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Performance of the *Brachiaria* hybrid 'Mulatto II' under different doses and forms of limestone application in the Amazon

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Acid soils have been responsible for the poor performance of most plant species, and liming is an efficient way of correcting the pH of such soils. The aim of this study was to assess the performance and establishment of the *Brachiaria* hybrid 'Mulatto II' under different doses and forms of limestone application. The experimental design was of five doses of limestone (0, 0.5, 1, 2, and 4 t ha^{-1}) and two forms of application (broadcasting over the surface, and broadcasting followed by hoeing the top 20 cm of soil) with three replications, in 3 x 3 metre plots of the *Brachiaria* hybrid 'Mulatto II'. The greatest number of germinated seeds was at the dose of 4 t ha^{-1} limestone when incorporated into the soil. For height, the greatest values found were at the maximum dose of limestone when incorporated into the soil. Dry matter production was not influenced by the form of limestone application, however production increased with the supply of limestone. The hybrid variety proved easily adaptable to different soil and climate conditions.

Key words: Liming, tropical pasture, fodder availability, dry matter.

INTRODUCTION

One of the foundations of Brazilian agribusiness is cattle farming. According to the IBGE Automatic Recovery System (SIDRA), the current Brazilian cattle herd comprises 215.2 million herd. Between 1987 and 2013 in Brazil, the herd increased by 60%, while in the states of the Amazon region, it increased by 280%, as the activity was the cheapest form of occupying and using the deforested area (Barbosa et al., 2015). In the last ten

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years, the northern region has significantly expanded its agricultural frontier into animal production (Dias-Filho, 2010) as the number of cattle slaughtered in the region correspond to approximately 22% of the domestic total (IBGE, 2015). In Acre, beef farming accounts for approximately 40% of the state's gross domestic product (GDP), and is the activity with the highest economic importance of the agricultural sector (Sá et al., 2010).

Livestock farming takes up approximately 220 million hectares, of which 70 million are in the Amazon states (Barbosa et al., 2015). However, approximately 80% of the deforested area in the Amazon rainforest is used for livestock, with half of that area displaying a severe degree of soil degradation (Araújo, 2008). The Brazilian agricultural sector is now more aware of environmental issues, so the challenge is for more efficient production through the use of such technologies as soil and pasture management (Dias-Filho, 2010).

The genus *Brachiaria* was introduced to Brazil around the 1950s, and represents 85% of the 180 million hectares of pasture grown in the country (Macedo, 2004), as it adapts to the most varied of soil and climate conditions (Soares filho, 1994) and is resistant to the spittlebug (Valle et al., 2000). In the State of Acre (AC), the forage grass with the largest planted area is *Brachiaria brizantha* 'Marandu', also known locally as *Braquiarão* (Dias-Filho and Andrade, 2006).

The *Brachiaria* hybrid 'Mulatto II' is the second hybrid introduced as a result of the tropical grass program of the Centro Internacional De Agricultura Tropical (CIAT) started in 1989 and which resulted in a hybrid from crosses and selections of *Brachiaria ruziziensis*, *Brachiaria decumbens* 'Basilisk' and *Brachiaria brizantha* (Argel et al., 2007). The results of Argel et al. (2005) demonstrated the superiority of the Mulatto II hybrid compared to the Mulatto I, important being its good adaptation to acid soils of low fertility and a moderate adaptation to soil moisture. The variety is able to develop deeper roots, leading it to withstand long periods of drought of up to six months (CIAT, 2006). Guiot and Melendez (2003) pointed out its high adaptability, which is due to its perennial, vigorous nature, and profuse, decumbent and stoloniferous habit, it furthermore demonstrated great tolerance to the spittlebug and to the non-significant damage caused by caterpillars throughout years of study. Thus, this variety encompasses productivity, resistance and digestibility, considering also that it has wide adaptability to the various climatic and soil conditions (Santos et al., 2015).

Good pasture management guarantees good livestock production under grazing, and for the evaluation of these, some aspects are considered such as: animal performance, pasture support capacity, animal production per hectare, the botanical composition of pasture, and stability of the vegetation cover (Gomide and Gomide, 2001). Brazil stands out as a potential global livestock producer due to the management and exploitation of tropical grasses' potential. These species, when well managed, present a high rate of biomass accumulation, presenting nutritional value and structural characteristics compatible with good animal performance (Silva and Nascimento Júnior, 2007; Euclides et al., 2000).

