

Full Length Research Paper

Wood ash on the fertilization of marandu grass in Brazilian cerrado soils

Maria Débora Loiola Bezerra, Edna Maria Bonfim-Silva*, Tonny José Araújo da Silva, Helon Hébano de Freitas Sousa, Thiago Franco Duarte, Ellen Souza do Espírito Santo and Adriano Bicioni Pacheco

Department of Agricultural and Environmental Engineering, Institute of Agricultural Sciences and Technology, Federal University of Mato Grosso, Rondonópolis, Brazil.

Received 11 December, 2015; Accepted 17 March, 2016

Wood ash can be an alternative fertilizer and soil corrective measure, directly contributing to the production of pastures. The objective of this research was to evaluate the growth and production of marandu grass fertilized with wood ash and grown in two soil classes of the Brazilian Cerrado. The experiment was conducted in a greenhouse during the period from December, 2012 to May, 2013. The experimental design was completely randomized in a factorial 2×6 , corresponding to two soil classes (Ultisol and Oxisol) and six doses of wood ash (0, 3, 6, 9, 12 and 15 g dm⁻³), with six replications. Pots with soil volume of 5 dm³ were used with five plants. Three cuts were performed in the shoot of plants in a 30-day interval and at each cut was the plant height, dry mass of leaves and stems and the leaf/stem ratio evaluated. The results were submitted to analysis of variance and, when significant, the qualitative factors (soil classes) were submitted to the Tukey test and the quantitative factors (wood ash doses) subjected to regression analysis, both at 5% probability. The wood ash as fertilizer provides greater growth and dry matter production of marandu grass grown in Ultisol and Oxisol. The use of wood ash as fertilizer may be an alternative for the destination of this waste, and it can provide a reduction of mineral fertilizer and consequently of pasture production costs in the Brazilian Cerrado.

Key words: Solid waste, alternative fertilizer, *Brachiaria brizantha*, ultisol, oxisol.

INTRODUCTION

Wood ash is a residue from the burning of wood in a boiler for energy production and, depending on its origin, it can show high levels of potassium, phosphorus, calcium and magnesium, and it can also be used as fertilizer and corrective, depending on the soil fertility and the culture requirements (Voundinkana et al., 1998). In addition to the macronutrients, it may also contain essential micronutrients for plant growth, such as copper,

zinc, iron and boron (Darolt and Osaki, 1991).

The large-scale generation of such solid waste by the industrial sector and the destination of this byproduct become a problem, being often disposed untreated on the environment. An alternative would be to use wood ash as a supplement in fertilizing cover crops and green manures in soils with high acidity, restoring part of the nutrients removed in the harvests, reducing the use of

*Corresponding author. E-mail: embonfim@hotmail.com. Tel: +55 66 81323814

Table 1. Chemical and granulometric analyses of Oxisol (0-20 cm layer) in area under Cerrado vegetation, Rondonópolis-MT, 2012.

pH	P	K	Ca	Mg	Al	H	CTC	OM	V	m	Sand	Silt	Clay
CaCl ₂	mg dm ⁻³	cmol _c dm ⁻³					g kg ⁻¹%.....	g kg ⁻¹		
4.1	1.1	47	0.2	0.1	1.0	4.7	6.1	19.7	6.9	70.4	575	50	375

P = Phosphorus; K = Potassium; Ca = Calcium; Mg = Magnesium; Al = Aluminium; H = Hydrogen; CTC = Cation exchange capacity; OM = Organic matter; V = Base saturation; m = Aluminum saturation

Table 2. Chemical and granulometric analyses of Ultisol (0-20 cm layer) in area under Cerrado vegetation, Rondonópolis-MT, 2012.

pH	P	K	Ca	Mg	Al	H	CTC	OM	V	m	Sand	Silt	Clay
CaCl ₂	mg dm ⁻³	cmol _c dm ⁻³					g kg ⁻¹%.....	g kg ⁻¹		
4.9	4.8	25	1.0	0.6	0.1	1.5	3.3	6.2	50.9	5.7	830	50	120

P = Phosphorus; K = Potassium; Ca = Calcium; Mg = Magnesium; Al = Aluminium; H = Hydrogen; CTC = Cation exchange capacity; OM = Organic matter; V = Base saturation; m = Aluminum saturation

