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Dynamics of defoliation of associated grasses

Dinámica de la desolación de las hierbas asociadas

Dinâmica de desfolhação de gramíneas associadas

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Abstract

The behavior of variables related to defoliation dynamics was evaluated, and their respective oscillations in two intercropping of tropical climate grasses managed under two grazing intensities. We used pastures formed with two intercropping (BRS Zuri, Xaraés and Basilisk; BRS Quênia, Marandu and BRS Paiaguás), managed in two grazing intensities: 40 and 60% of the pre-grazing height. In the consortium between BRS Zuri, Xaraés and Basilisk, the first canonical variable explained 72.1 and 79.2% of the total variation of the defoliation pattern for the grazing intensity levels of 40 and 60%. In the consortium between BRS Quênia, Marandu and BRS Paiaguás, the first canonical variable explained 84.3 and 89.0% of the total variation of the defoliation pattern for the grazing intensity levels of 40 and 60%. The choice of forage species of tropical climate to form the consortium may be decisive in order to perpetuate plant diversity. From the population density of tillers, it is possible to observe that grasses belonging to functional groups A and B (Zuri, Xaraés, BRS Quênia and Marandu) have a higher probability of coexisting in the same area. The choice of forage species for the establishment of intercropped pastures is important to ensure the coexistence between them and the persistence of the consortium. The analysis of canonical variables assists in explaining the dynamics of defoliation of intercropping through the estimates of severity and frequency of defoliation of extended tiller and pseudostem.

Keywords: Frequency of defoliation; Pre-grazing; Pseudostem; Severity of defoliation.

Resumen

Se evaluó el comportamiento de las variables relacionadas con la dinámica de la defoliación, y sus respectivas oscilaciones en dos cultivos intercalados de pastos climáticos tropicales se manejaron bajo dos intensidades de pastoreo. Utilizamos pasturas formadas con dos cultivos intercalados (BRS Zuri, Xaraés y Basilisk; BRS Quênia, Marandu y BRS Paiaguás), manejados en dos intensidades de pastoreo: 40 y 60% de la altura previa al pastoreo. En el consorcio entre BRS Zuri, Xaraés y Basilisk, la primera variable canónica explicó el 72,1 y el 79,2% de la variación total del patrón de defoliación para los niveles de intensidad de pastoreo del 40 y 60%. En el consorcio entre BRS Quênia, Marandu y BRS Paiaguás, la primera variable canónica explicó 84.3 y 89.0% de la variación total del patrón de defoliación para los niveles de intensidad de pastoreo de 40 y 60%. La elección de especies forrajeras de clima tropical para formar el consorcio puede ser decisiva para perpetuar la diversidad de plantas. A partir de la densidad de población de los macollos, es posible observar que los

pastos pertenecientes a los grupos funcionales A y B (Zuri, Xaraés, BRS Quênia Kenya y Marandu) tienen una mayor probabilidad de coexistir en la misma área. La elección de especies forrajeras para el establecimiento de pasturas intercaladas es importante para asegurar la coexistencia entre ellas y la persistencia del consorcio. El análisis de las variables canónicas ayuda a explicar la dinámica de la defoliación del cultivo intercalado a través de las estimaciones de la gravedad y la frecuencia de la defoliación de la macolla y el seudotallo extendidos.
Palabras clave: Frecuencia de defoliación; Pre-pastoreo; Pseudcolm; Gravedad de la defoliación.

Resumo

O comportamento das variáveis relacionadas à dinâmica de desfolhação em dois consórcios de gramíneas de clima tropical manejados sob duas intensidades de pastejo. Foram utilizadas pastagens formadas com dois consórcios (BRS Zuri, Xaraés e Basilisk; BRS Quênia, Marandu e BRS Paiaguás), manejados em duas intensidades de pastejo: 40 e 60% da altura do pré-pastejo. No consórcio entre BRS Zuri, Xaraés e Basilisk, a primeira variável canônica explicou 72,1 e 79,2% da variação total do padrão de desfolhação para os níveis de intensidade de pastejo de 40 e 60%. No consórcio entre BRS Quênia, Marandu e BRS Paiaguás, a primeira variável canônica explicou 84,3 e 89,0% da variação total do padrão de desfolhação para os níveis de intensidade de pastejo de 40 e 60%. A escolha de espécies forrageiras de clima tropical para formar o consórcio pode ser decisiva para perpetuar a diversidade de plantas. A partir da densidade populacional dos perfilhos, é possível observar que gramíneas pertencentes aos grupos funcionais A e B (Zuri, Xaraés, BRS Quênia e Marandu) apresentam maior probabilidade de coexistência na mesma área. A escolha de espécies forrageiras para o estabelecimento de pastagens consorciadas é importante para garantir a coexistência entre elas e a persistência do consórcio. A análise de variáveis canônicas ajuda a explicar a dinâmica da desfolhamento do consórcio através das estimativas de severidade e frequência da desfolhamento do perfilho estendido e do pseudocolmo.
Palavras-chave: Frequência de desfolhação; Pré-pastejo; Pseudcolmo; Severidade de desfolhação.

1. Introduction

The use of intercropped pastures has been considered a promising ecological management practice, as it aims the diversity of species in pastoral environments and can positively increase the primary and secondary productivity of the pastoral system (Stejskalová *et al*., 2013; Roca-Fernández et al., 2016; Duchini et al., 2018; Sonkoly et al., 2019).

