Calcário líquido na correção da acidez de um Cambissolo Distrófico para produção de *Brachiaria* em Humaitá, Amazonas.

Liquid limestone in the acidity correction of a Dystric Cambisol for *Brachiaria* production in Humaitá, Amazonas.

Piedra caliza líquida para corregir la acidez de un distrito de Cambisol para la producción de *Brachiaria* en Humaitá, Amazonas.

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Resumo

No manuseio, além de certa inviabilidade para pequenos produtores, quando comparado ao uso de calcário líquido com alta pureza e reatividade. Portanto, é importante uma melhor compreensão da dinâmica do calcário líquido empregado na correção da acidez do solo. Assim, este trabalho propõe o uso de calcário líquido para corrigir a acidez de um cambissolo distrófico no cultivo de pastagens em Humaitá, AM. O experimento foi conduzido em casa de vegetação, onde foram preparados vasos de plástico para a semeadura de *Brachiaria brizantha*, em delineamento em blocos casualizados, com cinco tratamentos e quatro repetições (T1 = testemunha, T2 = 2,5 L, T3 = 5 L, T4 = 10 L e T5 com calcário comum). Após 90 dias de plantio, foram avaliados o tamanho da parte aérea e da raiz da massa fresca e seca de cada tratamento, bem como o número de perfilhos. O perfilhamento de B. *brizantha* foi altamente responsivo à adição de calcário líquido e comum, de modo que quanto maior a dose, maiores os resultados. Por outro lado, os tratamentos para a produção de brotos frescos e secos e de biomassa radicular não diferiram significativamente entre si, explicando por que o produto ainda não é bem aceito e utilizado pelos comerciantes e agricultores.

Palavras-chave: Calagem; Pastagem; Produtividade.

Abstract

Conventional solid limestone most commonly used in agriculture generally has disadvantages in handling, in addition to a certain infeasibility for small producers when compared to the use of liquid limestone with high purity and reactivity. Therefore, a better understanding of the dynamics of liquid limestone employed in soil acidity correction is important. Thus, this work proposes the use of liquid limestone to correct the acidity of a Dystric Cambisol in pasture cultivation in Humaitá, AM. An experiment was carried out in a greenhouse, where plastic pots were prepared for sowing *Brachiaria brizantha*, in a randomized block design with five treatments and four replications (T1 = witness, T2 = 2.5 L, T3 = 5 L, T4 = 10 L and T5 with common limestone). After 90 days of planting, the shoot and root size of both fresh and dry mass of each treatment were evaluated, as well as the number of tillers. The tillering of B. *brizantha* was highly responsive to the addition of liquid and common limestone, so that the higher the dose, the greater the results. In contrast, the treatments for fresh and dry shoot and root biomass production did not differ significantly between themselves, explaining why the product is still not well accepted and used by dealers and farmers.

Keywords: Liming; Pastureland; Productivity.

Resumen

En el manejo, además de una cierta inviabilidad para pequeños productores en comparación con el uso de piedra caliza líquida con alta pureza y reactividad. Por lo tanto, es importante una mejor comprensión de la dinámica de la piedra caliza líquida empleada en la corrección de la acidez del suelo. Por lo tanto, este trabajo propone el uso de piedra caliza líquida para corregir la acidez de un Cambisol Districto en el cultivo de pasturas en Humaitá, AM. Se realizó un experimento en un invernadero, donde se prepararon macetas de plástico para sembrar *Brachiaria brizantha*, en un diseño de bloques al azar con cinco tratamientos y cuatro repeticiones (T1 = testigo, T2 = 2.5 L, T3 = 5 L, T4 = 10 L y T5 con caliza común). Después de 90 días de siembra, se evaluó el tamaño del brote y la raíz de la masa fresca y seca de cada tratamiento, así como el número de macollos. El macollamiento de B. *brizantha* fue altamente sensible a la adición de caliza líquida y caliza común, de modo que cuanto mayor es la dosis, mayores son los resultados. En contraste, los tratamientos para la producción de brotes frescos y secos y de biomasa de raíces no diferían significativamente entre sí, lo que explica por qué el producto aún no es bien aceptado y utilizado por los comerciantes y agricultores.