Table 3. Chemical characterization of the wood ash.

pH	P ₂ O ₅	K ₂ O	Zn	Cu	MnNAC+Water	BWater	Ca	S
-----g kg ⁻¹ -----								
7.85	14.2	3.2	0.0	0.1	0.0	0.0	9.0	16

P₂O₅ = Phosphorus; K₂O = Potassium; Zn = Zinc; Cu = Copper; Mn NAC+Water = Manganese in neutral ammonium citrate and water; Ca = Calcium; S = Sulphur

correctives and commercial fertilizers, and consequently the production costs. Studies prove positive effect of wood ash regarding the structural and productive characteristics of marandu grass (Bonfim-Silva et al., 2013; Santos et al., 2014; Bonfim-Silva et al., 2014). There is still no information of the influence of this waste in the production of forage grasses in different soil classes.

The Cerrado soils have low fertility because they contain low levels of available nutrients, depending on the source material. Wood ash application may be a low-cost alternative to re-establish fertility. Despite the tolerance of pastures to acid and low fertility soils, the absence of correction and fertilization of the soil and the intensive use can lead to their degradation, such management practices are needed because the soil fertility severely limits the ability of crops to achieve maximum productivity (Bezerra et al., 2014).

In this context, the experiment aimed to evaluate the growth and production of marandu grass fertilized with wood ash and grown in two soil classes of the Brazilian Cerrado.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse at the Federal University of Mato Grosso, Rondonópolis Campus, during the

period from December, 2012 to May, 2013. The forage grass used was *Brachiaria brizantha* cv. Marandu, grown in pots with soil volume of 5 dm³, representing the experimental units. The experimental design was completely randomized in a factorial 2 x 6, corresponding to two soil classes (Oxisol and Ultisol) and six wood ash doses (0, 3, 6, 9, 12 and 15 g dm⁻³), with six replications. Soil samples were collected in the 0 to 20 cm layer, in area under Cerrado vegetation, both in the region of Rondonópolis-MT. They were passed through a sieve of 2 mm aperture, homogenized, and then chemical and granulometric characterization was done (Tables 1 and 2), according to the methodology proposed by EMBRAPA (1997). The soil for the composition of the pots was sieved on a 4 mm aperture mesh. The wood ash was derived from the ceramic sector activity, analyzed as fertilizer (Table 3), according to Darolt et al. (1993), and showed pH of 7.85. The soil correction was not performed by liming because the wood ash raises the soil pH. The soil was incubated with wood ash for 30 days.

Wood ash does not have nitrogen in its composition because in the wood burning process occurs the loss of this nutrient by volatilization (Oberberger et al., 2006). Therefore, the nitrogen fertilizer was performed for crop establishment and after each cut, at a dose of 200 mg dm⁻³, using urea as source. The maximum capacity of the soil water retention was determined in the laboratory using the gravimetric method (Bonfim-Silva et al., 2011). Soil moisture was maintained at 80% of the maximum soil water retention through the daily weighing of all experimental plots. The interval between the marandu grass cuts was of 30 days. At each cut, the evaluation of plant height, dry mass of leaves, dry mass of stems, and the leaf/stem ratio was carried out. The first two cuts of the forage were performed at 5 cm from the soil and the third cut near the soil (Bonfim-Silva et al., 2007).

The determination of the height of the plants was obtained with a

graduated scale, from the soil to the curvature of the forage canopy. The plant material was collected at each cut, dried in an oven with forced air at 65°C for 72 h until a constant mass (Silva and Queiroz, 2002) and after drying, weighed in semi-analytical scale for determining the dry mass. The leaf/stem ratio represents the ratio between the dry mass of leaves and the dry mass of stems in each plot. The results were submitted to analysis of variance by F test and, when significant, the qualitative factors (soil classes) were submitted to Tukey test and the quantitative factors (wood ash doses) submitted to regression analysis, both at 5% probability, through the statistical program SISVAR of the Federal University of Lavras (Ferreira, 2008).

