WCCLF 2021
II WORLD CONGRESS ON INTEGRATED CROP-LIVESTOCK-FORESTRY SYSTEMS
May 4th and 5th, 2021 - 100% Digital

ESTABLISHMENT AND PRODUCTION OF FORAGE GRASSES UNDER DIFFERENT LEVELS OF SHADING IN AN INTEGRATED SYSTEM

Caroline Carvalho de OLIVEIRA [1]; Mariana PEREIRA [2]; Valéria Ana Corvalã dos SANTOS [3]; Gabriela Tomadon ROMAGNOLI [4]; Ademar Pereira SERRA [5]; Manuel Claudio Motta MACEDO [6]; Roberto Giolo de ALMEIDA [6]

[1] Animal Scientist. Postdoctoral Student. Instituto Federal Goiano; [2] Animal Scientist. PhD student. Hohenheim University; [3] Animal Scientist. Professor. Centro Universitário Aparício Carvalho; [4] Agricultural Engineer Student. Universidade Federal de Mato Grosso; [5] Agricultural Engineer. Analyst. Embrapa Beef Cattle; [6] Agricultural Engineer. Researcher. Embrapa Beef Cattle

ABSTRACT

The aim of this research was asses the establishment, yield and nutritive value of forage cultivars of *Brachiaria* and *Panicum* genus under different level of shading in integrated crop-livestock-forestry system (ICLF). The experiment was carried out in Embrapa Beef Cattle, Campo Grande-MS, Brazil, between April 2018 and June 2019. The randomized blocks design was used with split-plot scheme for establishment and production stage, with three repetitions. In order to assess the forages establishment, the treatments of the plots were the forages (*Brachiaria brizantha* cv. Marandu, cv. BRS Piatã, *Brachiaria* spp. cv. BRS Ipyporã, *Panicum maximum* cv. Massai and *Panicum* spp. cv. BRS Tamani) and split-plots the levels of shading between *Eucalyptus* rows [sampling points A (North), B (Center) and C (South)]. To assess the forage yield and nutritive value, the forage harvest took place at 60-day intervals (split-split-plots: cut 1, 2 and 3). The forage cultivars Piatã, Marandu and Massai showed higher leaf blade yield under shading environment, on the other hand Piatã was outstanding in relation to biomass yield and nutritive value.

Key words: *Brachiaria*; *Panicum*; shade

INTRODUCTION

The integrated systems have been developing in Brazil since 1970 decade and adopted with higher intensity from 2010, results of the improvement of Low Carbon Emission in Agriculture (ABC Plan). These integrated systems of production are promoted as worth options of sustainable intensification way for diversification and efficient use of the agriculture land. Besides, this integrated system decreases the environmental impact, especially with the carbon sequestration and mitigation of greenhouse gas emission. But, the implementation of trees into the production system can affect the biomass production of the forages species cultivars due to modification of the environment with shading. In ICLF, with the increment of trees growth there is decreasing in photosynthetically active radiation (PACIULLO et al., 2011), which affect the photosynthesis and biomass production associated with decreasing in nutritive value. Definition of forage species is crucial for the success of the system, because the species must have features quite specific as resistant to shading, besides the adaptation of the soil and environment in the region. Among the tropical forage grasses species used in Brazil, the *Brachiaria* and *Panicum* genders shows the features that is possible to implement into the integrated system, but the researches surround the shading tolerant must be improved in order to improve the biomass yield and nutritive value.

MATERIAL AND METHODS

The evaluation for this research in integrated crop-livestock-forest systems were carried out in April 2018 to June 2019 at the Embrapa Beef Cattle Research Center in Campo Grande, Mato Grosso do Sul State, the soil class of the area is a distroferric red latosol (LVdf), as described by Santos et al.

(2013). The area is located between the geographical coordinates: 20°27’04” S and 54º42’57” W, altitude of 530 m. The climatic pattern in the region is described, in accordance with Kottek et al. (2006), as transition zone between Cfa and Aw wet tropical. The mean annual rainfall is 1560 mm, with a wet summer and a dry winter, in Cerrado biome.

