

Tropical Forage Grasses Intercropped Under Lenient Grazing Intensities Promote Greater Soil Cover

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Received: Oct. 3, 2019

Accepted: Dec. 5, 2019

Published: Dec. 23, 2019

doi:10.5296/jas.v8i2.16121

URL: <https://doi.org/10.5296/jas.v8i2.16121>

Abstract

The diversity of grasses in the intercropping promotes greater soil cover regardless of the grazing intensity used. The aim was evaluated how cultivation systems (monoculture and intercropped) influence the proportion of soil discovered under different grazing intensities. The experiment was conducted at the premises of the Brazilian Agricultural Research Company. The pastures were combined two cultivation systems: monoculture of *Panicum maximum* cv. BRS Zuri; intercropping of *Panicum maximum* cv. BRS Zuri, *Brachiaria brizantha* cv. Xaraes and *Brachiaria decumbens* cv. Basilisk. Four evaluation cycles were performed, which totaled in 2136 observations. In the contrast between evaluation cycles, it is possible to infer that cycles II, III and IV have a negative effect in relation to cycle I, because after the first evaluation there is an increase in the proportion of soil discovered in the pastures studied. In relation to cultivation systems, the intercropped managed at high grazing intensities impacts negative effects, and it is possible to observe the highest values of uncovered soil, as well as the lowest tussock distribution values. The intercropping of tropical climate pastures has greater soil cover when managed in lenient grazing intensity.

Keywords: cultivation systems, straw, tussocks

1. Introduction

Agricultural management stemming from the increase in straw in soil cover or incorporated enhances primary productivity, due to the positive influence on soil biology and chemical composition, in addition to promoting greater atmospheric carbon sequestration (Han et al. 2018), similarly, to vegetation cover decreases to soil loss by erosion, reducing penetration resistance, positively impacting the root development of the plant (Cassol and Lima 2003; Theodoro et al. 2018).

The mixing grasses belonging to different functional groups can improve natural resource uptake, at the same time, due to plant variability in the same physical space, promote reduction in spontaneous vegetation (Van Ruijven and Berendse, 2003; Cardinale et al. 2007; Sanderson et al. 2007; Duchini et al. 2018). However, these events are observed only in temperate environments.

For regions of tropical climate, there is a predominance of pastures grown in monoculture, and even if it is well managed there are reports of invasive plants coexisting with grass of agronomic interest (Menarin et al. 2017). In view of this, Barbosa et al. (2018) suggested a proposal for an intercropping between *Panicum* and *Brachiaria*, because in theory the

combination of these two genera will occupy distinct space niches, promoting greater soil coverage through tussock and straw deposition.

On the other hand, it is necessary to remember that in intermittent stocking management to residual height targets influence residual residue post-grazing (Benvenuti et al. 2015; Silva et al. 2016), thus, it is expected that the diversity of grasses in the intercropping promotes a greater soil cover regardless of the grazing intensity used.

The aim evaluated how cultivation systems (monoculture and intercropped) influence the proportion of soil discovered under different grazing intensities.

2. Material and Methods

Experimental location

The experiment was carried out in Brazilian Agricultural Research Company (EMBRAPA Beef Cattle), located in Campo Grande - MS (20°27'S 54°37'W and 530 m above sea level). The experimental area was 2.25 hectares (ha) subdivided into 9 units of 0.25 ha, where the treatments were randomly allocated. In addition, an area of 1.75 ha was used as a backup for the maintenance of the animals that were used to lower the height of the pastures, with pasture implementation in September 2016, and the start of evaluations in December 2017 through April 2018.

Climate

The climate of the region according to the Köppen classification is the tropical rainy savannah type, subtype Aw, characterized by the well-defined occurrence of the dry period during the colder months of the year and rainy season during the summer months. The temperature and precipitation data during the experimental period were recorded by the meteorological station (A702-INMET) located in Campo Grande-MS (Figure 1), and it is possible to observe good rainfall distribution during the period of data collection.

