase due to the concentration of stems near the soil surface as described for *Urochloa brizantha* (Tamele et al., 2018).

The %DeM in the canopy managed at 50 cm was lower (P<0.05) than in the monoculture grass canopy. Furthermore, %DeM decreased linearly with increasing pre-defoliation canopy heights in the SPS (Table 1). In this way, increasing the pre-defoliation height resulted in a reduction of dead material in the harvested forage, as the post-harvest height also increased. The taller pre-defoliation heights distanced the harvested strata from the ground level, meaning the upper 25 cm included more green leaves and stems as reported by Fonseca et al. (2012). However, Fontes et al. (2014), who studied four stubble heights (10, 20, 30, and 40 cm) in *U. decumbens* pastures under intermittent grazing, did not observe variations in %DeM among the defoliation goals.

The TD in the grass canopy managed at a 50 cm pre-defoliation height in the SPS was equivalent to that of the control (monoculture) (P>0.05). The other lower grass canopies had lower TD than the control (Table 1). Shading may have inhibited the emergence of new tillers in the treatments harvested at 20, 30, and 40 cm. According to Paciullo et al. (2007), tree shading can reduce the tiller density of *U. decumbens* from 534 to 216 tillers m^{-2}. In the common treatments (four defoliation heights in SPS), there was a linear increase in TD as the pre- and post-defoliation heights increased. The 50 cm SPS defoliation height had 26.30% more tillers than the 20 cm height in the SPS.

The similar response in TD between the monoculture and the 50 cm SPS defoliation height did not extend to morphological aspects. The plants in the 50 cm SPS were taller, which enabled the development of aerial tillers. Considering that the stem serves as a substrate for the emergence of aerial tillers, the higher stubble heights have led to an increase in aerial tillering. This explains the linear increase in TD as a response to greater pre-defoliation canopy heights in SPS (Table 1). The aerial tillers in SPS grass compensated for the low number of basal tillers, which is common in monoculture signal grass defoliated at 20 cm. It is worth noting that these factors require further study in SPS, as they could represent a significant adaptation of the forage canopy under shading.

The tillering dynamics result from changes in the quantity and quality of light in the understory of silvopastoral systems. The tree canopy filters radiation wavelengths with higher photosynthetic responses in the grass (i.e., blue and red bands), as noted by Rodrigues et al. (2014). Consequently, there are fewer photoassimilates available for new tissue growth. Additionally, low temperatures and competition for light, water, and nutrients reduce the grass growth rate, as well as the emergence and development of new tillers.

The pre-defoliation canopy height ranging from 40 to 50 cm led to plant-part composition and yield similar to those of plants defoliated at 20 cm under full sunlight. The defoliation height of 20 cm corresponds to 95% LI in *U. decumbens* 'Basilisk' (Braga et al., 2009). Thus, the highest pre-defoliation and stubble heights in SPS likely resulted in LI closer to those of grass under full sunlight at 95% LI. This is important for maintaining a positive energy balance in plants, enabling them to produce assimilates above their respiration and growth needs and store them in the stem base and roots (C. V. Soares et al., 2013). These stores are then utilized for regrowth after defoliation and new tiller production (Gastal & Lemaire, 2015). In contrast, lower-managed canopies with less residual material in the SPS may have faced limited reserve storage, leading to energy constraints that restrict new tiller production.

No significant difference (P>0.05) was observed in L/S across all evaluated canopies (Table 1). This outcome may be associated with the management strategy employed, which defined the stubble height as 50% of the entry height. This strategy resulted in the harvesting of the leaf-rich upper part of the canopy in all treatments. The *U. decumbens* 'Basilisk' plant increased its L/S ratio in response to an increasing number of eucalyptus trees within the SPS in another study (Rodrigues et al., 2014). This response was attributed to the intense shading, which reduced the growth and development of the forage.

The FBD was higher (P<0.05) in the full sun canopy than in those within the SPS (Table 1). However, the four defoliation heights in the SPS showed no differences in FBD (Table 1). Compared to the SPS canopies, the average FBD of *U. decumbens* 'Basilisk' in full sun was 100% higher than that of SPS canopy grass. This response pattern was also observed by Lopes et al. (2017), Santos et al. (2016), and Oliveira et al. (2021). Hence, the lower FBD is a consequence of changes in the forage plant structure to intercept more light in a shaded environment. The reduction in density negatively affects forage intake by grazing animals, as the animal may prehend less forage per bite.