The combination of different groups of grasses can ensure the longevity of plant production throughout the seasons (Duchini et al., 2013; Gross et al., 2014; Schweiger et al., 2018). But to succeed in the consortium in tropical climate pastures, it is necessary that the grasses belong to different functional groups following the classification proposed by Cruz et al. (2002) and Rodrigues et al. (2012): functional group A, grasses with higher productive potential, being represented by the cultivars of *Panicum maximum* sp. (Castagnara et a*l*., 2011; Garcez & Monteiro, 2016; Braz et al., 2017); functional group B, grasses with moderate requirement in soil fertility, such as *Bachiaria brizantha* cv. Marandu and *Bachiaria brizantha* cv. Xaraés (Euclides et al., 2008); functional group C, grasses with high survival rate of tillers, represented by *Brachiaria decumbens* cv. Basilisk (Portela et al. 2011; Santos et al., 2011; Santos et al., 2013) and lower decrease in biomass production, such as *Brachiaria brizantha* cv. BRS Paiaguás (Euclides et al., 2016; Beloni et al., 2018; Oliveira et al., 2020).

The effects related to plant-animal interaction should also be considered in the grouping of tropical grasses. An effective way of analyzing these effects is through the defoliation dynamic of each individual tiller (Heitschmidt et al., 1990; Lemaire et al., 2009), because the severity of tiller defoliation elucidates how the animal searches and seizes the structural components of the pasture and it allows to make theoretical inferences about the intake of forage (Baumont et al., 2004). The frequency of defoliation translates how much the tiller and its respective morphological components are selected (Hodgson, 1966).

Grazing management can be determinant in defoliation dynamics in higher grazing intensities, because they are usually related to higher stocking rates, which can reduce defoliation depth and increase the frequency of defoliation in the same tiller (Mazzanti et al., 1994). Thus, it can generate balance in the process of search and seizure of forage in a heterogeneous pasture.

Therefore, the behavior of the variables related to defoliation dynamics was evaluated, and their respective oscillations in two intercropping of tropical climate grasses were managed under two grazing intensities.

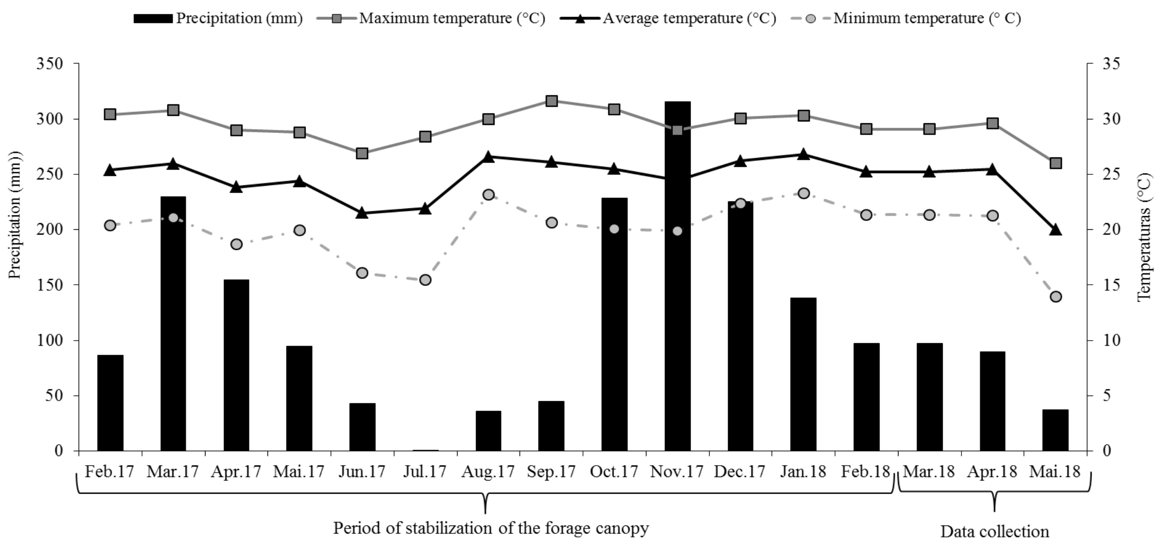
2. Materials and Methods

Area and experimental period/ Climate

The experiment was carried out in the premises of the Brazilian Agricultural Research Company (EMBRAPA Beef Cattle), located in the city of Campo Grande-MS Lat. 20º27'S, Long. 54º37'W and Alt. 530m. The experimental area was 3 hectares (ha) subdivided into 12 pickets of 0.25 ha, where the treatments were randomly allocated. With implantation and stabilization of the pastures from September 2016 to February 2018, and beginning of the assessments from March 2018 to May 2018.

Climate of the region according to the Köppen classification is the tropical rainy savannah type, subtype Aw. The temperature and precipitation data during the experimental period were recorded by the meteorological station (A702-INMET) located in the city of Campo Grande-MS (Fig. 1).

Fig. 1. Averages referring to temperature and precipitation in the period from February 2017 to May 2018.



Soil/Pre-experimental management and treatments

The parameters related to soil texture and chemical composition were presented by Barbosa et al. (2018). Based on soil analysis in September 2017 applied 1 ton/ha of dolimitic limestone; in November 2017 80 kg/ha of phosphorus pentoxide and potassium oxide was applied; in December, February and March, the application of 150 kg/ha of nitrogen was applied.

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The pastures were combined into two intercropping: ZXD (*Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraés and *Brachiaria decumbens* cv. Basilisk; QMP (*Panicum maximum* BRS Quênia, *Brachiaria brizantha* cv. Marandu and *Brachiaria brizantha* cv. BRS Paiaguás).

