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FORAGE NUTRITIVE VALUE IN CROP–LIVESTOCK–FORESTINTEGRATED SYSTEMS UNDER TREE MANAGEMENT

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ABSTRACT
The objective of this study was to evaluate the nutritive value of pastures in agroforestry systems after trees thinning. The experiment was carried out from October 2016 to March 2018 at Embrapa Southeastern Livestock, in São Carlos, SP, Brazil. The experiment was composed by pastures of palisade grass (Urochloa brizantha “BRS Piatã”), under rotational stocking, in four systems: intensive (INT); crop-livestock (iCL), in which pasture was renewed annually with corn sowed simultaneously with palisade grass; livestock-forest (iLF); and crop-livestock-forest (iCLF). In the iLF and iCLF systems, eucalyptus trees (Eucalyptus urograndis clone GG100) were planted in April 2011, in single rows, with 15×2m spacing. In 2016, the trees were thinned, and the spacing was changed to 15×4m. Forage samples were obtained during six grazing cycles and crude protein (CP) and in vitro digestibility (IVDMD) were determined. The data were submitted to analysis of variance and comparison of means by the Tukey test (5%). The results showed the highest levels of CP for iLF and iCL (12.37, and 10.96%, respectively); for IVDMD there was no significant difference. It can be concluded that the pastures in the systems with trees showed higher nutritional value after the tree thinning.
Key words: crop-livestock-forest; crude protein; eucalyptus

INTRODUCTION

Brazilian cattle breeding is based on the use of areas composed by degraded pastures, characterized by low production and nutritional value, which need management techniques to promote the recovery of pastures and promote the improvement of productive capacity (CARVALHO et al., 2017). Several techniques can be used to promote the recovery of pastures, among them, several types of integrated systems, such as integrated crop-livestock (iCL), livestock-forest (iLF), agroforestry systems (SAF's) and crop-livestock-forest (iCLF) are good options (RODRIGUES, GIULIATTI & JÚNIOR, 2020).

According to Balbino et al. (2011), CLF systems can be defined as sustainable production strategies that integrate agricultural, livestock and forestry activities in the same area, through intercropping, succession or rotation, reducing the impact of agriculture on the environment. These systems consist of associations among grain crops, pastures, and native or planted trees, aiming to produce grains, fibers, wood, meat, milk and bioenergy (KLUTHCOUSKI & YOKOYAMA, 2003).

In established systems, depending on tree population density, excessive shading promoted by trees can impair the development of crops and pastures (PEZZOPANE et al., 2017). According to Almeida et al. (2011), pastures under shade present changes in their structure, such as: lower canopy height and forage mass, however, they present higher CP and IVDMD.

According to Luz (2019), the analysis of pasture dynamics within each season and during the dry and rainy seasons, can, for example, reveal what differences exist between the systems in each season, with grazing being a determining factor to decrease both the supply and the quality of forage in pastures over time, even if the conditions are not limiting for plant growth. It can also indicate if the grazing intensity in a specific period is leading the pasture to degradation in the studied systems. The absorption of mineral elements by plants has no direct relationship with light, however, the shading of trees over crops affects biological processes that can alter their mineral composition, such as photosynthesis, transpiration, and respiration, among others (CLARK, 1981; MENDES, 2013), which can have a negative impact on productive potential (competition for light).

For a balanced production between the constituents of the production system, trees management practices, as pruning and thinning, are necessary. Trees thinning is employed to improve the development of the remaining trees and provide higher light transmission to the understory pastures, increasing their productivity (PACIULLO et al., 2007; NICODEMO et al., 2016).

The objective of this study was to evaluate the effects of thinning eucalyptus trees on nutritive value of palisade grass in agroforestry systems.

MATERIAL AND METHODS

The study was carried out in crop–livestock–forest integrated systems at Embrapa Southeastern Livestock, São Carlos, São Paulo, Brazil (21°57'S, 47°50'W, 860 m a.s.l.), from October 2016 to March 2018. The local climate is classified as highland tropical (Köppen's classification: Cwa), with two well-defined seasons, a dry season from April to September, with average temperature of 19.9 °C and 250 mm of accumulated rainfall; and a rainy season from October to March, with average temperature of 23 °C and 1100 mm of accumulated rainfall. The soil of the experimental area is a Dystrophic Red Latosol, with a sandy loam texture (FAO Classification: Hapludox, US Soil Taxonomy), according to Calderano Filho et al. (1998).