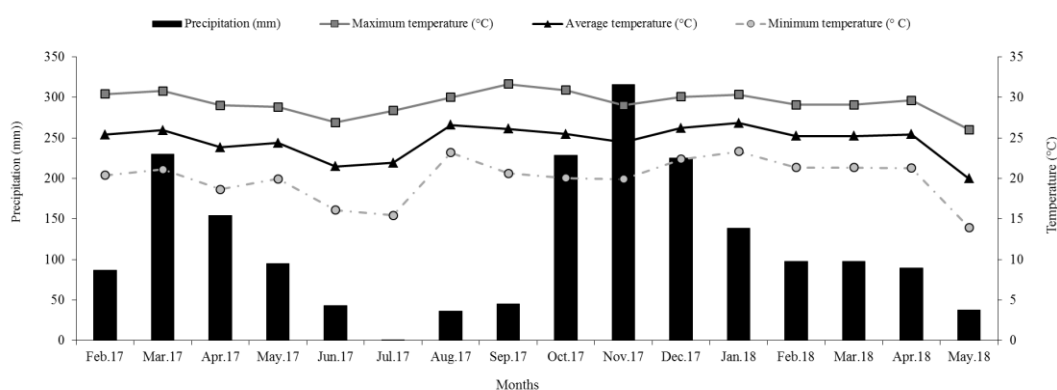


Figure 1. Average, minimum and maximum temperatures and monthly precipitation from February 2017 to May 2018

Soil

Before the implantation of the experiment, soil was collected in the 0 – 20 cm layer and sent

to the laboratory for chemical and textural analysis (September 2016). The soil of the experimental area was classified as Dystrophic Red Latosol (Santos et al. 2018); characterized by clayey texture; pH in H₂O 5.65; 41.6 g dm⁻³ organic matter; 0.71 mg dm⁻³ phosphorus; 0.16 cmolc dm⁻³ potassium; 2.20 cmolc dm⁻³ de calcium, 0.95 cmolc dm⁻³ magnesium; 5.48 cmolc dm⁻³ aluminum and hydrogen; 37.66% base saturation; 8.79 cmolc dm⁻³ cation exchange capacity.

Pre-Experimental Management and Treatments

Based on the results of the soil analysis, 1 ton ha⁻¹ of dolomitic limestone (September 2016) was applied in the implantation of the experiment. The stabilization was carried out with covering fertilization of 80 kg ha⁻¹ of P₂O₅ and K₂O (November 2017), and 150 kg ha⁻¹ of nitrogen were applied, divided in three applications (December 2017, February and March 2018).

The pastures were combined two cultivation systems: monoculture of *Panicum maximum* cv. BRS Zuri and intercropping of *Panicum maximum* cv. BRS Zuri with *Brachiaria brizantha* cv. Xaraes and *Brachiaria decumbens* cv. Basilisk. The pastures were distributed in nine paddocks, three paddocks intended for monoculture, and the rest of the paddocks were destined for the intercropping managed under two grazing intensities.

The sowing was done in February 2017, based on the expectation of initial generation of 50% of the tiller population of *Panicum* and of 50% equally divided among the species of *Brachiaria* spp. In order for this population density to be achieved, cultural values of 20% for the species of *Panicum* and of 50% for each cultivar (cv.) of *Brachiaria* spp. were considered, according to the number of viable pure seeds of each lot.

The lowering of the pasture height was performed by Caracu breed cows, with approximately 24 months of age and average body weight of 450 kg belonging to the EMBRAPA herd. The pre-grazing goals were based on previous measurements of light interception by the forage canopy of each intercropping in order to identify the height at which the pastures intercepted about 95% of the incident light, and the heights of pre-grazing of 80 cm for monoculture, managed in moderate grazing intensity (50%); and for the intercropping, a pre-grazing height of 70 cm was established, in two grazing intensities 40% and 60%, respectively.