The sowing procedures of the intercropped are described in the work of Barbosa et al. (2018). The sowing rate was based on the germination expectation of 100 plants/m² (50 Panicum plants and 25 plants from each *Brachiaria*). The estimate of plant germination per square meter was based on previous experiments carried out by Barbosa et al. (2018), where a germination rate of 50% was observed for the genus *Brachiaria* and 20% for grasses of the genus *Panicum*.

The pasture structure for each grazing intensity was previously molded from May 2017 to February 2018, the lowering of the pasture height was performed by Caracu cows, with approximately 24 months of age and average body weight of 450 kg belonging to the EMBRAPA herd. This period was necessary to ensure that grasses could adapt to the grazing intensities imposed.

The heights of pre-grazing of 70 cm and 60 cm for the intercropping ZXD and QMP, were respectively established. In addition, two grazing intensities, 40% (Lenient) and 60% (High) of the pre-grazing height, were established as post-grazing goals.

The goal of grazing intensity was based on the average height of the forage canopy of the genus *Panicum*, since this was the predominant grass in the intercropping. With the aid of a graduated ruler, 60 points were recorded per picket related to the height of the species of the genus *Panicum* allowing a maximum variation of 10% between the measured height and that specified for each intensity. The grazing method adopted was intermittent stocking. The adjustment of the instantaneous stocking rate was based on the forage biomass for each desired grazing intensity.

Evaluations

The data collection period began after the stabilization of the pastures, when they reached the pre-grazing height (From March to May 2018).

Forage mass and botanical composition

In the pre and post grazing the forage mass was estimated by collecting six samples per picket. Forage collection was performed by cutting the forage close to the soil, which was contained in the interior of 1m² squared frames, and the samples were packaged in plastic bags and identified. The samples were taken to the laboratory for botanical separation with identification and tiller count per species of each consortium. Subsequently, the morphological components were separated for each cultivar for the quantification of the leaf lamina mass, pseudostem and dead material. After the separations, the samples were pre-dried in a forced air circulation drying oven at 55 ºC until reaching constant weight.

Defoliation pattern

To detect the oscillations in the defoliation pattern during the lowering period of the pastures, the technique of marked tillers was used (Hodgson, 1966). For this, during the pre-grazing, 45 vegetative tillers were marked per picket, 15 of each grass of the consortium, identified and distributed in equidistant points. The identification of each tiller was performed by means of colored ribbons on an iron rod to facilitate the identification of the marked tillers. In the marked tillers, the measurements of extended tiller were taken, corresponding to the distance between the ground and the apex of the highest leaf when vertically positioned. The pseudostem measurement was also taken, being the distance between the soil and the lygula of the last leaf lamina completely expanded. These measurements were performed with the aid of a centimeter graduated ruler.

After the height measurements of the extended tiller and pseudostem in the pre-grazing, the animals had access to the pickets. Every two days, the evaluations of the extended tiller and pseudostem of each grass were performed again, being classified as intact (the tillers that did not have size reduction by grazing), or defoliated (when the size reduction occurred compared to the measurement performed in the pre-grazing). The animals remained in the pickets for eight days, allowing to perform four evaluations of defoliation dynamics during the canopy lowering period.

From these measurements, the severity of defoliation (plant tissue removed at each touch) was quantified according to the following formula: severity (%) = ((initial length-final length) ÷ initial length); and the frequency of defoliation, calculated from the following formula: frequency (%) = number of touches /tiller/cultivar ÷ total number of marked tillers ÷ interval between assessments (Days) (Hodgson, 1966; Heitschmidt et al., 1990).

Statistical analysis

For characterization of the forage canopy: forage mass data, population density of tillers were grouped into means. To perform the analyses, 36 observations were quantified for each consortium, according to their respective grazing intensity. Defoliation data were analyzed according to a completely randomized model, in a factorial arrangement 2 (Intercropping) x 2 (Grazing intensities). When appropriate, Tukey's mean comparison test was performed and a 5% significance level was considered. For the analyses, the ExpDes package (Ferreira et al., 2014) of the software R version 3.5.0 was used.

The information related to the extended tiller defoliation frequency (ETDF), pseudostem defoliation frequency (PDF), extended tiller defoliation severity (ETDS) and pseudostem defoliation severity (PDS) were used to estimate the first and second canonical variables, as well as the standardized canonical coefficients for each consortium within each grazing intensity. The Candisc function of the software R version 3.5.0 for this estimation was used.

3. Results

Structure of the forage canopy

The pre-grazing heights for each consortium presented values close to what was established as a management criterion. For both intercropping, approximately 50% of the forage mass was composed of leaf laminas. In the intercropping managed at 60% height removal, the highest stocking rates were observed, consequently, the lowest values of leaf lamina and pseudostem mass were observed in the post-grazing. After the stabilization period of the intercropping, it was observed the coexistence of the grasses, however, not presenting the desired proportions, because the cv. Basilisk and cv. BRS Paiaguás present a less than 10% population of tillers (Table 1).

Table 1. Structural characteristics and management of the intercropped of *Panicum* spp. and *Brachiaria* spp. managed with 40% and 60% of removal of the height of the forage canopy.