Palabras clave: Encalado; Pastizales; Productividad.

1. Introduction

Brazil is one of the countries with the greatest potential for livestock production on pasture, determined by its climatic conditions and territorial extension (Zimmer et al., 1995;

Dias-Filho, 2014), which is the most economical and practical way of producing and offering food to cattle (Ferraz and Felício, 2010). In contrast to the confinement system, pasture production does not depend on unstable factors, such as increases in grain prices (Torres Jr and Aguiar, 2013). However, of the 102 million hectares of planted pastures (IBGE, 2006) in Brazil, 70% show some degree of degradation (Dias-Filho, 2011; Zimmer et al., 2012). The growing increase in planted areas (112 million according to IBGE (2017)) raises great attention to the risks to national livestock due to the low investment in improving soil fertility.

Nowadays it is known that there is no other type of feeding method that is more competitive than the fodder harvested in the field by the animal (Nussio, 2000), due to its role in the production process, which enables the supply of food to the population more sustainably (Pereira, 2004). In cultivated pastures, Brachiaria grasses occupy a prominent place, with more than 70% of the planted area, equivalent to 80 million hectares with Brachiaria alone, due to the ability to adapt to climatic conditions, to extremely acidic and low natural fertility soils (Alcântara et al., 1993; Fageria and Baligar, 2008; Zimmer et al., 2012). On poor soils, the productive capacity of pastures is reduced, due to the acidity of the soil and the lack of nutrients available to plants. On the other hand, the increase in productivity can be obtained by correcting acidity, liming and fertilizing, together with improving pasture management.

Under acidity conditions, liming promotes soil pH elevation, Al3+ neutralization and Ca2+ and Mg2+ supply, allowing the proliferation of roots with positive reflexes in the growth of the aerial part of the plants (Quaggio, 2000). The most commonly used soil acidity improvers in agriculture come from ground limestone, which has in its constitution mixtures of minerals such as dolomite and calcite, which have mixtures of calcium carbonate and/or magnesium. However, for neutralization of soil acidity to occur, there must be a contact between the soil particles with limestone or the products of its transformation. Thus, there is a need to incorporate limestone into the soil as best as possible, which cannot always be done under field conditions (Weirich Neto et al., 2000).

According to Lopes et al. (1990), among the various characteristics of quality-related soil acidity correctives, the two most important are granulometry and neutralization content, which determine the effective calcium carbonate equivalent (ECCE). As explained by Evangelista and Rocha (1991), a limestone with ECCE equal to 70% means that 1000 Kg of this will, in three months, have the same correction effect of 700 Kg of pure and finely ground CaCO3. Its reaction rate and the degree of reactivity of limestone depend on the size of its particles (Lopes, 1989). Thus, the neutralization of soil acidity by limestone occurs as follows

(Alcarde, 2005):

$$CaCO_3 + H_2O_{\ (soil)} \quad Ca^{2+} + CO_3^{2-}$$

$$CO_3^{2-} + H_2O_{\ (soil)} \qquad HCO_3^{-} + OH^{-} \qquad (Kb_1 = 2{,}2 \times 10^{-4})$$

$$HCO_3^{-} + H_2O_{\ (soil)} \quad H_2O + CO_2 + OH^{-} \quad (Kb_2 = 2{,}4 \times 10^{-8})$$

However, limestones most commonly used in agriculture have relatively low ECCE and therefore take longer to react in the soil, are difficult to handle and have low viability for small farmers due to the difficulty in obtaining and applying the product, and losses during application by external factors (wind) and application methods.