RESULTS AND DISCUSSION

In the first evaluation, the variable plant height was adjusted to the quadratic regression model when grown in Oxisol, with the largest height of marandu grass being 47.93 cm in the wood ash dose of 9.12 g dm⁻³. For the Ultisol, the height of plants was adjusted to the linear regression model with an increase of 44.96% comparing the highest dose of the experimental interval (15 g dm⁻³) with the absence of fertilization with wood ash (Figure 1A). The height of marandu grass plants, in the second evaluation, showed no significant difference between the doses of wood ash and in the last cut of the forage grass cultivated in Ultisol, the plant height was adjusted to the linear regression model, with a decrease of 18.31% relating the absence of the application with the dose of 15 g dm⁻³ wood ash (Figure 1B).

In the first cut, the height of the marandu grass grown in both soils from the dose of 9 g dm⁻³ exceeded 40 cm. In a study aimed at reconciling greater leaf production and lower production of stems with dead material of *B. brizantha* cv. Marandu irrigated in the field; the greatest heights ranged from 35 to 40 cm, thus justifying the fertilization with wood ash to obtain significant growth of the forage (Rodrigues, 2004). On the contrary, in the third cut, the forage grass did not reach this minimum margin of plant height, since there was no reapplication of the residue from the second cut and the nutrients began to run out.

The Ultisol, even in the absence of fertilization with wood ash, provided greater plant height, standing out about the Oxisol, in the first and third cut. This may be due to higher natural fertility through the nutrient concentration in Ultisol, especially phosphorus, an important nutrient for plant growth. Nonetheless, in the second cut, there was no significant difference between the two soils, indicating that the Oxisol fertilized with wood ash raises the height of marandu grass, equating up to the Ultisol. Gonçalves and Moro (1995) observed that the use of forest biomass ash, under laboratory conditions, substantially increased soil fertility, responsible for the rise in productivity of *Eucalyptus grandis*. In the third evaluation, in particular, there was a reduction in plant height with the increase of wood ash doses, in virtue of the ash solubilization in the soil and the

availability of nutrients (Demeyer et al., 2001) for the marandu grass in the first cut, and as the nutrients were extracted at the time of the cuts, they were restricted to plants, since there was no re-application of the wood ash.

According to Garay et al. (1997), plant height is an important structural feature for the adoption of appropriate management, indicating the time of entry of the animals in the pasture. The consumption increases with the elevation of the pasture height to a level in which it remains constant, depending on the species and animal category (Hodgson, 1990).

In the first evaluation of the forage grass, the dry mass of leaves was adjusted to the linear regression model, where the highest wood ash dose increased by 78.41 and 66.25% in the dry matter production of marandu grass leaves grown in Ultisol and Oxisol, respectively, when compared to the treatment without fertilization (Figure 2A). In the second evaluation of the plants, the dry mass of leaves of the marandu grass grown in Oxisol was adjusted to the linear regression model increasing by 17.49% in the production when comparing the dose of 15 g dm⁻³ with the absence of application of wood ash. The marandu grass grown in Ultisol showed dry mass of leaves with adjustment to the quadratic regression model, in which the least amount of leaves was 4.4 g pot⁻¹ using 7.09 g dm⁻³ of wood ash (Figure 2B).

In the third cut, the dry mass of leaves was adjusted to the quadratic regression model in which the maximum production (2.63 g pot⁻¹) was observed when the marandu grass was grown in Oxisol using the wood ash dose of 10.87 g dm⁻³ (Figure 2C). It was found, as in this study, the positive effect of wood ash doses on *Brachiaria brizantha* grown in Oxisol, in the first two cuts, with higher results for the dry mass of leaves with increasing doses of this waste (Santos, 2012). In this way, it is emphasized the potential of using fertilization with wood ash in forage, since the dry mass of leaves represents the portion of highest nutritional value, once the leaves are more digestible than the stems and the senescent material, and also have higher crude protein levels (Paciullo, 2002), being therefore preferred by the animal.

In the third cut, the significant difference in dry mass of leaves of marandu grass only when grown in Oxisol indicates that despite being a soil with low natural fertility, the application of the residue can exceed the production potential of this soil about that of greater natural fertility. The agricultural production in low fertility soils requires nutritional supplementation, which can be made with organic fertilizers, such as wood ash (Bonfim-Silva et al., 2014). The dry matter yield of stems of marandu grass in the first cut was adjusted to the linear regression model with an increase of 87.9% for Ultisol and of 77.24% for Oxisol, from the higher dose of wood ash when compared to the absence of the same (Figure 3A).