The randomized block design was used with split-plot scheme for establishment stage, with three repetitions. In order to assess the forages establishment, the treatments of the plots were the forages (*Brachiaria brizantha* cv. Marandu, cv. BRS Piatã, *Brachiaria* spp. cv. BRS Ipyporã, *Panicum maximum* cv. Massai and *Panicum* spp. cv. BRS Tamani) and split-plots the levels of shading between *Eucalyptus* rows [sampling points A (North), B (Center) and C (South)]. To assess the forage yield and nutritive value, after establishment stage, forage harvest occured at 60-day intervals (split-split-plots: cut 1, 2 and 3).

The integrated crop-livestock-forest systems were installed in January 2012. Soybean (*Glycine max* cv. BRS 285) was seeded in November 2011 in a conventional tillage system, and rows were marked out in advance for the later preparation of trenches in which *Eucalyptus* would be planted with the different spatial arrangements described subsequently. The planting of *Eucalyptus* clones was carried out after soybean was established. Preparation and planting took place in January 2012, with the planting trenches prepared using below-ground fertilizer, applying 200 g of the formula NPK 06-30-06 with 0.5% of zinc and 0.5% of boron per meter of trench. Cover fertilization of the *Eucalyptus* plants was carried out in two plots (3 and 9 months after planting), applying formula NPK 20-00-20 with 0.5% of boron and 0.5% of zinc, at a rate of 120 g plant^{-1} in each dressing.

For the planting, the tube surrounding each seedling was used to open a hole with the same dimensions as the root system of the seedling. The *Eucalyptus* seedlings measured on average 30 cm in height and were irrigated on the day of planting with 2 L of water per seedling. The spacing between the stands of Eucalyptus was 14 m, the gap was the space occupied by soybean crop (*Glycine max* cv. BRS 285) at the first year. After the harvested soybean, millet was sown as soil mulch for later planting in no-till system. In November 2012, the spaces between the *Eucalyptus* stands were again used for the cultivation of soybean in the summer, under no-till planting. After the soybean had been harvested, the forage grass, *Brachiaria brizantha* cv. Marandu, was sown in March 2013. Animals were put out to pasture, after the forage grass had been established, in June 2013. The first grazing in the area took place when the Eucalyptus trees showed diameter at breast height (DBH) bigger than 6 cm, which allowed for lower branches to be removed to obtain better quality timber and so that the animals could then move into the area.

Three Eucalyptus clones were used: Urocam VM1 (*Eucalyptus urophyla* × *E. camaldulensis*), Grancam 1277 (*E. grandis* × *E. camaldulensis*) and Urograndis I144 (*E. urophyla* × *E. grandis*) and two spatial arrangements (single and double row).

In the single row arrangement, the spacing was 14 m between stands and 2 m between trees in the row (14 m × 2 m), totaling 357 trees ha^{-1}. In the double row arrangements, spacing of 14 m between stands of trees were used, 3 m between rows within the stand and 2 m between trees in the row (3 m × 2 m) + 14 m, totaling 588 trees ha^{-1}.

The present experiment was carried out in March 2018 with the desiccation of weeds and seeding of the forage cultivars in April 2018 under plots of 12 m x 2.5 m and 0.5 m spaced between plots. The seeding rate was adjusted in 300 and 70 viable pure seeds per square meters for cultivars of gender *Panicum* and *Brachiaria*, respectively. In December 2018 after 230 days of sowed was made the uniformed cut at 15 cm height, which was followed by cuts into 60 days after regrowth. The cut for forage yield were in February (cut 1), April (cut 2) and June (cut 3) 2019 yr, which was considered for evaluation the height of 10 cm above the canopy of each cultivar. Right after the cut for forage harvest all experimental plots was uniformed at 15 cm of canopy height. For evaluation of forage yield were considered three points following the gradient of shading with point A (North) corresponding 3 meters of trees simple row, B (Center) into the center point between trees rows and point C (South) to 3 meters of double trees rows. By portable spectrometer were defined the photosynthetically active radiation (PAR) in each sampling point in the morning and in the afternoon. In order to evaluate the forage components were considered the sampling area of 1 m x 1 m in each point. The canopy height was obtained through the graduate rule in centimeter and the soil cover by visual observation in percentage. Thus, the forage cut was conducted right after in the level of soil. The forage samples were forwarded to laboratory to weight and separation of components as leaf blade, stem + sheath and senescent material. All these components were weighted and inserted in forced air circulation oven to 65^0C temperature until constant weight being weighted after the dry to obtain the dry matter content. The components of leaf blade were milled with a 20 *mesh* sieve and analyzed through near-infrared spectroscopy (NIRS) to defined the crude protein (CP) and neutral detergent fiber (NDF) (MARTEN et al., 1985).