In order to minimize these problems, it has been proposed to use calcium carbonate-based fluid fertilizers to be sprayed into the soil to provide Ca2+ and possibly correct soil acidity. These products have high purity and reactivity (100%), as they consist of nanoparticles (0.5 – 0.8 microns), and have a ECCE of 140. Because they are fluid, they improve the dispersion of particles when applied to the soil and prevent dust emissions, reducing losses. Another important factor is the ease of transportation of this product, which occupies less volume compared to limestone, making it possible for small and large farmers to use it, even in regions with difficulties in purchasing, as for example in Amazonian regions, where transportation is a limiting factor.

The sources and preparation processes of these liquid fertilizers allow greater flexibility compared to solids and, according to Bittencourt and Beauclair (1992), there is also easier handling, uniformity of soil application, elimination of storage problems and lower operating costs.

Therefore, it is important to understand the dynamics of calcium carbonate-based fluid fertilizers to correct soil acidity. Thus, this work aimed to use liquid limestone to correct the acidity of a Dystric Cambisol in the production of brachiaria grass in Humaitá, AM.

2. Material and Methods

The experiment was carried out in a greenhouse of the Institute of Education, Agriculture and Environment (IEAA-UFAM), in the municipality of Humaitá-AM. It was collected 5.0 dm^{-3} of soil, with bulk density of 1.2 $mg.dm^{-3}$, and transferred to plastic vases with capacity of 6 dm^{-3}. The soil collected was classified as a Cambissolo Háplico Alitico Plintico (Campos, 2009) [Dystric Cambisol (Alumic, Clayic)]. The soil was sampled deformed under a 0.0-0.20 m layer, then processed and obtained the fine-earth fraction for texture determination and routine chemical analysis for fertilization and liming (Table 1), according to the methodology proposed by Claessen et al. (1997).

Table 1. Chemical characterization of Dystric Cambisol at a depth of 0-20 cm.

pH (H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	H+Al	[1]OM
	---mg.dm^{-3}---		-------------------------mmol$_c$.dm^{-3} -----------------------					g.dm^{-3}
4.41	1.10	23.00	0.12	0.09	2.13	2.62	4.75	16.00

[1]organic matter. Source: own.

The experimental design was randomized blocks with five treatments and four replications. One treatment consisted of limestone application to increase base saturation to 50%, which is the most common management for soil acidity correction; the other treatments correspond to different doses of liquid fertilizer, which make up one ton of limestone. Thus, we have the following: T1 = Witness, T2 = 2.5 L, T3 = 5 L, T4 = 10 L and T5 with common limestone. The liquid fertilizer has in its chemical composition 22.5% Ca^{2+}; 16% Mg^{2+} and 18% S, with 100% reactivity and ECCE 140. The common limestone used has in its chemical composition: ECCE 85.08%; 36.4% CaO; 14% MgO. The applied amount of common limestone was 1000 kg ha-1.

Sowing of *Brachiaria brizantha* cv. *Marandú* was carried out with ten seeds per vase and, after the establishment of the plants, thinning was done, leaving five seedlings per vase. After 90 days, soil samples with deformed structure (clods) were sampled for determining soil acidity components in four layers: 0.0-0.05 m, 0.05-0.10 m, 0.10-0.20 m and 0.20-0.30 m. The following agronomic traits of Brachiaria were evaluated: number of tillers - established by counting the total number of tillers at the beginning of flowering, randomly sampled; aerial height and plant root size. Then, the dry mass of the aerial part and roots were determined after drying in an oven at 60 ° C until constant weight.

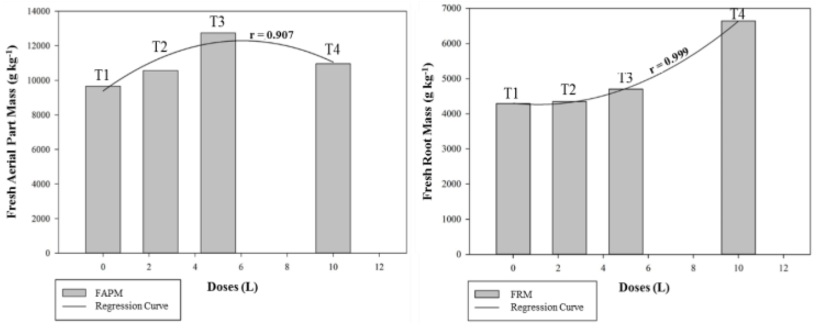
The data obtained in the experiment were subjected to analysis of variance and, when significant, the Tukey test at 5% was applied to compare the means by the computer application Assistat 7.6 (Silva and Azevedo, 2002).