In the second cut of the forage grass, there was a 33.17% increase in dry matter yield of stems of marandu grass in Oxisol comparing the higher wood ash dose with

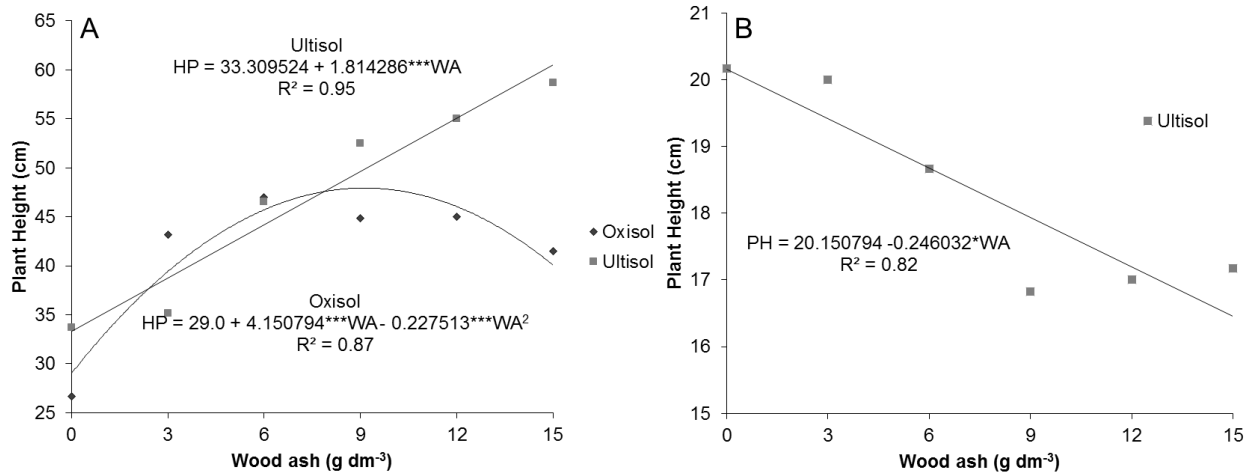


Figure 1. Height of marandu grass plants subjected to wood ash doses in Oxisol and Ultisol in the first cut (A) and in Ultisol in the third cut (B). PH = plant height. WA = wood ash. * and *** significant at 5 and 0.1% probability, respectively.