Increasing the defoliation height in the SPS did not affect most chemical variables of *U. decumbens* 'Basilisk' (Table 2). Mineral matter decreased as the defoliation height increased, while NFC increased with defoliation height. When comparing the grass monoculture canopy with those in the SPS, there were no statistical differences except for MM in the 50-cm defoliated canopy in the SPS, which was 13.20% lower than in monoculture (Table 2).

Table 2
Chemical composition of *Urochloa decumbens* 'Basilisk' canopies in monoculture (CON) and silvopastoral system with varying pre-defoliation canopy heights

Variable	CON	Defoliation height (cm)				Regression equation	R^2	CV (%)
		20	30	40	50			
NDF (%)	65.3	64.13	63.74	64.91	64.61	$\hat{Y}$= 64.35	-	2.11
ADF (%)	34.2	32.20	31.08	31.62	30.97	$\hat{Y}$ = 31.47	-	3.58
CP (%)	12.3	13.76	13.97	13.23	13.64	$\hat{Y}$ = 13.65	-	8.28
MM (%)	11.6	12.45	11.98	11.38	10.07*	$\hat{Y}$ = 14.177-0.077x	90.98	6.58
EE (%)	3.7	3.96	3.81	3.40	3.42	$\hat{Y}$ = 3.65	-	16.56
NFC (%)	7.1	5.70	6.50	7.09	8.25	$\hat{Y}$ = 4.000+0.082x	97.21	22.48

NDF: neutral detergent fiber; ADF: acid detergent fiber; CP: crude protein; MM: mineral matter; EE: ether extract; NFC: non-fibrous carbohydrates; * Significantly different from the control by Dunnett's test at 5% probability.

There was no fit (P>0.05) to the studied regression models for the NDF and ADF variables, which averaged 64.35% and 31.47% (Table 2). Indeed, raising the pasture could lead to an increase in the structural components of the cell wall throughout the plant. However, the increase in stubble heights (50% in all management treatments) resulted in a greater proportion of leaves and a reduction in dead material, not altering the NDF and ADF levels. Similarly, the artificial shading of *U. brizantha* 'Marandu' do not affect the NDF content of forage compared to full sun (Reis et al., 2013).

The increase in NFC helps explain the stable NDF and ADF levels. As the leaf area increases, the photosynthesis rate also increases. Thus, the amount of photoassimilates exceeds the plant's growth and respiration demand, generating a surplus that contributes to increasing the NFC levels (Silva et al., 2015).

There was no difference in NFC levels between the monoculture and SPS canopies, but there was a linear positive effect of the pre-defoliation canopy height of the SPS canopies on this variable (Table 2). This result may also be associated with the harvesting of younger tissues in the upper part of the different canopies. The synthesis of polysaccharides in the cell wall is higher in older parts of C4 grasses (Ermawar et al., 2015). Additionally, the increase in NFC may also be linked to the reduction in ash content, as the other variables (CP, NDF, and EE) remained constant at different heights.

The levels of CP and EE in the canopies within the SPS were similar (P>0.05) to those in the monoculture canopy (Table 2). Furthermore, the pre-defoliation canopy heights in the SPS did not influence these characteristics (Table 2). According to Barros et al. (2009), increased shading can lead to higher CP levels in C4 grass forage. Due to the slow growth rate of shaded plants, they remain in the early stages of development (rich in CP) for longer. Additionally, the shading from the trees increases competition, reduces grass photosynthesis, and makes it difficult for the plants to absorb and assimilate nitrogen (A. B. Soares et al., 2016; Sonawane et al., 2018). Therefore, the CP levels in all the shaded treatments did not respond to increasing defoliation heights.

Conclusion

Forage production, tiller density, and bulk density in Urochloa decumbens 'Basilisk' are higher in grass monoculture compared to the silvopastoral system. Pre-defoliation canopy heights of 40 and 50 cm optimize the productive and structural characteristics of the grass in the silvopastoral system.

The chemical composition of the produced forage did not undergo significant alterations, either between the two systems or among different pre-defoliation heights.

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