Forage Intake of *Nellore* Steers Grazing a *Cajanus Cajan* Legume-Grass Intercropped Pasture

Oliveira, P. P. A.*; Furtado, A. J.†; Bruno, J. F.*†; Pasquini Neto, R.†; da Silva, G. V.†; Lobo, A. A.†; Abdalla-Filho, A. L.*†; Perna Junior, F.†; Alves, T. C.*; Medeiros, S. R.*; Pedroso, A. F.*; Rodrigues, P. H. M.†
*Embrapa Southeast Livestock, São Carlos, SP, Brazil
†Faculty of Veterinary Medicine and Animal Science, University of São Paulo, Pirassununga, SP, Brazil

Keywords: Markers; iNDF; Pigeon pea; TiO_2; tropical pastures; *Urochloa* spp.

Abstract. This study evaluated forage, supplement, and total (forage + supplement) dry matter intake (DMI, expressed as kg/day and as percentage of average live weight, %ALW) of *Nellore* steers in different production systems, including a *Cajanus cajan* (Pigeon pea) legume-grass intercropped pasture by using external (titanium dioxide, TiO_2) and internal (indigestible neutral detergent fiber, iNDF) markers. The experiment was carried out at Embrapa Southeast Livestock, São Carlos, SP, Brazil, in the rainy (January) and dry (July) seasons of 2021. Eighteen animals *Nellore* steers were randomly distributed into three treatments with three replications (1.5 ha paddocks each): 1) degraded pasture of *Urochloa decumbens* cv. Basilisk (DEG); 2) Intercropped legume-grass pasture composed by *U. decumbens* cv. Basilisk, *U. brizantha* cv. Marandu and *Cajanus cajan* cv. BRS Mandarin limed and fertilized with P, K, S, micronutrients (INT) and 3) mixture pasture of *U. decumbens* cv. Basilisk and *U. brizantha* cv. Marandu limed and fertilized with P, K, S, micronutrients and 200 kg N-urea ha^{-1} $year^{-1}$ (REC). The statistical model considered treatment and season as fixed effects, and the treatment×season interaction was tested. Data were submitted to analysis of variance (PROC MIXED) and means were compared by the Fisher test at 5%. Significant treatment×season interaction was found ($P < 0.05$). During the rainy season lower values of forage and total DMI were found for the INT treatment when compared to REC. However, during the dry season, the treatment with Pigeon pea inclusion (INT) presented higher values of forage and total DMI. The DEG and REC system steers reduced their DMI from the rainy season to the dry season, even receiving a mineral energetic-protein supplement with urea, while the INT steers maintained DMI between seasons without receiving the energetic-protein supplement. These results highlight the potential of including Pigeon pea in pasture-based systems, especially during the dry season when tropical grasses present low nutritional quality and forage availability.

Introduction

The livestock activity is facing many challenges such as the need to increase food production to meet the growing population by improving animal performance without impairing the environment in more sustainable production systems. Despite playing a fundamental role in the country's economy, Brazilian livestock production has been the target of numerous criticisms related to climate change, mainly because it depends on extensive pasture areas, often with some degree of degradation, and accentuated seasonality of production and nutritional quality. Among management strategies and agricultural practices, the inclusion of leguminous forage in ruminant diets can be considered to offset these limitations in systems where livestock are increasingly becoming dependent on low-quality pastures. In this context, the use of leguminous forage as an alternative source of protein has become an urgent research topic, and one of the potential species being evaluated is pigeon pea (*Cajanus cajan*). A consortium between pigeon pea and tropical grasses can contribute to greater forage availability for feeding grazing ruminants, thus reducing the need of nitrogen fertilizers and protein/mineral supplements, especially in the dry season of the year. However, studies are still needed to evaluate dry matter intake (DMI) when intercropping tropical pastures and pigeon pea, allowing a better understanding of the sustainability and environmental consequences of this production system. In this paper we present results of forage, supplement, and total DMI in different pasture-based production systems compared to a *Cajanus cajan* legume-grass mixed pasture during the rainy and dry seasons of the year. We hypothesize that is possible to increase DMI with the inclusion of the legume due to its characteristics, especially during the dry season, when tropical grasses present low production and nutritional quality.