The experiment was conducted with four treatments with two repetitions (8 experimental units), presented in Figure 1. The four treatments consisted in four production systems: intensive (INT); crop-livestock (iCL), livestock-forest (iLF); and crop-livestock-forest (iCLF).

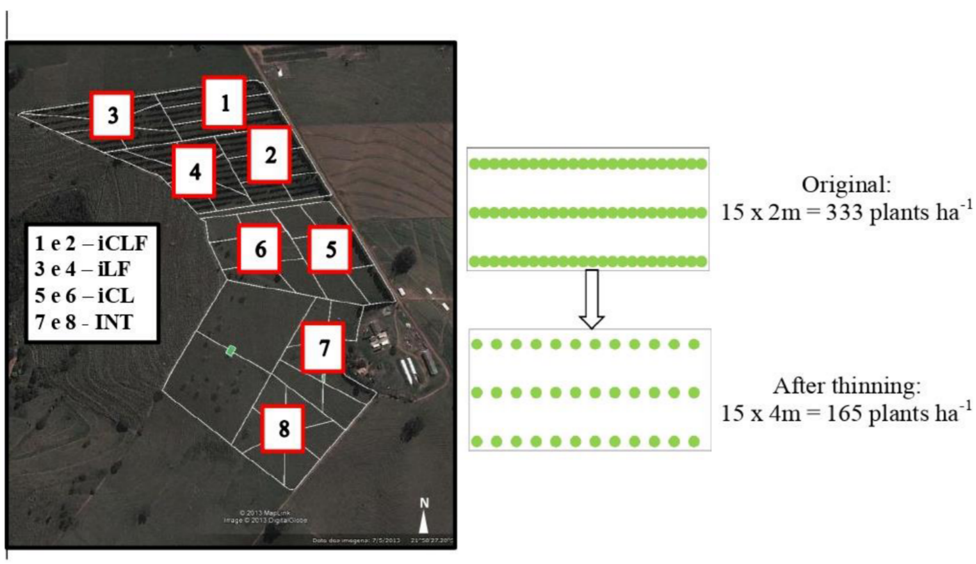

Figure 1. Image of the experimental area with the production systems used in the study (left) and representation of the distribution of trees in the iLF and iCLF systems (right). Intensive (INT); crop-livestock integration system (iCL); livestock-forest integration system (iLF); and crop-livestock-forest integration system (iCLF).

The pastures in the evaluated systems were established in 2011 and composed by *Urochloa brizantha* "BRS Piatã". In the iLF and iCLF systems, eucalyptus trees (*Eucalyptus urograndis* clone GG100) were planted in April 2011, in single rows, with a near east-west orientation and a 15 × 2m spacing (15m between rows and 2m between trees in the rows), which resulted in a population density of 333 trees ha^{-1}. In July 2016, trees were thinned, which consisted in cutting 50% of the trees in each row and spacing changed to 15 × 4m (165 trees ha^{-1}).

The experimental units of the systems were composed of 6 hectares, divided into six paddocks managed under rotational stocking, with cycles of 6 days of occupation and 30 days of rest. Annually, in the iCL and iCLF systems, pasture renovation was performed in two paddocks per integrated system. For this, corn (*Zea mays* L. hybrid AG 8690 PRO 3) was sown first, and palisade grass was sown after the corn was harvested for ensilage. The fertilization used for sowing and covering was calculated based on soil analysis and the expected productivity, after the crop was harvested, the pasture remained for later grazing of the animals. Grazing was performed by Nelore and Canchim (3/8 Nelore+5/8 Charolais) bulls, which were 11 months old and weighed 200 kg on average when put in the systems.