The data were submitted to analysis of variance and, when there were significant differences between means up to 5% significance, the means were compared by Tukey test with 5% probability, using SAS software 9.2.

RESULTS AND DISCUSSIONS

In the trial period, the *Eucalyptus* trees showed on average height of 20 m. In relation to point A (North) the shading gradient close to simple rows showed higher PAR, followed by point C (South) close to double trees rows and point B (Center) corresponding to central point between the trees rows with 440, 339 and 295 µmol m^{-2} s^{-1}, respectively. Higher PAR in central point (B) was observed due to sun inclination during the day and year stations associated with trees height that promoted higher shading in this point.

In Table 1 there are the results related to the establishment of the forage cultivars after 230 days from seeding. The implementation of the forages in the end of the rain season in 2018 associated with delay of following rainfall season resulted in higher period of forages establishment. The forage canopy height was affected by interaction between cultivar *vs.* sampling point ($p<0.05$). In point A with higher PAR there was no significant difference in forage height with average of 44.6 cm. In point B with lower PAR the Piatã showed higher height (97 cm) with Marandu under intermediary position (66.7 cm) and the other cultivars as Ipyporã, Tamani and Massai did not differ among them showing average of 46.1 cm. Piatã showed higher height in all sampling points and Ipyporã, Tamani and Massai did not differ while Marandu showed higher height in sampling point C followed by B and A (Table 1).

It was observed effects on sampling point on cover soil, dry matter content and forage yield into the stage of cultivars establishment (Table 1). Cover soil and forage yield were higher in B and C points (average of 53.5% and 1,882 kg DM day^{-1}) in relation to point A (31% and 877 kg DM day^{-1}). While the content of dry matter was higher in point A (26%) where observed higher PAR followed by point B with intermediary and C with lower value.

In Table 2 were showed the results related to period of production of forage cultivars in three forage harvests conducted in space of 60 days. It was observed significant difference in canopy height among the forage cultivars which Marandu showed higher height (58.4 cm) and Ipyporã lower height (44.9 cm) while Piatã, Massai and Tamani were on average 54.7 cm. The variables total forage biomass and leaf blade biomass showed interaction effects between forage cultivar *vs.* cut age ($p<0.05$). Total forage biomass and leaf blade were higher in second cut (April) in relation to first cut (February) and third cut (June) which did not differ among the cultivars, with exception of Tamani which showed lower leaf blade yield in third cut. As observed before, the rainfall in the beginning of rainy season in 2018 were lower than historic average which may explain lower yield in the first cut in relation to second cut when the rainfall accumulated improved the forage growth. In third cut in June which occurred in the dry season of the year showed impact on biomass production decreasing its increment. Total forage dry matter in first and third cuts did not differ among the cultivars with average of 710 and 651 kg DM ha^{-1}, respectively. In second cut Marandu and Massai showed higher yield (average of 2,646 kg DM ha^{-1}) than the other that did not differ (average of 2,039 kg DM ha^{-1}). Leaf blade biomass in first cut Tamani showed higher yield (570 kg DM ha^{-1}) and Piatã lower yield (313 kg DM ha^{-1}). Ipyporã, Marandu and Massai did not differ that showed average yield of 436 kg DM ha^{-1}. In second cut Massai showed higher yield (1,417 kg DM ha^{-1}) and Ipyporã and Tamani lowers yield (888 kg DM ha^{-1}). Marandu and Piatã showed intermediary yield (average of 1,184 kg DM ha^{-1}). In third cut there was no significant difference among the forages species which showed on average of 317 kg DM ha^{-1}. Interaction effect was observed between cultivar *vs.* sampling point for leaf blade biomass ($p<0.05$). Ipyporã and Tamani did not change leaf blade biomass between the sampling points, on the other hand Piatã and Marandu showed higher yield on point B lower in point A and intermediary in point C, while Massai showed higher yields in points B and C and lower in point A. In relation to variables, total forage biomass and leaf blade biomass showed higher variation among cultivars in conditions of higher yield as the second cut and in sampling point B and C (Table 2).