	Intercropping			
	ZXB		QMP	
Variable	40%	60%	40%	60%

Pre-grazing				
Canopy height (cm)	71	71	61	66
Leaf lamina mass (ton/ha)	2.5	2.4	2.0	2.3
Pseudostem mass (ton/ha)	1.6	1.3	1.8	1.6
Mass of dead material (ton/ha)	0.8	1.0	1.3	0.9
Instantaneous stocking rate (AU 0.25/ha)	6	10	6	9
Post-grazing				
Canopy height (cm)	42	29	37	24
Leaf blade mass (ton/ha)	0.3	0.1	0.2	0.1
Pseudostem mass (ton/ha)	1.7	0.6	1.4	0.8
Mass of dead material (ton/ha)	1.3	1.4	1.1	1.2
Tillers population				
Panicum maximum cv. BRS Zuri (m^2)	255	363	-	-
Brachiaria brizantha cv. Xaraés (m^2)	165	91	-	-
Brachiaria decumbens cv. Basilisk (m^2)	23	23	-	-
Panicum maximum cv. BRS Quênia (m^2)	-	-	338	402
Brachiaria brizantha cv. Marandu (m^2)	-	-	188	185
Brachiaria brizantha cv. BRS Paiaguás (m^2)	-	-	54	83

ZXB: *Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraés e *Brachiaria decumbens* cv. Basilisk; QMP: *Panicum maximum* BRS Quênia, *Brachiaria brizantha* cv. Marandu e *Brachiaria brizantha* cv. BRS Paiaguás. AU: animal unit (450 kg).

Defoliation dynamics between intercropped

Interaction between intercropped and grazing intensities was not observed for the variables related to defoliation dynamics. The ETDS of the QMP consortium was 10% higher compared to the ZXB consortium, and PDS in the QMP consortium was 26% higher compared to the ZXB. The ETDF and PDF do not present oscillations between the intercropped. In grazing intensities, the variables related to defoliation dynamics present proportionality (Table 2).

Table 2. Defoliation dynamics of the intercropped of *Panicum* spp. and *Brachiaria* spp. managed with 40% and 60% removal of the height of the forage canopy.

	Intercropping	Grazing intensity	*P* value

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Variable	DF	ZXB	QMP	40%	60%	C	GI	C*GI	SE
ETDS (%)	112	28.08^{b}	31.27^{a}	29.01	30.04	0.027	0.481	0.099	0.738
PDS (%)	112	16.18^{b}	21.92^{a}	20.13	18.12	0.012	0.378	0.365	1.14
ETDF (%)	112	7.31	7.02	7.24	7.12	0.660	0.859	0.970	0.329
PDF (%)	112	2.38	2.89	2.63	2.62	0.150	0.981	0.318	0.175

DF: residue degrees of freedom. ZXB: *Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraés e *Brachiaria decumbens* cv. Basilisk; QMP: *Panicum maximum* BRS Quênia, *Brachiaria brizantha* cv. Marandu e *Brachiaria brizantha* cv. BRS Paiaguás. *P* value: probability of significant effect. SE: mean standard error. C: intercropping. GI: grazing intensity. C*GI: interaction between intercropped and grazing intensity. SE: mean standard error. Means followed by lowercase letters in the lines differ from each other by the Tukey test, at 5%. ETDF: extended tiller defoliation frequency. PDF: pseudostem defoliation frequency. ETDS: extended tiller defoliation severity. PDS: pseudostem defoliation severity.

ZXB Intercropped

In the ZXB intercropped, regardless of defoliation intensity, the standardized canonical coefficients of the first canonical variable (Can1) showed that the ETDS and PDS are the variables that most interfere over the first canonical variable, in the positive and negative quadrants, respectively. This indicates that these are the variables that most interfere on the differentiation between the defoliation patterns of the forage evaluated (Table 3). Fig. 2 shows standardized canonical coefficients for defoliation dynamics in the first and second canonical variables of the intercropped of *Panicum* spp. and *Brachiaria* sp. managed with 40% and 60% of removal of the forage canopy height. In the ZXB intercropped, the first canonical variable explained 72.1 and 79.2% and the second 20.8 and 28.0% of the total variation of the defoliation pattern, for the grazing intensity levels of 40 and 60%, respectively (Fig. 2).

Table 3. Standardized canonical coefficients for defoliation dynamics.

	Intercropping			
	ZXB		QMP	
Variable	40%	60%	40%	60%
	First canonical variable			
ETDS	1.05	0.365	-0.748	-0.234
PDS	-0.849	-0.953	-0.045	0.433
ETDF	-0.441	-0.208	-0.642	-0.449
PDF	-0.269	-0.082	0.758	0.787
	Second canonical variable			
ETDS	0.055	-0.737	0.446	0.832
PDS	-0.962	-0.589	0.691	0.044
ETDF	-0.421	0.175	-0.154	-0.567
PDF	0.827	0.627	0.535	-0.194

ZXD: *Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraés e *Brachiaria decumbens* cv. Basilisk; QMP: *Panicum maximum* BRS Quênia, *Brachiaria brizantha* cv. Marandu e *Brachiaria brizantha* cv. BRS Paiaguás. ETDF: extended tiller defoliation frequency. PDF: pseudostem defoliation frequency. ETDS: extended tiller defoliation severity. PDS: pseudostem defoliation severity.

It is observed on Can1 that there is a difference between the grasses when the ZXB intercropped is managed with 40% grazing intensity. Therefore, from the association with the canonical coefficients (Table 3) and the Can1 (Fig. 2) the cv. Basilisk presents high values of PDS, while the cv. Xaraés shows elevated ETDS and cv. BRS Zuri presents a pattern close to neutrality in both variables

However, when the grazing intensity increases to 60%, still in the Can1, the defoliation dynamic presents oscillations among the grasses intercropped, in which the cv. Basilisk followed by cv. BRS Zuri present the highest values of PDS, and cv. Xaraés stands out with High ETDS values.