Pasture assessments were carried out in six growth cycles, representative of the seasons of the year, by cutting all the grass at ground level, in four sampling sites of 0.25 m^2 per repetition, with a metallic 0.5 × 0.5m square frame, randomly positioned for each treatment. Subsamples of 200 g were taken to determine dry matter content by drying in an air forced dry oven (60 °C, 72 h) and to determine nutritive value. For this, the subsamples were ground in a Wiley mill with a 0.5mm sieve and determined crude protein (CP) content and in vitro dry matter digestibility (IVDMD). The samples were analyzed by the Fourier transform-near infrared (NIR) technique using a spectrometer model NIRFlex N-500 with polarization interferometer (Büchi, Flawil, Switzerland). These measurements were performed using a calibration model developed and validated by Embrapa Southeastern Livestock (R^2 = 0.944 for CP, and R^2 = 0.923 for IVDMD) specifically for species and cultivars of *Urochloa spp*. The data were subjected to analysis of variance with the PROC ANOVA of SAS and comparison of means by the Tukey test at 5%.

RESULTS AND DISCUSSIONS

In the general average, the CP levels of the treatments showed significant differences, the iCLF system presented 12.37% of CP, followed by the iLF system (10.96%), iCL (7.47%) and INT (7.02%). Only in the winter of 2017 the CP content of the iLF treatment did not differ from the iCL and INT treatments, and in the summer of 2018 the iCL treatment was similar to the systems with trees (iCLF and iLF).

Regarding the IVDMD of pastures, in the general average, the systems with trees showed higher values during the evaluated cycles (52.52 and 50.29%, for iCLF and iLF, respectively), however, there were no significant differences during the seasons. Differences between treatments were limited only to spring cycles in 2016 and 2017.

The results obtained showed that for most of the evaluated cycles, the pastures of the iCLF and iLF systems (shaded systems) showed higher levels of CP and IVDMD (Table 1), in addition to the thinning providing satisfactory forage production, while the other treatments have shown no beneficial values.

Nicodemo et al. (2016) and Pezzopane et al. (2017), also obtained better nutritive value for pastures cultivated in the shaded environment of systems with trees and concluded that trees management practices, such as pruning and thinning, may decrease, even for a short time, the competition for light in these systems. In general, these authors attribute the highest levels of CP in plants grown under shade over those grown in full sun.

Table 1. Crude protein content (CP) and in vitro digestibility (IVDMD) of forage in iCL, iCLF, INT and iLF in the 2016/2017 and 2017/2018 growing seasons in São Carlos, SP.

Systems	Seasons/Year						Average
	Spring/16	Summer /17	Autumn/17	Winter/17	Spring/17	Summer/18	
	CP (%)						
iCL	6.15 b	8.00 c	9.79 b	4.27 b	7.49 b	9.13 ab	7.47
iCLF	14.76 a	14.48 a	13.31 a	7.41 a	12.14 a	12.10 a	12.37
INT	6.99 b	8.13 c	9.66 b	4.12 b	6.24 b	7.00 b	7.02
iLF	11.62 a	11.42 b	12.36 ab	5.84 ab	12.03 a	12.48 a	10.96
Average	9.88	10.51	11.28	5.41	9.48	10.18	
P	**<.0001**	**<.0001**	**0.0157**	**<.0001**	**<.0001**	**0.0011**	
	IVDMD (%)						
iCL	54.60 b	52.94 a	45.74 a	39.55 a	45.92 ab	49.09 a	47.97
iCLF	64.67 a	58.57 a	50.22 a	38.63 a	51.19 a	51.93 a	52.53
INT	52.70 b	51.88 a	47.23 a	35.92 a	40.53 b	45.93 a	45.70
iLF	58.07 ab	56.10 a	48.61 a	34.29 a	50.04 a	54.65 a	50.29
Average	57.51	54.87	47.95	37.09	46.92	50.40	
P	**0.0084**	**0.0475**	**0.4143**	**0.2135**	**0.0053**	**0.0946**	

*Means followed by different letters in the same column differ by the Tukey test at 5% probability.

CONCLUSIONS

The pastures within the agroforestry systems presented higher nutritive value than the systems without trees, after the management of the tree component.

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