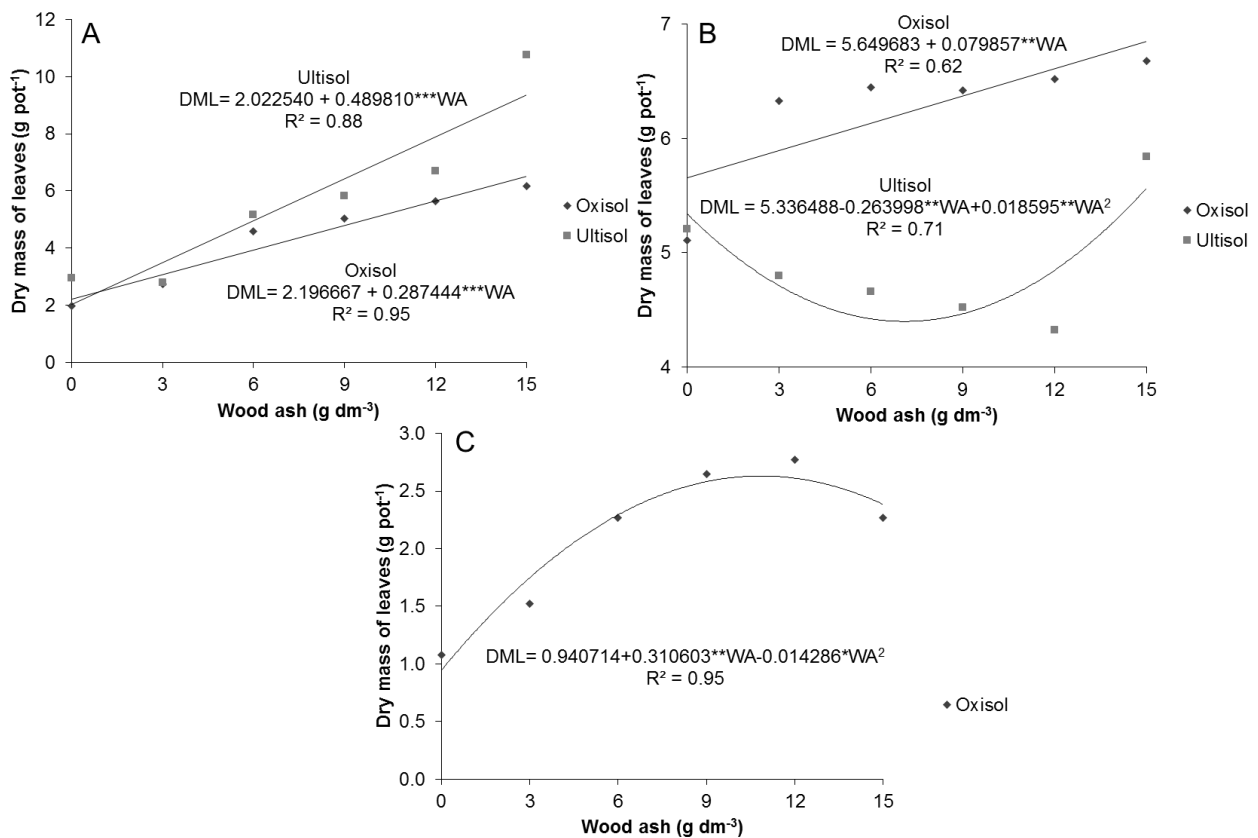


Figure 2. Dry mass of leaves of marandu grass subjected to wood ash doses in and Ultisol in the first (A) and second cuts (B) and in Oxisol in the third cut (C). DML = dry mass of leaves. WA = wood ash. *, ** and *** significant at 5, 1 and 0.1% probability, respectively.

the absence of application of this waste, while the lowest dry matter of stems (1.37 g pot^{-1}) was found at a dose of

6.96 g dm^{-3} , applied in Ultisol (Figure 3B). The dry mass of stems in the last cut was adjusted to the quadratic