With 40% of grazing intensity in the ZXB intercropped, the second canonical variable (Can2) emphasizes the highest values of PDF in the cultivars belonging to the genus *Brachiaria*. In addition, the highest PDS values are observed for the cv. Basilisk, already identified in Can1.

When a reduction of the forage canopy height occurs (60%), Can2 showed that ETDS increases for cv. Basilisk and cv. BRS Zuri, and the PDF showed higher values for cv. Xaraés.

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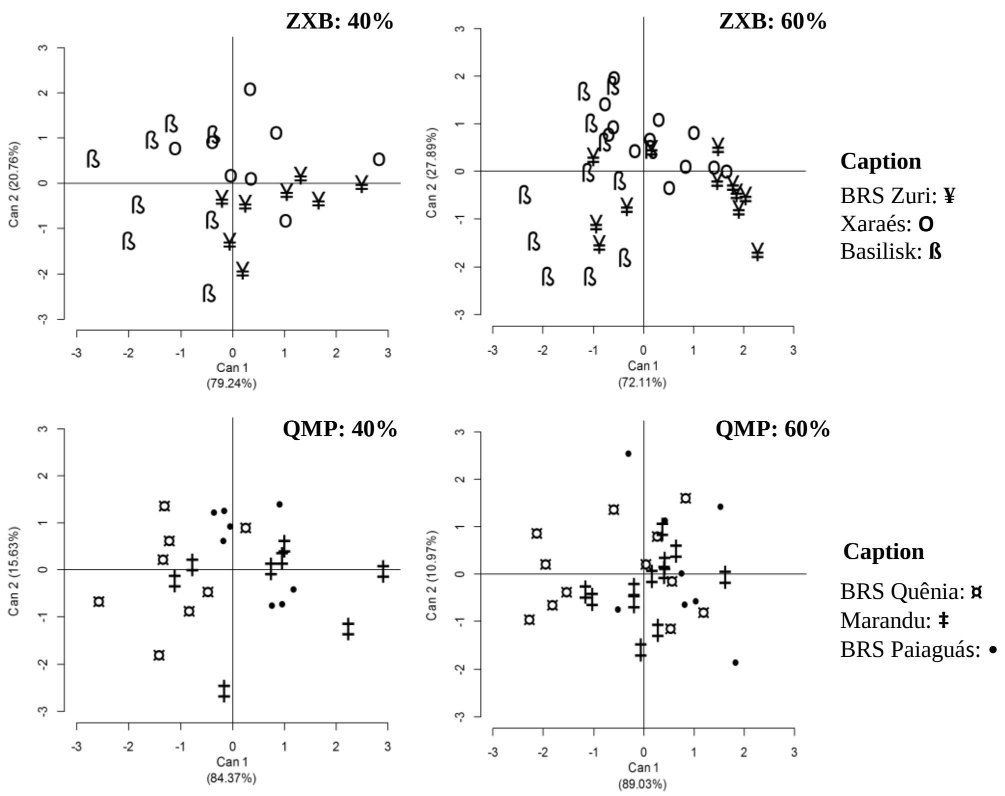
Fig. 2 – Distribution of defoliation pattern.



Distribution of the first (*x-axis*) and second (*y-axis*) canonical variable of each grass on the intercropped managed with 40% and 60% of removal of the forage canopy height. ZXD: *Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraés e *Brachiaria decumbens* cv. Basilisk; QMP: *Panicum maximum* BRS Quênia, *Brachiaria brizantha* cv. Marandu e *Brachiaria brizantha* cv. BRS Paiaguás.

QMP Intercropped

In the QMP intercropped managed with an intensity of 40% of the forage canopy removal, the standardized canonical coefficients of Can1 showed that the ETDS and PDF are the variables that most interfere with the first canonical variable, in a negative and positive way, respectively. When 60% of the forage canopy height was removed, the standardized canonical coefficients of the Can1 showed that the PDS, PDF and ETDF are the variables that most interfere with the first canonical variable. This indicates that these are the variables that most interfere on the differentiation between the defoliation patterns of the forage evaluated (Table 3).

In the QMP intercropped, Can1 explained 84.3 and 89.0%, whilst Can2 showed 10.9 and 15.6% of the total variation of the defoliation pattern, for grazing intensity levels of 40 and 60%, respectively (Fig. 2).

The canonical coefficients of Can1 (Table 3) reveal that in the QMP intercropped with the intensity of 40% the cv. BRS Quênia presents the highest values of ETDS in the positive quadrants (Fig. 2) while the ETDF and PDF are more effective on cv. BRS Paiaguás.

In the grazing intensity of 60%, the association between the canonical coefficients (Table 3) and Can1 (Fig. 2), due to equidistribution of the points, the cv. BRS Quênia presents high values of PDS, PDF and ETDF. While cv. BRS Paiaguás in the negative quadrants presents the highest values of ETDF and cv. Maradu presents greater distribution of points close to neutrality.

4. Discussion

Defoliation dynamics between intercropped

The results show that at the level of defoliation depth there is a difference between the intercropped (Table 2). Moreover, it is possible to infer that the QMP intercropped presented ETDS close to the values considered adequate (30-40%) to maximize the intake of forage (Baumont et al., 2004; Lemaire et al., 2009, Fernandes et al., 2020).