Methods and Study Site

The study was approved and followed the guidelines of the Committee for the Use and Care of Institutional Animals (CEUA) of Embrapa (nº 05/2016) and School of Veterinary Medicine and Animal Science of University of São Paulo (nº 6228200521), being conducted at Embrapa Southeast Livestock, São Carlos, SP, Brazil. The treatments consisted of three pasture-based systems: 1) Degraded pasture (DEG) of *Urochloa decumbens* Stapf cv. Basilisk; 2) Recovered pasture (REC), established with a mixture of *U. decumbens* cv. Basilisk and *U. brizantha* (Hochst ex A. Rich) Stapf cv. Marandu, managed with a moderate stocking rate, limed and fertilized during the rainy season with P, K, S, micronutrients and 200 kg N-urea ha^{-1} $year^{-1}$; and 3) Intercropped pasture (INT), a mixture of *U. decumbens* cv. Basilisk and *U. brizantha* cv. Marandu intercropped with *Cajanus cajan* (L. Millsp.) cv. BRS Mandarim also using a moderate stocking rate, limed and fertilized during rainy season with P, K, S and micronutrients. Each treatment was distributed in three grazing units (1.5 ha paddocks) in a completely randomized design. The experiment was carried out in two seasons of 2021: rainy (January) and dry (July). Eighteen *Nellore* steers (nine non-cannulated with 221 ± 7 kg and 9 ± 1 months old, and nine cannulated in rumen with 445 ± 44 kg and 15 ± 1 months) were randomly distributed into the treatments, with water and supplementation provided *ad libitum*. During the rainy season all treatments received the same mineral supplement, while in the dry season DEG and REC received a mineral energetic-protein mixture (with urea) and INT received a mineral mixture (without urea). The DMI of supplements (DMIs) were estimated by the difference between the offered and the leftovers in the trough after five days. To evaluate the forage DMI (DMIf) in the different systems, indirect methods with external (titanium dioxide, TiO_2) and internal (indigestible neutral detergent fiber, iNDF) markers were used. TiO_2 was conditioned in small paper capsules and provided for the animals with the aid of an oral applicator. The external marker was administered for 9 days in the amount of 15 g per animal per day. After 5 days of TiO_2 administration, feces samples were collected after spontaneous defecation in the paddocks. The samples were frozen and at the end of the experimental period were dried in a forced ventilation oven (60°C – 72h), grounded to 1 mm in a "Willey" mill and TiO_2 was analyzed (Myers et al., 2004) using a ICP-OES (Thermo iCAP 6000 series - Dual View Thermo Fisher Scientific, Waltham, Massachusetts, United States). Forage samples were collected by hand-plucking, following the methodology described by (Sollenberger et al. 1995), and as well for the feces samples, were grounded at 2 mm in a "Willey" mill, placed inside TNT bags and incubated for 288 h in the rumen of cannulated animals for further determination of the iNDF content (Lippke et al., 1986). The DMIf was calculated following the equation:

$$\mathrm{DMIf} = \frac{\left[\frac{\mathrm{TiO}_{2(\mathrm{supplied})}}{\mathrm{TiO}_{2(\mathrm{recovered\ in\ feces})}}\, x\, \mathrm{iNDF}_{(\mathrm{feces})}\right]}{\mathrm{iNDF}_{(\mathrm{forage})}}.$$

Total DMI was considered the sum of DMIs and DMIf. DMI were expressed as kg/day and as percentage of the animals' average live weight (%ALW). The statistical model considered treatment and season as fixed effects, and the treatment×season interaction was tested. Data were submitted to analysis of variance (PROC MIXED) and means were compared by the Fisher test at 5%.