One of the efficient ways of achieving good livestock productivity is genetic improvement. This process of using controlled hybrids is still poorly controlled in the genetic improvement of tropical forages, being the majority of germplasm banks used by direct selection of available genotypes (Pereira et al., 2001). This breeding process is only justified when the natural variability of the species has already been exploited enough to avoid undesirable traits (Cameron, 1983).

Acid soils limit the production of most crops and influence the availability and toxicity of elements, microbial activity, and root development that limits the absorption of nutrients and water by plants (Fageria and Baligar, 2003). High concentrations of toxic elements such as aluminum (Al) and manganese (Mn) inhibit root development, which consequently has a negative influence on the absorption of water and nutrients by plants, especially calcium (Ca) and magnesium (Mg) (Lathwell and Grove, 1986).

Liming is an effective and inexpensive way to neutralise soil acidity and improve crop productivity (Nolla et al., 2013). This practice reduces the toxicity of Al and Mn, and increases the availability of other elements such as potassium (P), calcium (Ca) and magnesium (Mg), increases the cation exchange capacity (CEC), promotes nitrogen fixation (N_2), and improves soil structure (Bermardi et al., 2012; Carvalho and Nascente, 2014). Considering the importance of liming for the breeding and establishment of crops, the aim of this study was to evaluate the forage performance and establishment of the *Brachiaria* hybrid 'Mulatto II' under different doses and forms of limestone application in the Juruá Valley region, Acre, Brazil.

MATERIALS AND METHODS

The experiment was conducted in the experimental area of the Federal University of Acre, Floresta Campus, (UFAC), in the town of Cruzeiro do Sul, located at 07°37'52" S, 72°40'12" W, as shown in Figure 1. The work was carried out from December 2013 to February 2014. According to Cavalcante and Souza (2010), the Koppen classification of the climate in the region is type Af, tropical humid with well-distributed rainfall throughout the year and the absence of a dry season. The average altitude of the region is 170 m, with an annual average rainfall of 2074 mm.

Data for rainfall, average air temperature, evaporation and relative humidity measured during the experiment can be seen in Figures 2 and 3, respectively.

The soil of the experimental area was classified as a dystrophic Yellow Argisol with no evidence of a reduction zone (greyish). Soil samples were collected from 15 random points, at a depth of 0 to 20 cm (Figure 3), and sent to the Department of Soils and Fertilisers on the Jaboticabal Campus of the São Paulo State University, where a chemical analysis of the soil was performed. Recommended fertilisation was carried out according to the results

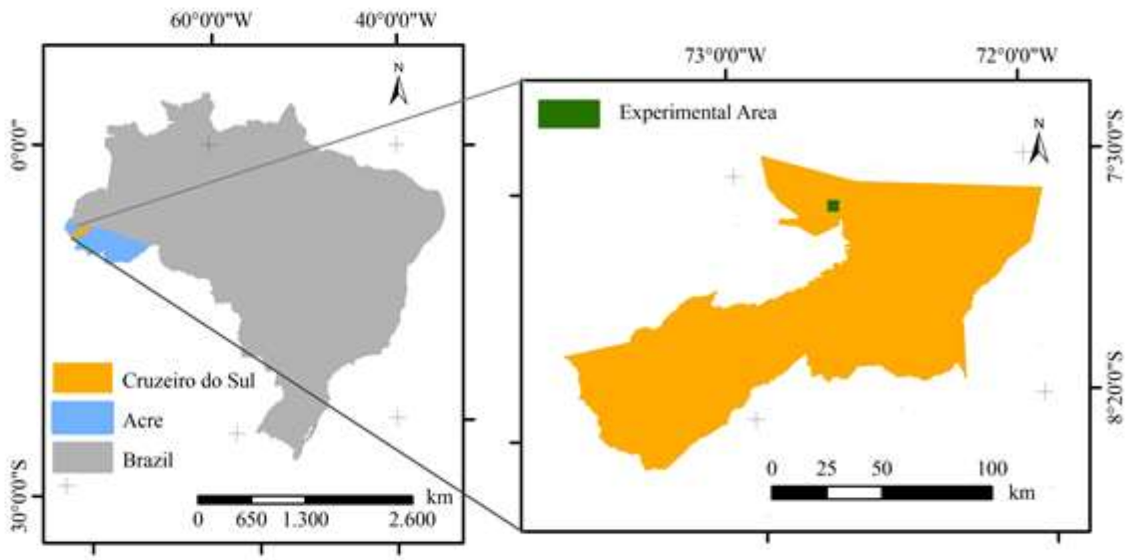

Figure 1. Location of the experimental area in the town of Cruzeiro do Sul, Acre, Brazil.