Possibly this event is associated with a larger population of tillers that the QMP intercropped presented (580-670 m^{-2} tillers for grazing intensity levels of 40 and 60% respectively; Table 1). This can be explained by the fact that denser forage canopies produce lighter tillers with lower volumetric density (Da Silva & Sbrissia, 2010), which may favor in higher defoliation depths and potentialize forage intake (Benvenutti et al., 2009). The results show that at the level of defoliation depth there is a difference between the intercropped (Table 2). Moreover, it is possible to infer that the QMP intercropped presented ETDS close to the values considered adequate (30 and 40%) to maximize the intake of forage (Baumont et al., 2004; Lemaire et al., 2009).

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ZXB Intercropping

Considering the defoliation pattern of the ZXB intercropping presented by the Can1 for the intensity of 40%, it is possible to note that the 'Basilisk' and 'Xaraés' grasses allowed higher estimates of ETDS and PDS, while cv. BRS Zuri provides a standard of defoliation severity for extended tiller and normal pseudostem. It is possible that this is associated with the way that the height goals were defined, since the height was based on the pre-grazing and post-grazing period, using the cv. BRS Zuri. Its size higher than that of the grasses belonging to the genus *Brachiaria* and its higher pseudostem growth caused the animals to modify the positioning of the bite. This is a strategy adopted to prioritize the consumption of vegetable tissues less lignified per bite (Carvalho et al., 2013), which may have influenced the higher intake of plants of the genus *Brachiaria*.

On the other hand, cv. Basilisk presents little contribution on the forage mass, due to lower tiller population in relation to other cultivars (Table 1), being below the goal that was established in the implantation of the intercropping. Therefore, during the period of canopy stabilization, the process of organogenesis of this grass was possibly impaired due to the high severities of defoliation in the tiller and pseudostem, impacting on beheadings of meristems, and causing a premature mortality of tillers (Santana et al., 2017; Rueda et al., 2018). Thus inhibiting the competitiveness of the cv. Basilisk for resources, and flexibilizing the perennity of the grasses 'Xaraés' and 'BRS Zuri'. However, when grazing intensity is increased to 60%, the ZXB intercropping shows that there were increases in defoliation on the cv. BRS Zuri, since to supply the forage dry matter intake, the animals increased the defoliation depth of the pseudostem. Nevertheless, the occurrence of this event does not favor the cv. Basilisk, as a population density of tillers is also observed below expectations (Table 1). This suggests that, when a similar defoliation scale occurs between larger and smaller tropical climate grasses, there will be intra-specific competition for resources in the intercropping, being something undesirable when the plant biodiversity is to be perpetuized (Hodgkinson, 1980).

For both intercropped, Can2 reinforces that the cultivars belonging to the genus *Brachiaria* have greater preference, due to the higher values of PDF. Although pseudostem is the least desirable botanical component due to low nutritive value (Fonseca et al., 2013), in the *Brachiaria*, pseudostem has an easier harvesting due to lower shear force (Benvenutti *et al*., 2009; Jacobs *et al*., 2012), justifying the largest defoliation scale.

QMP intercropping

Under moderate grazing intensity (40%) the cv. BRS Quênia presents the highest number of tillers (Table1), and in addition, high values of ETDS are observed in relation to the other grasses of the intercropping. However this did not impact on higher preference rates, because the highest values of ETDF and PDF were observed in cv. BRS Paiaguás, indicating that in this management situation the effect of tiller population density does not influence the preference process among the grasses.

When grazing intensity increases (60%) the animals exert a greater depth of defoliation and preference in cultivars 'BRS Quênia' and 'BRS Paiaguás'. In the QMP intercropping it is acceptable that *Panicum* presents greater preference due to greater population density of tillers (Table 1) allied to greater ease of harvesting due to accessibility of the botanical components of the tiller (Zanini et al., 2012). Although cv. Marandu presented the second highest population density of tillers in the intercropping, it did not imply on higher preference values, because as well as cv. BRS Quênia and cv. BRS Paiaguás, it presented higher estimates of ETDF.

Possibly, the highest values in the frequency of defoliation in cv. BRS Paiaguás is associated with high nutritive value (Valle et al., 2013; Oliveira et al., 2019) and the smallest pseudostem diameter in relation to other tropical climate grasses (Nakao et al., 2018) which potentializes into higher defoliation values.

At the same time, the occurrence of supergrazing in cv. BRS Paiaguás can impair its longevity in the intercropping, because in terms of competitiveness, grasses of the genus *Brachiaria* spp. in relation to *Panicum* spp. have lower gain in leaf area after defoliation (Silva *et al*., 2016). Thus the early shading of the dominant grass can reduce the passage of light to the base of the canopy (Almeida et al., 2017), inhibiting the development of the basilary buds and young tillers (Santos et al., 2017) compromising the lower-sized grass growth.

Implications

The choice of forage species of tropical climate to form the intercropping may be decisive in order to perpetuate plant diversity. Thus, from the population density of tillers, it is possible to observe that grasses belonging to functional groups A and B have a higher probability of coexisting in the same area.

In addition, the genus *Panicum* contributes more significantly in the forage mass. Therefore, it is the grass that most influences the consumption and it is responsible for balancing the stocking rate, but this will only occur when the management and maintenance criteria supply its own production requirement.