Vegetation cover

The vegetation cover of the pastures was evaluated with the aid of a nylon rope of thirty meters graduated every meter by a knot. In post-grazing, the rope was aligned in the diagonal position within the picket and at each point (knot) was classified the area with vegetation cover (Tussock or straw) and discovery area (Adapted from Theodoro et al. 2018). The rope was allocated in three regions within each paddock, totaling 90 points per paddock. During the evaluations, there was no spontaneous vegetation. Four evaluation cycles were performed, which totaled in 2136 observations.

Statistical analysis

Because the database was of binary origin, it was necessary to use a logistic regression model. Non-significant random variables were removed from the initial model and a new model was adjusted. When all random variables were removed, a linear model of fixed effects was used. For the analyses, the *glm* function of the *Lme4* package (Kuznetsova et al. 2017) of the R version 3.6.1 program used. Through the generated model, the mean square decomposition of the precision error (Mean bias, systematic bias and random error) was decomposing of the mean square using the *MES* program (Tedeschi, 2006).

3. Results

There was no interaction for grazing intensity and evaluation cycles, however, oscillations were observed between residual height targets, and there is disproportionate during evaluation cycles (Table 1).

Table 1. Deviance analysis for the factors used in the models in different cultivation systems

Factors	Degrees of freedom	χ^2	Pr(> χ^2)*
Evaluation cycles	3	53.84	<0.001
Cultivation systems	2	102.89	<0.001
Evaluation cycles: Cultivation systems	6	3.14	0.791

*Probability of significant effect based on chi-square distribution (χ^2).

Complete Model

When the unfolding was performed considering the main variables, there are not interactions between the evaluation cycles and grazing intensity by the likelihood ratio test (Table 2), so there is a need to perform the model adjustment to verify that changes occur in the slope of estimates.

Table 2. Estimates of fixed effects considered in the model for different cultivation systems

Variable	Estimative	CI (97.5%)	Standard error	Z value	Pr(> z)*
Intercept	2.40	[1.21; 3.57]	0.603	3.98	<0.001
CII	-1.07	[-2.30; 0.161]	0.630	-1.70	0.089
CIII	-1.55	[-2.76; -0.340]	0.617	-2.51	0.012
CIV	-1.15	[-2.37; 0.087]	0.629	-1.82	0.069
M50%	-1.34	[-2.59; -0.093]	0.638	-2.11	0.035
C60%	-1.70	[-2.94; -0.465]	0.632	-2.70	0.007
CII: M50%	0.541	[-0.794; 1.87]	0.681	0.794	0.427
CIII: M50%	0.585	[-0.714; 1.88]	0.663	0.882	0.378
CIV: M50%	0.269	[-1.06; 1.60]	0.679	0.396	0.692
CII: C60%	0.746	[-0.569; 2.06]	0.671	1.11	0.266
CIII: C60%	0.581	[-0.708; 1.86]	0.658	0.883	0.377
CIV: C60%	0.319	[-1.03; 1.67]	0.690	0.461	0.645

CI: confidence interval. *Likelihood ratio test. CII: cycle II; CIII: cycle III; CIV: cycle IV. M50%: monoculture handled at 50%. C60%: intercropping managed in grazing intensity of 60%.

Adjusted Model

Disregarding the interaction effect makes the model simpler, making it more flexible to visualize variables that have a significant effect. Therefore, due to the inclination of the estimates for the evaluation cycles II, III and IV there was a negative effect. For the intercropping managed with 60% post-grazing intensity and monoculture managed at intensity of 50%, there is negative effects (Table 3).

Table 3. Estimates of fixed effects considered in the adjusted model for the different cultivation systems

Variable	Estimative	CI (97.5%)	Standard error	Z value	Pr(> z)*
Intercept	1.92	[1.58; 2.24]	0.169	11.38	<0.001
CII	-0.481	[-0.800; -0.160]	0.163	-2.94	0.003
CIII	-1.02	[-1.32; -0.712]	0.156	-6.52	<0.001
CIV	-0.808	[-1.14; -0.470]	0.172	-4.70	<0.001
M50%	-0.873	[-1.10; -0.639]	0.119	-7.34	<0.001
C60%	-1.16	[-1.39; -0.920]	0.121	-9.56	<0.001

CI: confidence interval.*Likelihood ratio test. CII: cycle II; CIII: cycle III; CIV: cycle IV. M50%: monoculture handled at 50%. C60%: intercropping managed in grazing intensity of 60%.