3. Results and Discussion

The results show that treatment 3 (5 L ha-1 of liquid CaCO3) contributed the most to the development of fresh aerial part mass (FAPM) (Figure 1), with a production loss of

1786.12 kg ha^{-1} when treatment 4 (10 L ha^{-1}) was applied, while the control presented the lowest biomass, with a value of 9658.33 kg ha^{-1}. This behavior was adjusted to a 90% correlation quadratic regression curve ($r = 0.907$; $p < 0.05$), showing that the best dose for B. brizantha FAPM increment is between 5 and 5.5 L ha-1 of liquid CaCO3.

Figure 1. Production of fresh biomass of aerial part and roots according to the increase in the dose of liquid limestone.



Source: own.

On the other hand, fresh root mass (FRM) showed an exponential growth (Figure 1), without much response until the 3rd treatment, but with a high increase when applied the 4th treatment (10 L ha-1), reaching about 6641.66 kg ha-1. Thus, there is a duality in FAPM and FRM between doses 5 and 10 L ha-1, thus being in an optimum state of use according to the commercial objectives of the crop and/or producer, since not always a system well developed root system is synonymous of aerial biomass yield.

As in the FAPM, the dry aerial part mass (DAPM) also presented a higher yield with treatment 3 (5574.00 Kg ha-1) (Figure 2), without much variation among the other treatments in relation to the control, which showed a dry biomass of 4208.33 kg ha-1. However, its correlation was lower than that of FAPM, with a value of 78%, due to the similarities between treatments 1, 2 and 4.

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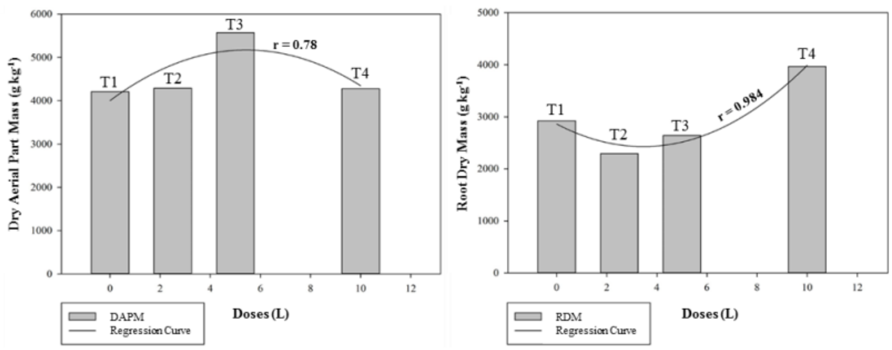
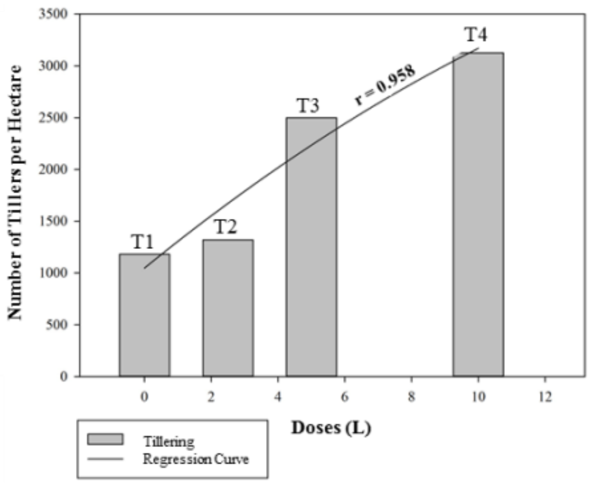
Figure 2. Production dry biomass of aerial part and roots according to the increase in the dose of liquid limestone.