Table 1. Forage canopy height, soil cover, dry matter content, forage yield in sampling point[1] with different levels of photosynthetically active radiation (PAR) in establishment stage of forage cultivars.

Cultivar	**Sampling point**		
	A	**B**	**C**
		Height (cm)	
Piatã	51.3 Ab	97.0 Aa	93.7 Aa
Marandu	42.0 Ac	66.7 Bb	82.7 Aa
Ipyporã	47.7 Aa	46.0 Ca	48.0 Ba
Tamani	43.7 Aa	42.7 Ca	42.7 Ba
Massai	38.3 Aa	49.7 Ca	49.0 Ba
Variable	**A**	**B**	**C**
Cover soil (%)	31 b	49 a	58 a
Dry matter content (%)	26.0 a	23.8 b	21.7 c
Forage yield (kg DM ha^{-1})	877 b	1,767 a	1,997 a

[1]Sampling point: A (PAR = 440 µmol m^{-2} s^{-1}; shading = 54%), B (PAR = 295 µmol m^{-2} s^{-1}; shading = 69%) and C (PAR = 339 µmol m^{-2} s^{-1}; shading = 65%). Different uppercase letters indicate significant difference by Tukey ($p\leq0.05$) in column. Different lowercase letters indicate significant difference by Tukey ($p\leq0.05$) in line.

In relation to crude protein (CP) in leaf blade was observed interactive effects of cultivars vs cut age and the interaction between survey points *vs*. cut age (Table 2). In first cut Massai showed lower CP (11.3%) in comparison to others that did not differ among them with average of 13.9%. In second cut Piatã showed higher CP in relation to Marandu and Massai. In third cut Tamani showed higher CP (12.3%), Massai was intermediary (10.9%) and Piatã, Ipyporã and Marandu lower CP (average 9.6%). Panicum, Massai and Tamani showed higher CP in dry season which correspond to third cut in comparison to *Brachiaria*. In relation to CP in sampling points the point B (center) showed lower PAR, but higher CP through the cut age as reported in literature (ALMEIDA et al., 2019). Neutral detergent fiber (NDF) in leaf blade differed just of cultivar which Piatã showed lower content (67%), Massaai higher content (75.1%), Ipyporã (71.2%), Marandu (70.3%) and Tamani (74.2%) with no difference among then with exception of Piatã. In the evaluation of nutritive value which involves CP and NDF the Piatã showed higher values with exception to third cut.

Table 2. Forage canopy height, total forage biomass, leaf blade biomass and crude protein content according to cut age and sampling points[1] with different levels of photosynthetically active radiation (PAR) after establishment of forage cultivars.