Model Validation

After model adjustment it was possible to verify that 100% of the error was random source, and that the predicted data are similar to the observed data (Table 4).

Table 4. Decomposition of the average prediction error square for the set model

MSEP decomposition (%)			
Mean bias	Systematic bias	Random error	P value
0.00	0.00	100.00	0.999

P value: probability of significant effect of predicted data in relation to the observed data.

Contrasts Between Significant Variables

In the contrast between evaluation cycles it is possible to infer that cycles II, III and IV have a negative effect in relation to cycle I (Table 5), because after the first evaluation there is an increase in the proportion of soil discovered in the pastures studied (Figure 2A). In relation to cultivation systems, the intercropping managed at high grazing intensities impacts negative effects (Table 5), and it is possible to observe the highest values of uncovered soil, as well as the lowest a tussock distribution values (Figure 2B).

Table 5. Estimates of fixed effects considered in the adjusted model for the contrast between grazing cycles, and between grazing intensities for cultivation systems

Variable	Estimative	Standard error	Z value	Pr(> z)*
Pasture evaluation cycle				
CII - CI	-0.481	0.163	-2.94	0.017
CIII - CI	-1.02	0.156	-6.52	<0.001
CIV - CI	-0.808	0.172	-4.70	<0.001
CIII - CII	-0.538	0.115	-4.68	<0.001
CIV - CII	-0.327	0.135	-2.42	0.072
CIV - CIII	0.211	0.124	1.70	0.318
Grazing intensities for each cultivation system				
M50% - C40%	-0.873	0.119	-7.34	<0.001
C60% - C40%	-1.16	0.121	-9.56	<0.001
C60% - M50%	-0.285	0.108	-2.64	0.023

CI: cycle I; CII: cycle II; CIII: cycle III; CIV: cycle IV. *Likelihood ratio test. M50%: monoculture handled at 50%. C40%: intercropping managed in grazing intensity of 40%. C60%: intercropping managed in grazing intensity of 60%.