Source: own.

Regarding root dry mass (RDM), only treatment 4 was superior to the control, with a value of 3966.66 kg ha^{-1} against the 2925.00 Kg ha^{-1} of the control (Figure 2). Nevertheless, it showed an exponential behavior similar to that of FRM, where the treatment with the highest dose also showed to be more efficient for the underground biomass increment. Regarding the number of tillers (Figure 3), treatments 3 and 4 were the most significant, in which treatment 3 showed a value of 2500 tillers per hectare and the 4th treatment a value of 3125 tillers per hectare. The lower tillering was confirmed in the control, which obtained a total of 1180.55 tillers per hectare, indicating that this species is highly responsive to the addition of $CaCO_3$, but it also indicates that the higher the recommendation dose for a given area, the higher it will be workforce with cultural treatment, depending on the culture.

Figure 3. Production of the amount of tillers per hectare according to the increase in the dose of liquid limestone.



Source: own.

According to the averages obtained, it was also observed that in addition to treatments 3 and 4, the 5th (common limestone) was also statistically higher than treatments 1 and 2 for the number of tillers (Table 2).

Table 2. Fresh and dry matter production (kg ha^{-1}) and number of tillers *Brachiaria* plants cv. Marandu under different doses of limestone 90 days after planting.

Tratamentos	Fresh Matter (kg ha^{-1})		Dry Matter (kg ha^{-1})		Nº of tillers
	Aerial Part	Roots	Aerial Part	Roots	(ha)
T1(testemunha)	9658.33 a	4291.66 a	4208.33 a	2925.00 a	1180.55 b
T2 (2.5 L ha^{-1})	10572.22 a	4347.22 a	4291.66 a	2294.44 a	1319.44 b
T3 (5 L ha^{-1})	12750.00 a	4702.77 a	5574.00 a	2641.44 a	2500.00 a
T4 (10 L ha^{-1})	10963.88 a	6641.66 a	4280.55 a	3966.66 a	3125.00 a
T5 (1000 kg ha^{-1})	16075.00 a	5269.44 a	5797.44 a	3355.55 a	2569.44 a
CV (%)	29.58	17.00	20.25	20.52	15.00

Means followed by the same lowercase letter in the lines do not differ from each other by the Tukey test ($p < 0.05$). CV = coefficient of variation. Source: own.

This can be explained by increased soil pH, which is directly linked to increased phosphorus availability in the soil. Phosphorus is the most required nutrient in the first growth of forage grasses (Cantarutti et al., 1999), since its main role is associated with the establishment of the root system. The tillering is relevant, since the emission of leaves and tillers guarantees the perennial grass forage.

The results show that there was no significant effect of the application of liquid limestone for the production of dry and fresh mass of the aerial part and roots. The results corroborate with Alves (2015), who studying liquid limestone doses in soils cultivated with Marandu and Mombaça forages did not find any difference in the aerial dry matter production with the application of liquid limestone, even in increasing doses in both cultivars. The author also verified that for the dry matter of the root system, there was a reduction in production for both grasses in relation to the control treatment, without the application of liquid limestone.

Considering the use of common limestone, the DAPM showed the best result for treatment 5, which obtained an average value of 5797.44 Kg ha-1, but did not differ statistically from other treatments tested (Table 2).

These results were higher than those found by Ezequiel and Favoretto (2000), who obtained 35 days dry mass production of 1625 Kg ha-1 with colonião grass. Results found by Barros et al. (2002) showed an increase in dry mass production of 7600 Kg ha-1, being higher than those found in this study. Already Benett et al. (2008) working with nitrogen fertilization in Brachiaria brizantha observed an increase in dry mass production.

Studies of leaf dry mass production in forage grasses are important because the leaves are the organ of the plants preferentially consumed by animals, besides being the main source of nutrients for grazing ruminants (Rodrigues et al., 2008).