	Cultivar				
	Piatã	**Ipyporã**	**Marandu**	**Massai**	**Tamani**
	Canopy height (cm)				
	57.8 ab	44.9 b	58.4 a	53.4 ab	52.9 ab
	Total forage biomass (kg DM ha^{-1})				
Cut 1	612 Ba	651 Ba	830 Ba	602 Ba	854 Ba
Cut 2	2,110 Ab	1,894 Ab	2,583 Aa	2,708 Aa	2,114 Ab
Cut 3	628 Ba	784 Ba	737 Ba	639 Ba	467 Ba
	Leaf blade biomass (kg DM ha^{-1})				
Cut 1	313 Bb	358 Bab	479 Bab	472 Bab	570 Ba
Cut 2	1,186 Aab	880 Ac	1,181 Ab	1,417 Aa	895 Ac
Cut 3	314 Ba	338 Ba	305 Ba	316 Ba	312 Ca
A	433 Ba	514 Aa	512 Ba	492 Ba	666 Aa
B	781 Aab	493 Ac	832 Aab	916 Aa	607 Abc
C	600 ABab	569 Aab	621 ABab	797 Aa	504 Ab
	Crude protein (%)				
Cut 1	14.0 Aa	14.6 Aa	13.7 Aa	11.3 Ab	13.4 Aa
Cut 2	10.4 Ba	10.1 Bab	8.3 Cc	8.7 Bc	9.0 Bbc
Cut 3	9.3 Bc	9.8 Bc	9.8 Bc	10.9 Ab	12.3 Aa

	Sampling point		
	A	**B**	**C**
	Crude protein (%)		
Cut 1	13.6 Aa	13.1 Aa	13.5 Aa
Cut 2	9.8 Ba	9.4 Cab	8.8 Cb
Cut 3	9.8 Bb	11.1 Ba	10.3 Bab

[1]Sampling points: A (PAR = 440 µmol m^{-2} s^{-1}; shading = 54%), B (PAR = 295 µmol m^{-2} s^{-1}; shading = 69%) and C (PAR = 339 µmol m^{-2} s^{-1}; shading = 65%). Different uppercase letters indicate significant difference by Tukey ($p \leq 0.05$) in column. Different lowercase letters indicate significant difference by Tukey ($p \leq 0.05$) in line.

CONCLUSIONS

The forage cultivars Piatã, Marandu and Massai showed higher leaf blade yield under shading environment, on the other hand Piatã was outstanding in relation to biomass yield and nutritive value.

ACKNOWLEDGMENTS

To Associação para o Fomento à Pesquisa de Melhoramento de Forrageiras (Unipasto) by financial support.

REFERENCES

ALMEIDA, R. G.; BARBOSA, R. A.; ZIMMER, A. H.; KICHEL, A. N. Forrageiras em sistemas de produção de bovinos em integração. In: BUNGENSTAB, D. J.; ALMEIDA, R. G.; LAURA, V. A.; BALBINO, L. C.; FERREIRA, A. D. (Eds.). **ILPF**: inovação com integração de lavoura, pecuária e floresta. Brasília, DF: Embrapa, 2019. p.379-388.

CARVALHO, M. M.; FREITAS, V. P.; XAVIER, D. F. Início de florescimento, produção e valor nutritivo de gramíneas forrageiras tropicais sob sombreamento natural. **Pesquisa Agropecuária Brasileira**, v.37, n.5, p.717-722, 2002.

KOTTEK, M.; GRIESER, J.; BECK, C.; RUDOLF, B.; RUBEL, F. World map of the Köppen-Geiger climate classification updated. **Meteorologische Zeitschrif**, v.15, p.259-263, 2006.

MARTEN, G. C.; SHENK, J. S.; BARTON II, F. E. **Near-infra red reflectance spectroscopy (NIRS):** analysis of forage quality. Washington: USDA, 1985. 110p.

PACIULLO, D. S. C.; GOMIDE, C. A. M.; CASTRO, C. R. T.; FERNANDES, P. B.; MÜLLER, M. D.; PIRES, M. F. Á.; FERNANDES, E. N.; XAVIER, D. F. Características produtivas e nutricionais do pasto em sistema agrossilvipastoril, conforme a distância das árvores. **Pesquisa Agropecuária Brasileira**, Brasília, v.46, n.10, p.176-1183, 2011.

SANTOS, H. G. DOS; JACOMINE, P. K. T.; ANJOS, L. H. C.; OLIVEIRA, V. A.; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A.; CUNHA, T. J. F.; OLIVEIRA, J. B. **Sistema brasileiro de classificação de solos**. 3. ed. Brasília, DF: Embrapa, 2013. 353p.