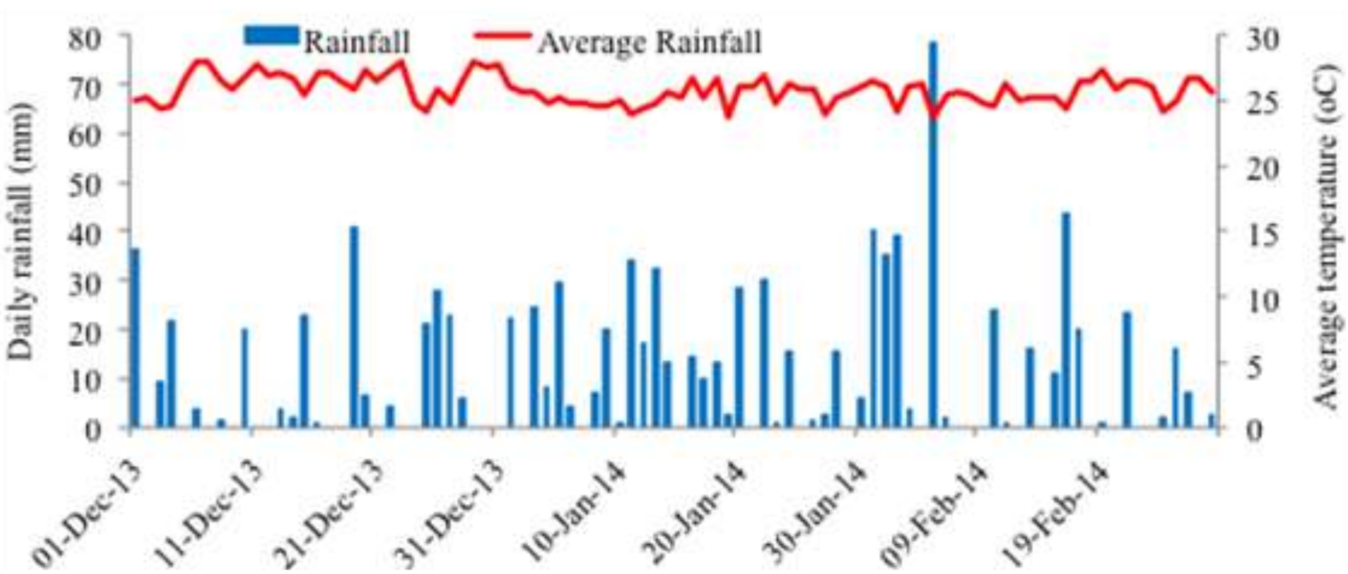

Figure 2. Average daily temperature and daily rainfall during the experimental period, in Cruzeiro do Sul, AC. Source: INMET (2017).

of the soil analysis (Table 1), to the technical circular with recommendations for the fertilisation and liming of pasture in Acre (Andrade et al., 2002), and to the Manual for Management and Fertilisation for the State of Acre (Wadt, 2005). Nitrogen fertilisation at 40 kg ha^{-1} was divided into three applications starting from the 21st day after planting.

The experimental design was of randomised blocks in a 5 × 2 factorial scheme, with five doses of dolomitic limestone filler at different concentrations (0, 0.5, 1, 2 and 4 t ha^{-1}) and two forms of application with three replications, in 3 m × 3 m plots of the *Brachiaria* hybrid 'Mulato II' (CIAT 36087). There were two blocks, one for each form of application, to test the differences between broadcasting over the surface and broadcasting followed by hoeing the top 20 cm of soil, as shown in Figure 4.

Agronomic evaluations of the forage were carried out from seed germination at 7, 14 and 21 days after planting, by a count of the germinated seeds. Plant height was determined with the aid of a tape measure from the average of five plants chosen at random in each plot, considering the height from the ground to the inflexion of the highest leaf.