In relation to grazing intensities (40 and 60% of height removal) the grasses belonging to the functional group C 'Basilisk' and 'BRS Paiaguás' present higher probability of disappearance due to supergrazing and for presenting less competitive aptitude, which makes their use in the intercropping less attractive. Therefore, it is recommended to form the intercropping of tropical climate pasture, grasses that present the same height, in order to maintain the same accessibility for defoliation, and to reduce the effects of intra-specific competition for resources.

5. Final considerations

The choice of forage species for the establishment of intercropped pastures is important to ensure the coexistence between them and the persistence of the intercropping.

The analysis of canonical variables assists in explaining the dynamics of defoliation of intercropped through the estimates of severity and frequency of defoliation of extended tiller and pseudostem.

Even in the intermittent grazing management system, the increase in efficiency causes changes due to the increase of defoliation depth of tillers and pseudostem, which may compromise the persistence of some species of the intercropping.

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References

Almeida, R. E. M.; Gomes, C. M., Lago, B. C., Oliveira, S. M., Junior, C. P., & Favarin, J. L (2017)). Produtividade de milho, produção e qualidade de forragem afetadas pelos métodos de consórcio do milho com *Panicum maximum*. *Pesquisa Agropecuária Brasileira*, *52*(3), 170-176. doi: 10.1590/S0100-204X2017000300004.

Barbosa, R. A., Medeiro-Neto, C. D., Zimmer, A. H., Macedo, M. C. M., Fernandes, P. B., & Sbrissia, A. F. 2018. Alternativas para o estabelecimento de consórcios de gramíneas tropicais. *Embrapa Gado de Corte Comunicado Técnico, 147*(1) 1-19.

Baumont, R., Cohen-Salmon, D., Prache, S., & Sauvant, D. (2004). A mechanistic model of intake and grazing behaviour in sheep integrating sward architecture and animal decisions. *Animal Feed Science and Technology*, *112*(2004), 5-28. doi: 10.1016/j.anifeedsci.2003.10.005.

Beloni, T., Santos, P. M., Rovadoscki, G. A., Balachowski, J., & Volaire, F. (2018). Large variability in drought survival among *Urochloa* spp. cultivars. *Grass and Forage Science, 73*(4), 947-957. doi: 10.1111/gfs.12380.

Benvenutti, M. A., Gordon, I. J., Poppi, D. P., Crowther, R., Spinks, W., & Moreno, F. C. (2009). The horizontal barrier effect of stems on the foraging behaviour of cattle grazing five tropical grasses. *Livestock Science, 126*(2009), 229-238. doi: 10.1016/j.livsci.2009.07.006

Braz, T. G. D. S., Martuscello, J. A., Jank, L., Fonseca, D. M. D., Resende, M. D. V., & Evaristo, A. B. (2017). Genotypic value in hybrid progenies of *Panicum maximum* Jacq. *Ciência Rural, 47*(9), e20160599. doi: 10.1590/0103-8478cr20160599

Carvalho, P. C. F. (2013). Harry Stobbs Memorial Lecture: Can grazing behavior support innovations in grassland management?. *Tropical Grasslands-Forrajes Tropicales, 2*(1), 137-155. 10.17138/TGFT(1)137-155

Castagnara, D. D., Zoz, T., Krutzmann, A., Uhlein, A., Mesquita, E. E., Neres, M. A., & de Oliveira, P. S. R. (2011). Produção de forragem, características estruturais e eficiência de utilização do nitrogênio em forrageiras tropicais sob adubação nitrogenada. *Semina: Ciências Agrárias, 32*(4), 1637-1647. doi: 10.5433/1679-0359.2011v32n4p1637.

Cruz, P., Duru, M., Therond, O., Theau, J. P., Ducourtieux, C., Jouany, C., & Ansquer, P. (2002). Une nouvelle approche pour caractériser les prairies naturelles et leur valeur d'usage. *Fourrages, 172*(2002), 335-354.

Da Silva, S. C., & Sbrissia, A. F. (2010). Análise de componentes principais entre características morfogênicas e estruturais em capim-marandu sob lotação contínua. Ciência Rural 40(3): 690-693. doi: 10.1590/S0103-84782010000300034.

Duchini, P. G., Guzatti, G. C., Echeverria, J. R., Américo, L. F., & Sbrissia, A. F. (2018). Experimental evidence that the perennial grass persistence pathway is linked to plant growth *strategy*. *Plos one*, *13*(11), e020736. doi: 10.1371/journal.pone.0207360.

Duchini, P. G., Guzatti, G. C., Ribeiro Filho, H. M. N., & Sbrissia, A. F. (2013). Tiller size/density compensation in temperate climate grasses grown in monoculture or in intercropping systems under intermittent grazing. *Grass and Forage Science*, *69*(4), 655-665. doi: 10.1111/gfs.12095.

Euclides, V. P. B., Macedo, M. C. M., do Valle, C. B., Barbosa, R. A., & Gonçalves, W. V. (2008). Produção de forragem e características da estrutura do dossel de cultivares de *Brachiaria brizantha* sob pastejo. *Pesquisa Agropecuária Brasileira*, *43*(12), 1805-1812. doi: 10.1590/S0100-204X2008001200023.

Euclides, V. P. B., Montagner, D. B., Barbosa, R. A., Valle, C. B. D., & Nantes, N. N. (2016). Animal performance and sward characteristics of two cultivars of *Brachiaria brizantha* (BRS Paiaguás and BRS Piatã). *Revista Brasileira de Zootecnia*, *45*(3), 85-92. doi: 10.1590/S1806-92902016000300001.