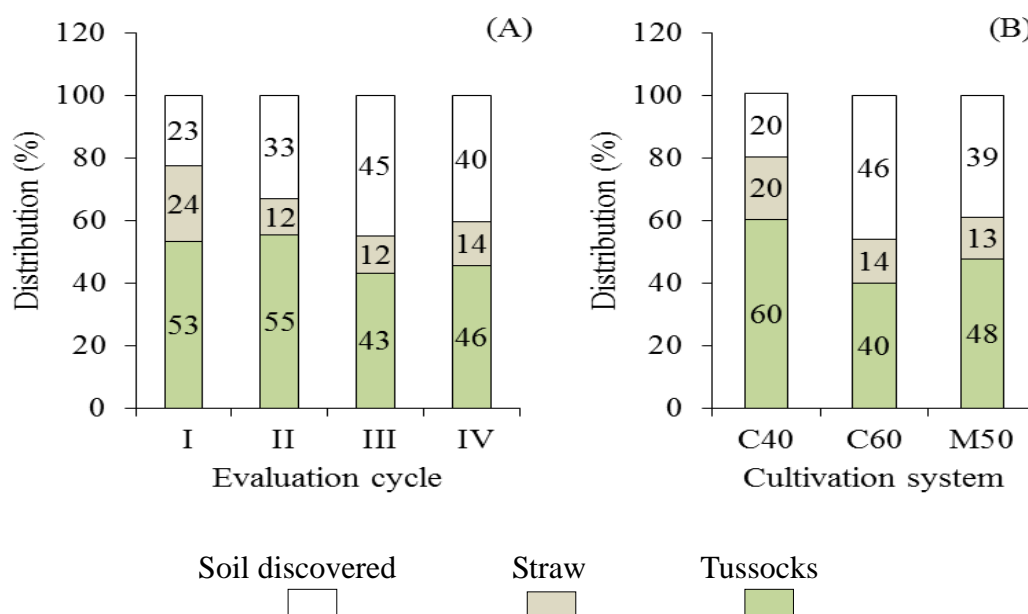


Figure 2. Horizontal distribution of tussocks, straw and soil discovered between grazing cycles (A) and cultivation systems (B). I: cycle I; II: cycle II; III: cycle III; IV: cycle IV. M50%: monoculture handled at 50%. C40%: intercropping managed in grazing intensity of 40%. C60%: intercropping managed in grazing intensity of 60%

4. Discussion

With the course of evaluations, it is possible to infer that cultivation systems tend to stability in the deposition of straw in soil cover, with values ranging from 12% and 14% (Figure 2A). Possibly, the fact that low straw estimates are observed is climate-related; at the time of the waters combined with the high incidence of solar radiation accelerates the decomposition of dead vegetation cover, negatively influenced by soil cover (Guimarães et al. 2016; Liu et al. 2018; Miehe et al. 2019). It should be noted that, through the mineralization of organic matter, the supply of nutrients to plants occurs (Buysse et al. 2013) which can decrease the input of chemical fertilizers in the system, resulting in economic and environmental gains.

Despite the differences in pre-grazing heights for cultivation systems, it is pertinent to emphasize that pastures were managed with the purpose of achieving the rate of critical foliar area, i.e., enhancing the maximum production of leaves when the canopy presents 95% of light interception (Davies, 1993; Menezes et al. 2019). On the other hand, residual height targets influence the period that pasture is at rest until it reaches the height of pre-grazing (Sbrissia et al. 2018).

The *Panicum* pastures managed at moderate grazing intensities there is acceleration in leaf area dynamics, promoting a greater number of grazing cycles throughout the year (Barbosa et al. 2007), and consequently impacts a short interval of uncovered soil time; reducing the manifestation of undesirable vegetation. Therefore, it can be inferred that in this experimental situation, the monoculture of 'BRS Zuri' was not challenged, because the management goal used should positively impact soil cover, however, this did not occur, due to the low values of distribution of tussock and straw (Tables 3 and 4; Figure 2B).

On the other hand, regardless of the cultivation system, spontaneous vegetation was not quantified during the experimental period (Figure 2), thus, it is possible that pastures in monoculture of 'BRS Zuri' managed in moderate grazing intensities inhibit the coexistence plants that have no agronomic interest. In addition, *Panicum* pastures managed at moderate heights it is possible to ensure higher estimates of secondary production (Euclides et al. 2018). On the other hand, this cultivation strategy is not ecologically promising, because it is noticed that approximately 39% of the area had uncovered soil (Figure 2B). In such a way, the management strategy in monoculture may impair the physical and chemical quality of the soil. This scenario it is recommended to periodically monitor the dynamics of nutrients in the soil, to prevent possible negative effects.

In pastures intercropped under severe grazing intensities (60%) it is possible to estimate the highest soil values discovered in relation to other cultivation systems (Figure 2B). The diversity of grasses does not positively affect, so apparently adopting low residual management heights in the consortium seems to be unpromising when soil conservation is intended.

On the other hand, in the intensity of lenient grazing it is noted that 80% of soil area is covered by tussock sanders and straw (Figure 2B), therefore, it is possible to infer that the management goal adopted positively impacts soil cover, indicating that there will be lower probabilities of degradation and soil losses, and improvements in soil chemistry, biology and physics, as observed by Epifanio et al. (2019) who managed pastures intercropped in moderate defoliation intensity, found that the cultivation system raised the organic maintaining soil content, an event that can directly influence carbon deposition in the soil.

5. Conclusion

The intercropping of tropical grasses promotes greater soil cover when managed in lenient grazing intensity.

Acknowledgements

To the coordination of improvement of higher education personnel-Brazil (CAPES)-Financing Code 001, Federal University of Mato Grosso do Sul and Embrapa-Beef Cattle for financial support.

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