Samples to determine dry matter production were obtained with the aid of a square metal structure, 0.5 m × 0.5 m (0.25 m^2) in size, which was randomly thrown three times within each experimental unit when the pasture reached 30, 50 and 70 cm. For each evaluation, forage biomass was collected, cut close to the soil, packed in plastic bags, which were identified for transportation to

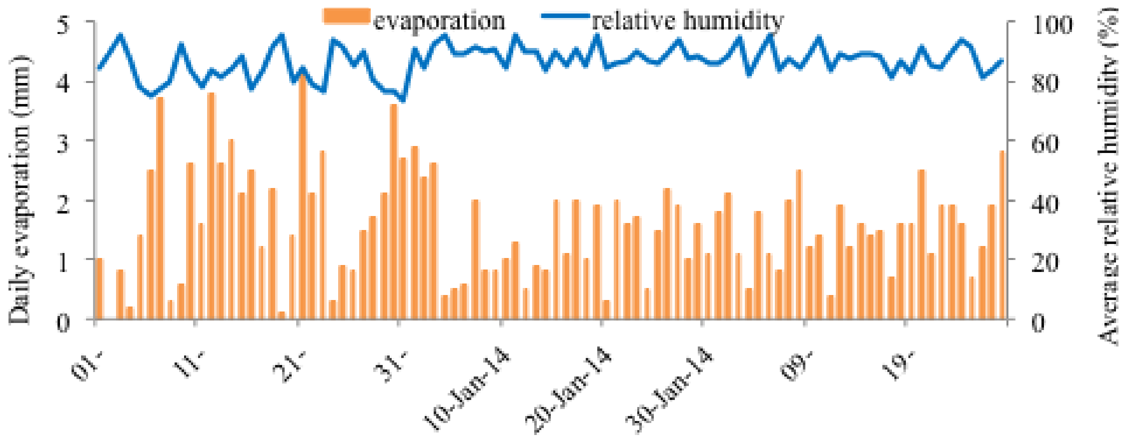

Figure 3. Daily evaporation and relative humidity during the experimental period, in Cruzeiro do Sul, AC. Source: INMET (2017).

Table 1. Chemical characterisation of the soil in the experimental area.

Depth (cm)	pH ($CaCl_2$)	OM (g/dm^3)	P (mg/dm^3)	K	Ca	Mg	H+Al	SB	T	(%)
				($mmol_c/dm^3$)						
0-20	4.2	25	4	1.3	7	4	52	12.3	64.3	19

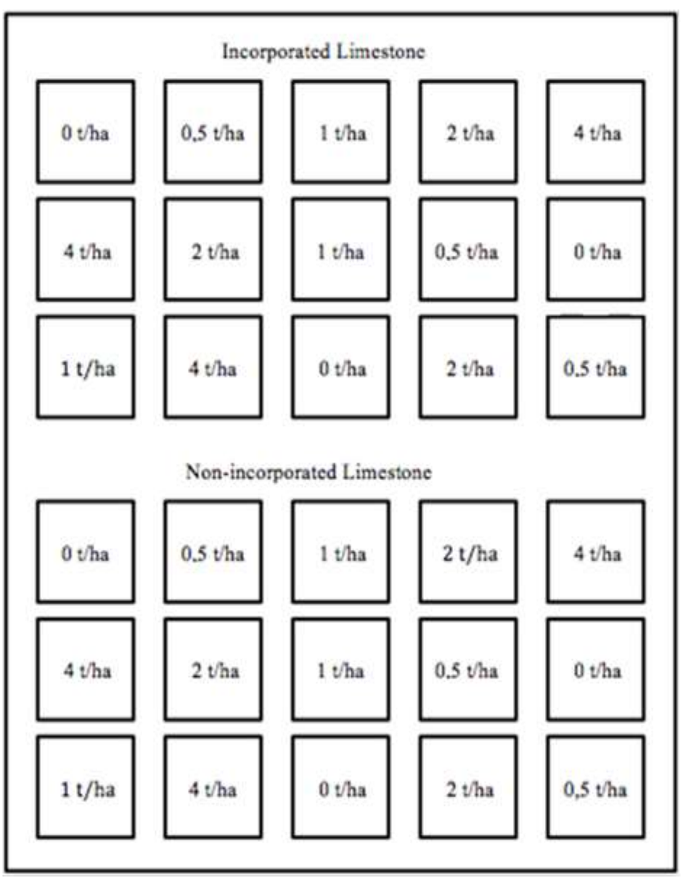

Figure 4. Sketch of the experimental area.

the laboratory, and weighed. The samples were then packed in paper bags and placed in a forced air ventilation oven at 65°C for 72 h.