Fernandes, P. B., Barbosa, R. A., de Oliveira, R. T., de Oliveira, C. V. V., & de Medeiros-Neto, C. (2020). Defoliation dynamics of *Brachiaria brizantha* pastures with distinct structural characteristics. *Bioscience Journal*, *31*(1), 203-211. doi: 10.14393/BJ-v36n1a2020-42211.

Ferreira, E. B., Cavalcanti, P. P., & Nogueira, D. A. (2014). ExpDes: an R Package for ANOVA and experimental designs. *Applied Mathematics*, *5*(19), 2952–2958. doi: 10.4236/am.2014.519280.

Fonseca, L., Carvalho, P. D. F., Mezzalira, J. C., Bremm, C., Galli, J. R., & Gregorini, P. (2013). Effect of sward surface height and level of herbage depletion on bite features of cattle grazing *Sorghum bicolor* swards. *Journal of animal Science, 91*(9), 4357-4365. doi: 10.2527/jas2012-5602.

Garcez, T. B., & Monteiro, F. A. (2016). Nitrogen use of '*Panicum*' and '*Brachiaria*' cultivars vary with nitrogen supply: II Nitrogen use efficiency rankings and partition. *Australian Journal of Crop Science, 10*(5), 622-631. doi: 10.21475/ajcs.2016.10.05.p6853B.

Gross, K., Cardinale, B. J., Fox, J. W., Gonzalez, A., Loreau, M., Wayne Polley, H., ... & van Ruijven, J. (2013). Species Richness and the Temporal Stability of Biomass Production: A New Analysis of Recent Biodiversity Experiments. *The American Naturalist, 183*(1), 1-12. doi: doi.org/10.1086/673915.

Heitschmidt, R. K., BRISKEt, D. D., & Price, D. L. (1990). Pattern of interspecific tiller defoliation in a mixed-grass prairie grazed by cattle. *Grass and Forage Science, 45*(2), 215-222. doi: 10.1111/j.1365-2494.1990.tb02201.x.

Hodgkinson, K. C. (1980). Frequency and extent of defoliation of herbaceous plants by sheep in a foothill range community in northern Utah. *Journal of Range Management, 33*(3), 164-169. doi: 10.2307/3898276.

Hodgson, J. (1966). The frequency of defoliation of individual tillers in a set stocked sward. *Journal of the British Grassland Society, 21*(4), 258-263. doi: 10.1111/j.1365-2494.1966.tb00483.x.

Jacobs, A. A. A., Scheper, J. A., Benvenutti, M. A., Gordon, I. J., Poppi, D. P., & Elgersma, A. (2013). Gradients in fracture force and grazing resistance across canopy layers in seven tropical grass species. *Grass and Forage Science, 68*(2), 278–287. 10.1111/j.1365-2494.2012.00900.x.

Lemaire, G., Da Silva, S. C., Agnusdei, M., Wade, M., & Hodgson, J. (2009). Interactions between leaf lifespan and defoliation frequency in temperate and tropical pastures: a review. *Grass and Forage Science, 64*(4), 341–353. doi: 10.1111/j.1365-2494.2009.00707.x.

Mazzanti, A., Lemaire, G., Gastal, F. (1994). The effect of nitrogen fertilization upon the herbage production of tall fescue swards continuously grazed by sheep. 1. Herbage growth dynamics. *Grass and Forage Science 49*(2): 111–120. doi: 10.1111/j.1365-2494.1994.tb01983.x.

Nakao, A. H., Andreotti, M., Soares, D. D. A., Modesto, V. C., & Dickmann, L. (2018). Intercropping *Urochloa brizantha* and sorghum inoculated with *Azospirillum brasilense* for silage. *Revista Ciência Agronômica, 49*(3), 501-511. doi: 10.5935/1806-6690.20180057.

Oliveira, C. V. V., Barbosa, R. A., Oliveira, R. T., Almeida, E. M., Paludo, F., Lima, J. S. & Fernandes, P. B (2020). The tissue flow in *Brachiaria brizantha* pasture under intermittent stocking. *Journal of Agricultural Studies, 8*(1), 9 17. doi: doi:10.5296/jas.v8i1.15441

Oliveira, R. T., Barbosa, R. A., Oliveira, C. V. V. & Fernandes, P. B. (2019). Multivariada da biomassa de forragem e valor nutritivo em pastos de *Brachiaria brizantha*. *Colloquium Agrariae*, *15*(4), 107-113. doi: 10.5747/ca.2019.v15.n4.a317.

Portela, J. N., Pedreira, C. G. S. & Braga, G.J. (2011). Demografia e densidade de perfilhos de capim‑braquiária sob pastejo em lotação intermitente. *Pesquisa Agropecuária Brasileira, 46*(3), 315-322. doi: 10.1590/S0100-204X2011000300013.

Roca-Fernández, A. I., Peyraud, J.L., Delaby, L. & Delagarde, R. (2016). Pasture intake and milk production of dairy cows rotationally grazing on multi-species swards. *Animal, 10*(9), 1448-1456. doi: 10.1017/S1751731116000331.

Rodrigues, C. S., Nascimento Júnior, D. D., Detmann, E., Da Silva, S. C., Sousa, B. M. D. L. & Silveira M. C. T. D. (2012). Functional clusters of tropical forage grasses. Revista Brasileira de Zootecnia, 41(), 1385-1393. doi: 10.1590/S1516-35982012000600010.

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