Results and Discussion

The average values of forage, supplement, and total DMI in the different pasture-based systems during the experimental period, as well as the statistical probabilities (P values), are presented in Table 1. Season effect was found for all intake variables ($P < 0.05$). Higher supplement DMI was found in the dry season of the experimental period, while higher forage and total DMI were found in the rainy season ($P < 0.05$). Treatment effect was found for supplement DMI ($P < 0.05$). For this variable, lower value was found for the steers in the INT when compared to DEG and REG treatments ($P < 0.05$).

Table 1 – Average values of forage, mineral supplement and total DMI in the different pasture-based systems during the experimental period.

Treatments	Seasons	Forage DMI		Supplement DMI		Total DMI	
		kg/day	%ALW	kg/day	%ALW	kg/day	%ALW
DEG		8.39	2.05	0.075[a]	0.020[a]	8.46	2.07
REC		8.71	1.97	0.070[a]	0.018[a]	8.78	1.99
INT		8.65	1.88	0.031[b]	0.008[b]	8.68	1.88
	Rainy	11.44	2.41	0.048	0.011	11.49	2.42
	Dry	5.72	1.52	0.068	0.019	5.79	1.54
Average		8.58	1.97	0.061	0.015	8.64	1.99
SEM		0.617	0.157	0.003	0.001	0.62	0.16
Statistical Probabilities (P value)							
Treatment		0.9574	0.8354	**<.0001**	**0.0008**	0.9613	0.8147
Season		**<.0001**	**0.0004**	**<.0001**	**0.0030**	**<.0001**	**<.0005**
Treatment × Season		**0.0377**	**0.0198**	0.0553	0.1202	**0.0393**	**0.0216**

[*] Different letters in the same column represent seasons that differ from each other ($P < 0.05$) by Fisher's test.
†Dry matter intake (DMI), Average live weight (ALW). Degraded pasture of *Urochloa decumbens* cv. Basilisk (DEG), Mixture of *U. decumbens* cv. Basilisk and *U. brizantha* cv. Marandu, fertilized with 200 kg of N-urea ha^{-1} $year^{-1}$ (REC), *U. decumbens* cv. Basilisk and *U. brizantha* cv. Marandu intercropped with *Cajanus cajan* (L. Millsp.) cv. BRS Mandarim (INT), Standard error of the means (SEM)

Significant ($P < 0.05$) treatment×season interaction was found for both DMIf and total DMI when expressed as kg/day and as %ALW (Figure 1). During the rainy season, lower values of DMIf and total DMI were found for the INT treatment when compared to REC (Figures 1a-d) ($P < 0.05$). However, during the dry season, the treatment with the inclusion of Pigeon pea (INT) present higher values of DMIf (Figure 1a-b) and total DMI when expressed as kg/day (Figure 1c) ($P < 0.05$). For total DMI expressed as %ALW during the dry season (Figure 1d), no differences were found among treatments ($P > 0.05$). The DEG and REC system steers reduced their DMI from the rainy season to the dry season, even when receiving an energetic-protein mineral supplement with urea, while the INT steers maintained DMI between seasons without receiving the urea supplement. Considering the cost of urea, this fact is advantageous.