The results were submitted to statistical analysis using the Analysis of Variance System for balanced data (SISVAR), described by Ferreira (2000). The data were submitted to analysis of variance for a completely randomised design in a 5 × 2 factorial scheme (Five doses of limestone and two forms of application). Interactions that were significant at 5% probability by F-test were properly broken down. The mean values were compared by Tukey's test at 5% probability.

RESULTS AND DISCUSSION

The number of germinated seeds was higher at the dose of 4 t ha^{-1} limestone when incorporated into the soil; in the treatment where no limestone was incorporated, the maximum applied dose gave the smallest amount of germinated seeds. In general, the treatment with the greatest number of germinated seeds was at a dose of 1 t ha^{-1} limestone with no incorporation of the $CaCO_3$ (Figure 5). Deminicis et al. (2004) and Pereira et al. (2004) found similar results in the production of seeds of *Brachiaria decumbens* Stapf under different strategies of limestone application.

The greatest values for height were found at the maximum dose of limestone when incorporated into the soil. However, it was found that the control treatment displayed mean values that were similar to the maximum doses, showing that there was no significant difference for the quantity of limestone applied, since it was possible

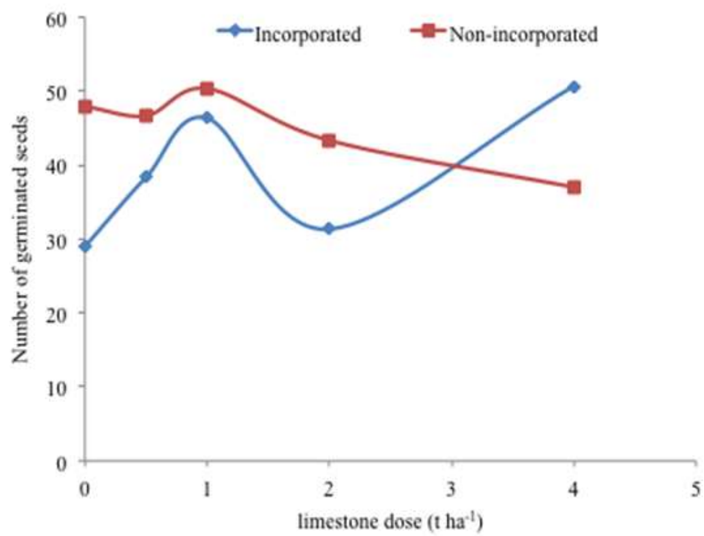

Figure 5. Effects of limestone doses (t ha^{-1}) and forms of application on the number of germinated seeds.

Table 2. Average height (cm) for the different treatments with incorporated and non-incorporated limestone in the three collections.

Treatment (t ha^{-1})	Incorporated			Non-incorporated		
	1st collection	2nd collection	3rd collection	1st collection	2nd collection	3rd collection
Control	35.67a	91.33a	114.11a	43.11a	86.55a	120.22a
0.5	40.66a	96.89a	117.55a	43.88a	100.33a	209.11a
1	51.88a	104.55a	132.33a	48.11a	105.55a	154.33a
2	45.00a	108.33a	119.89a	48.33a	100.77a	136.66a
4	54.22a	113.11a	133.00a	53.33a	83.89a	138.66a

* Mean values followed by the same letter in a column do not differ statistically. Tukey's test at 5% probability.

to achieve similar results even at a dose of 0 t ha^{-1} (control) (Table 2). This suggests that the effect may be closely related to the supply of Ca and Mg, since 90% of the value was achieved at the lowest dose of limestone.

Similar results were found by Guimarães (2000), where there was an increase in *B. humidicola*, *B. mutica*, *Echinochloa pyramidalis* and *E. polystachya*, despite the soil still presenting high acidity and high levels of exchangeable Al.