This also corroborates that crop yield depends on total biomass production and dry matter distribution between the productive and non-productive parts of the plant (Hole et al., 1983).

Regarding the variables fresh and dry matter of the root, no statistical difference was found between the different doses of limestone tested (Table 2).

It is possible to observe the same fact between the fresh matter values of the shoot as a function of the corrective doses, which did not differ statistically from each other. Therefore, the different corrective doses adopted in the experiment did not influence the determination of these agronomic parameters.

4. Conclusion and Suggestions

B. *brizantha* tillering was highly responsive to the addition of both liquid and common limestone, so that the higher the dose, the greater the results.

On the other hand, the parameters of fresh and dry biomass production from the aerial part and roots did not show differences at the 5% level between themselves, explaining why the product is still not well accepted and used by traders and farmers.

However, other factors such as economic viability and ease of local acquisition should be further investigated.

Due to the effectiveness of limestone, doors are opened for experiments on other varieties of pastures, seeking the sustainability of agricultural production means.

Referências

Alcarde, J. C. (2005). Corretivos da acidez dos solos: características e interpretações técnicas. São Paulo, ANDA. p. 24.

Alves, J. R. Doses de calcário líquido em solos cultivados com as forrageiras Marandu e Mombaça. 42f. Dissertação (mestrado em Zootecnia), Universidade Federal de Viçosa. 2015.

Barros, C. O., Pinto, J. C., Evangelista, A. R., Muniz, J. A., Andrade, I. F., & Santos, R. A. (2002). Rendimento e composição química do capim-Tanzânia estabelecido com milheto sob três doses de nitrogênio. *Ciência e Agrotecnologia*, 26(5), 1068-1075. https://doi.org/10.1590/S1516-35982010000600006

Benett, C. G. S., Buzetti, S., Silva, K. S., Bergamaschine, A. F., & Fabricio, J. A. (2008). Produtividade e composição bromatológica do capim-marandu a fontes e doses de nitrogênio. *Ciência e Agrotecnologia*, 32(5), 1629-1636. http://dx.doi.org/10.1590/S1413-70542008000500041

Bittencourt, V. C., & Beauclair, E. G. F. (1992). Fertilizantes Fluídos. *XX Reunião Brasileira de Fertilidade do Solo e Nutrição de Plantas*, 255-273.

Campos, M. C. C. (2009). *Pedogeomorfologia aplicada a ambientes Amazônicos do Médio Rio Madeira*. Doctoral Thesis. Recife: UFRP. 260p.

Cantarutti, R. B., Martins, C. E., Carvalho, M. M., Fonseca, D. M., Arruda, A. L., Vilela, H., & Oliveira, F. T. T. (1999). Pastagens. In Ribeiro, A. C., Guimarães, P. T. G., & Alvarez, V. V. H. (Eds.), *Recomendação para o Uso de Corretivos e Fertilizantes em Minas Gerais*. 5ª Aproximação. CFSEMG, 43-60.

Claessen, M. E. C., Barreto, W. O., Paula, J. L., & Duarte, M. N. (1997). *Manual de métodos de análise de solo*. (2nd ed.). Rio de Janeiro. p. 212.

Dias-Filho, M. B. (2011). *Degradação de pastagens: processos, causas e estratégias de recuperação*. (4th ed.). Belém-PA: Embrapa Amazônia Oriental.

Dias-Filho, M. B. (2014). *Diagnóstico das pastagens no Brasil*. Belém-PA: Embrapa Amazônia Oriental. p. 36.

Evangelista, A. R., & Rocha, G. P. (1991). *Forragicultura*. Lavras: ESAL- FAEPE. p. 195.