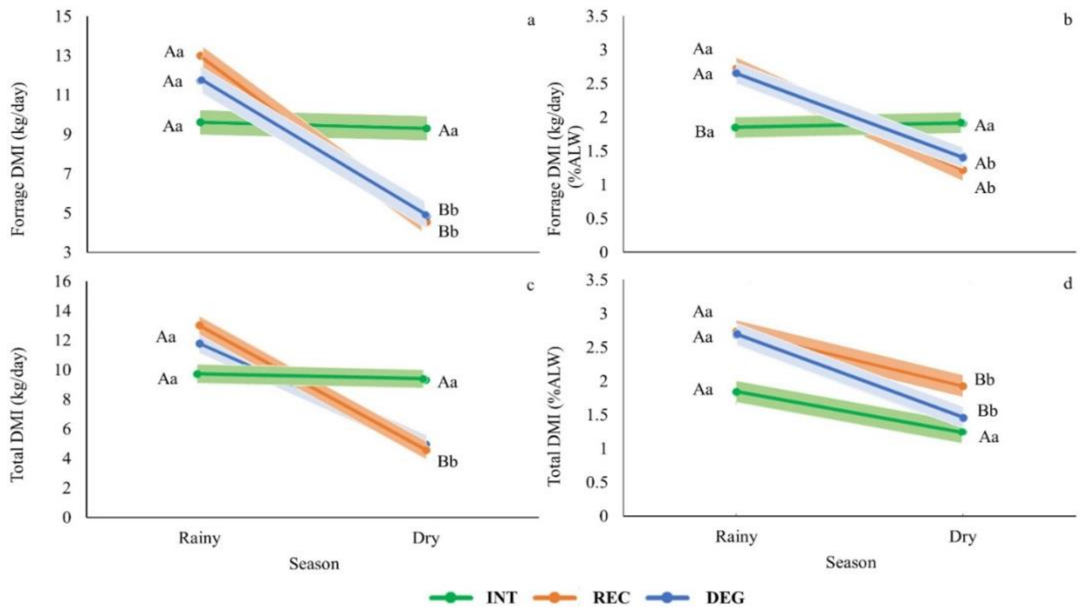

Figure 1 – Interaction treatment×season for forage DMI (kg/day) (a), forage DMI (%ALW) (b), total DMI (kg/day) (c), and total DMI (%ALW) (d).

Our results may be explained by the fact that Pigeon pea has low palatability in its vegetative phase, which coincides with the rainy season. Therefore, the animals preferentially consume only the tropical grasses, favoring the growth and N biological fixation of the legume. Later, in the dry season, when Pigeon pea reaches it reproductive phase, the palatability improves, and the animals start to consume it (mainly the pods and oldest leaves) as an important source of protein (Oliveira et al., 2017, 2022). These results confirm our hypothesis and highlight the potential of including Pigeon pea in pasture-based systems, especially during the dry season when tropical grasses present low nutritional quality and forage availability, with a reduction in the economic costs of production related to the supplementation of steers and fertilization of the pasture with urea.

Conclusions

The inclusion of Pigeon pea intercropped with tropical grasses was able to increase the DMI in the dry season, acting as an important source of forage and reducing the seasonality in which tropical grasses usually present low production and nutritional quality.

References

Lippke, H., Ellis, W. C., Jacobs, B. F. 1986. Recovery of indigestible fiber from feces of sheep and cattle on forage diets. *Journal of Dairy Science.*, 69: 403-412.

Myers, W. D., Ludden, P. A., Nayigihugu, V., Hess, B. W. 2004. Technical Note: a procedure for the preparation and quantitative analysis of samples for titanium dioxide. *Journal of Animal Science*., 82: 179-183.

Oliveira, P. P. A., Matta, F. P., Godoy, R. 2017. Consorciação com guandu na recuperação de pastagens degradadas, uma tecnologia de duplo propósito: adubação verde e pastejo consorciado diferido. *Circular Técnica.*, 75.

Oliveira, P. P. A., Godoy, R., Oliveira, B. A., Faria, A. P., Bonani, W. L., Rodrigues, P. H. M., Lelis, A. L. J. 2022. Avaliação de diferentes materiais genéticos de feijão-guandu em consórcio com capim-marandu na recuperação de pastagens degradadas. *Boletim de Pesquisa e Desenvolvimento.*, 52.

Sollenberger, L. E. and Cherney, D. J. 1995. Evaluating forage production and quality. In: Barnes, R. F., Miller, D. A., Nelson, C. J. (eds) *The Science of Grassland Agriculture*. Iowa State University Press, Ames, IA, 97-110.