The method of application, with incorporated or non-incorporated limestone, together with the amounts applied, did not give significant results in relation to the amount of dry matter (DM) produced by the forage; even so, there was an increase in forage weight when doses of limestone were applied, as shown in Tables 3 and 4. Incorporating the limestone into the soil gave the greatest mean value for production.

Luz *et al*. (2000), obtained better results for DM production in Tobiata grass (*Panicum maximum* 'Tobiata') when limestone was incorporated into the soil. These results, showing an increase in dry matter even at low applied doses of limestone, are explained by both the tolerance of the genus Brachiaria to high concentrations of aluminium, and by the effects that limestone causes in the soil, such as the increased absorption of nitrogen, phosphorus, potassium and sulphur (Quaggio et al., 1993) and the supply of calcium and magnesium as nutrients (Mascarenhas et al., 1976).

The values for dry matter production in tonnes per hectare showed that incorporating the limestone into the soil gave the greatest values, where a production of 14,556 t ha^{-1} DM was achieved with the application of 2 t ha^{-1} limestone; comparable results for production were found in 2004 in Gualaca, Panama (15.6 t ha^{-1} DM) (IDIAP, 2006). Nevertheless, the values were not so expressive as to consider that the application of limestone should be able to increase production in the Mulatto II cultivar.

Table 3. Values for dry matter - DM (%) for different forms of limestone application, incorporated and non-incorporated, at different collection times.

Treatment ($t\ ha^{-1}$)	Incorporated			Non-incorporated		
	1st collection	2nd collection	3rd collection	1st collection	2nd collection	3rd collection
Control	28.97[a]	26.50[a]	26.37[a]	27.68[a]	26.68[a]	33.18[a]
0.5	23.54[a]	22.94[a]	29.39[a]	29.10[a]	24.21[a]	29.53[a]
1	27.14[a]	26.72[a]	23.60[a]	26.08[a]	27.72[a]	33.78[a]
2	26.18[a]	25.76[a]	36.39[a]	23.66[a]	25.28[a]	31.40[a]
4	27.18[a]	23.91[a]	27.73[a]	21.92[a]	24.79[a]	30.49[a]

* Mean values followed by the same letter in a column do not differ statistically. Tukey's test at 5% probability.

Table 4. Mean values for dry matter (DM) production in $kg\ ha^{-1}$ of the variety 'Mulatto II' as a function of the amount of limestone applied in the two forms of application in the three cuts.

Treatment ($t\ ha^{-1}$)	Incorporated			Non-incorporated		
	1st collection	2nd collection	3rd collection	1st collection	2nd collection	3rd collection
Control	11.588	10.600	10.548	11.072	10.672	13.272
0.5	9.416	9.176	11.756	11.640	9.684	11.812
1	10.856	10.688	9.440	10.432	11.088	13.512
2	10.472	10.304	14.556	9.464	10.112	12.560
4	10.872	9.564	11.092	8.768	9.916	12.196

* Mean values followed by the same letter in a column do not differ statistically. Tukey's test at 5% probability.

Similar results were found by Sanzonowicz *et al*. (1987), where the application of different doses of limestone (0, 3 and 4.5 t ha^{-1}) in a pasture of *B. decumbens* did not increase dry matter production after three months of pasture or during succeeding years. This agreed with the results found in Rondônia by Gonçalves *et al*. (1984), where in Porto Velho there was no increase in forage production beyond the dose of 600 kg ha^{-1}; in Presidente Médice a dose of 400 kg ha^{-1} limestone achieved maximum production, and in Vilhena the pasture did not respond to liming.

According to the results, it was possible to establish a pasture of *Brachiaria* 'Mulato II' in the region of the Juruá Valley. Similar results were obtained in Lanos Orientales, Colombia, where the species showed good adaptation to various conditions of both soil and climate, demonstrating that the cultivar adapts easily, and is compatible with the quality and infrastructure of different environments (Centro Internacional De Agricultura Tropical (CIAT), 2004).

Conclusion

The doses of limestone and forms of application did not affect performance in the *Brachiara* hybrid 'Mulatto II' in which the application of limestone to pastures in Acre is only necessary at small doses, to renovate or maintain pastures that have low levels of calcium and magnesium in the soil. Additionally the introduction of new tropical pastures proved to be successful in Acre, irrespective of the dose of limestone and form of application.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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