Ezequiel, J. M. B., & Favoretto, V. (2000). Efeito do manejo sobre a produção e composição química de perfilhos do capim-colonião (Panicum maximum Jacq.). *Revista Brasileira de Zootecnia*, 29(6), 1596-1607. https://doi.org/10.1590/S1516-35982000000600002

Fageria, N. K., & Baligar, V. C. (2008). Ameliorating soil acidity of tropical Oxisols by liming for sustainable crop production. *Advances in agronomy*, 99, 345-399. https://doi.org/10.1016/S0065-2113(08)00407-0

Ferraz, J. B. S., & de Felício, P. E. (2010). Production systems–An example from Brazil. *Meat science*, 84(2), 238-243. https://doi.org/10.1016/j.meatsci.2009.06.006

Hole, C. C., Barnes, A., Thomas, T. H., Scott, P. A., & Rankin, W. E. F. (1983). Dry matter distribution between the shoot and storage root of carrot (Daucus carota L.) I. comparison of varieties. *Annals of Botany*, 51(2), 175-187. https://doi.org/10.1093/oxfordjournals.aob.a086456

IBGE – Instituto Brasileiro de Geografia e Estatística. *Censo agropecuário 2006: Brasil, Grandes Regiões e Unidades da Federação: segunda apuração*. Rio de Janeiro: IBGE, 2012. 758 p. Available in: https://biblioteca.ibge.gov.br/pt/biblioteca-catalogo?view=detalhes&id=261914. Accessed in: jun. 2020.

IBGE – Instituto Brasileiro de Geografia e Estatística. *Censo agropecuário: resultados definitivos 2017*. Rio de Janeiro, 8, 1-105, 2019. Available in: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=73096. Accessed in: jun. 2020.

Lopes, A. S. (1989). *Manual de fertilidade do solo*. São Paulo: ANDA/POTAFOS. p. 153.

Lopes, A. S., Silva, M. C., & Guilherme, L. R. G. (1990). Acidez do solo e calagem. (3rd ed.). São Paulo: ANDA. p. 22.

Nussio, L. G. (2000). Volumosos para bovinos de corte em confinamento. In Peixoto, A. M., Moura, J. C., Feria, V. P. *Confinamento de bovinos de corte*. FEALQ, 85-112.

Pereira, J. (2004). *As pastagens no contexto dos sistemas de produção de bovinos*. Manejo integrado: integração agricultura-pecuária. Viçosa-MG: UFV, 287-330.

Quaggio, J. A. (2000). *Acidez e calagem em solos tropicais*. Campinas: Instituto Agronômico. p. 111.

Rodrigues, R. C., Mourão, G. B., Brennecke, K., Luz, P. H. D. C., & Herling, V. R. (2008). Produção de massa seca, relação folha/colmo e alguns índices de crescimento do Brachiaria brizantha cv. Xaraés cultivado com a combinação de doses de nitrogênio e potássio. *Revista Brasileira de Zootecnia*, 37(3), 394-400. http://dx.doi.org/10.1590/S1516-35982008000300003

Silva, F. A. Z.; & Azevedo, C. A. V. (2002). Versão do programa computacional Assistat para o sistema operacional Windows. *Revista Brasileira de Produtos Agroindustriais*, 4(1), 71-78.

Torres J, A. M., & Aguiar, G. A. M. (2013). Pecuária de corte no Brasil–potencial e resultados econômicos. *Encontro de Adubação de Pastagens da Scot Consultoria-Tec-Fértil*, 1(2013), 9-14.

Weirich Neto, P. H., Caires, E. F., Justino, A., & Dias, J. (2000). Correção da acidez do solo em função de modos de incorporação de calcário. Ciência Rural, 30(2), 257-261. https://doi.org/10.1590/S0103-84782000000200010

Zimmer, A. H., Euclides, V. P., & Macedo, M. C. M. (1995). Manejo de plantas forrageiras do gênero Brachiaria. Plantas Forrageiras de Pastagens. Piracicaba: FEALQ, 69-100.

Zimmer, A. H., Macedo, M. C. M., Kichel, A. N., & Almeida, R. G. (2012). Degradação, recuperação e renovação de pastagens. Campo Grande-MS: Embrapa Gado de Corte. p. 42.

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