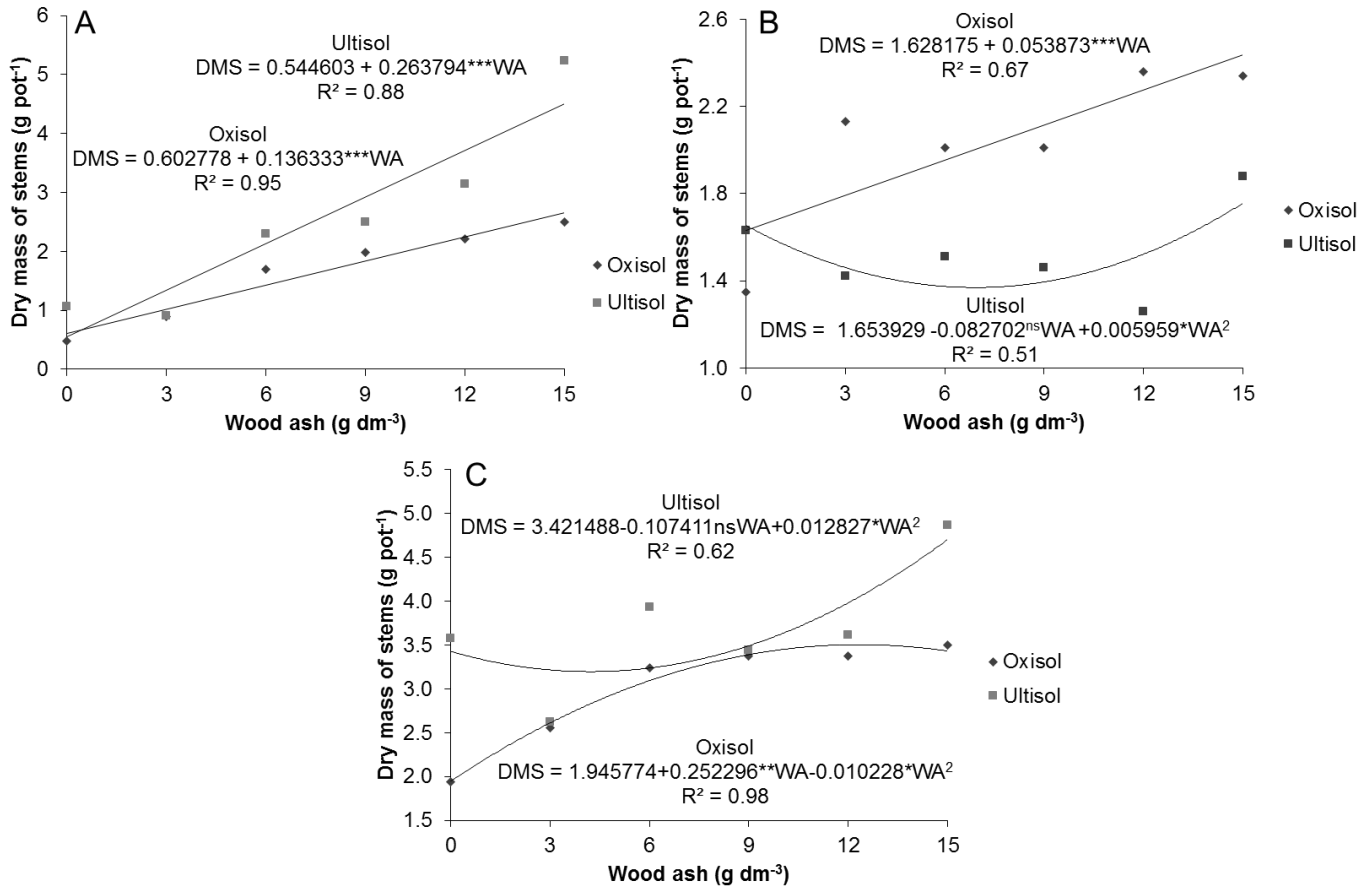


Figure 3. Dry mass of stems of marandu grass subjected to wood ash doses in Oxisol and Ultisol in the first (A), second (B) and third cuts (C). DMS = dry mass of stems. WA = wood ash. ^{ns}, * and *** no significant and significant at 5 and 0.1% probability, respectively.

regression model in which the maximum production was equal to 3.51 g pot⁻¹, observed at a dose of 12.38 g dm⁻³ when the marandu grass was grown in Oxisol. For the Ultisol, the adjustment of the results of this variable was given by the quadratic regression model with minimum point (3.20 g pot⁻¹) in the wood ash dose of 4.22 g dm⁻³ (Figure 3C).

As in the present study, the dry mass of stems of marandu grass in the first cut, in a study conducted by Bonfim-Silva et al. (2013), showed linear effect with increased doses of wood ash. There was a greater increase in dry mass of stems about the dry mass of leaves (Figure 2A) in both soils since forage grasses have a critical time when there is the greater targeting of their photoassimilates to the production of stems (Bianco et al., 2005). From the second cut, the rate of leaf growth slowed the success of the development of stems. This is a strategy of the plant to accumulate mass, since the excess of leaves causes self-shading, reducing the overall plant photosynthesis (Negreiros Neto, 2007). In the first cut of the marandu grass, the leaf/stem ratio were adjusted to the quadratic regression model, and the lowest score, of 2.32, was obtained in the wood ash dose

of 10.79 g dm⁻³, applied in Oxisol. As for the Ultisol, there was a decrease of 41.58% in the leaf/stem ratio when comparing the absence of ash application with the maximum dose of the experiment by 15 g dm⁻³ (Figure 4A).

The wood ash doses decreased the leaf/stem ratio by 21.68% in the second evaluation of the marandu grass when grown in Oxisol, compared with the absence with the maximum dose of this waste (Figure 4B). In the third cut of the marandu grass, there was no significant effect of wood ash doses on both soil classes. The reduction in the leaf/stem ratio of the marandu grass was due to the increase in the production of stems from the application of wood ash doses. As the nutrients have been extracted at the time of the cuts, they have become insufficient because there was no re-application of wood ash, which can interfere with the grass structure, compromising the grazing efficiency due to the decrease in the leaf/stem ratio (Rodrigues et al., 2008). The variable leaves/stems, according to Euclides et al. (2000), is directly related to the performance of grazing animals, important from the point of view of the nutritional value and of the management of forage species (Alden and Whitaker,

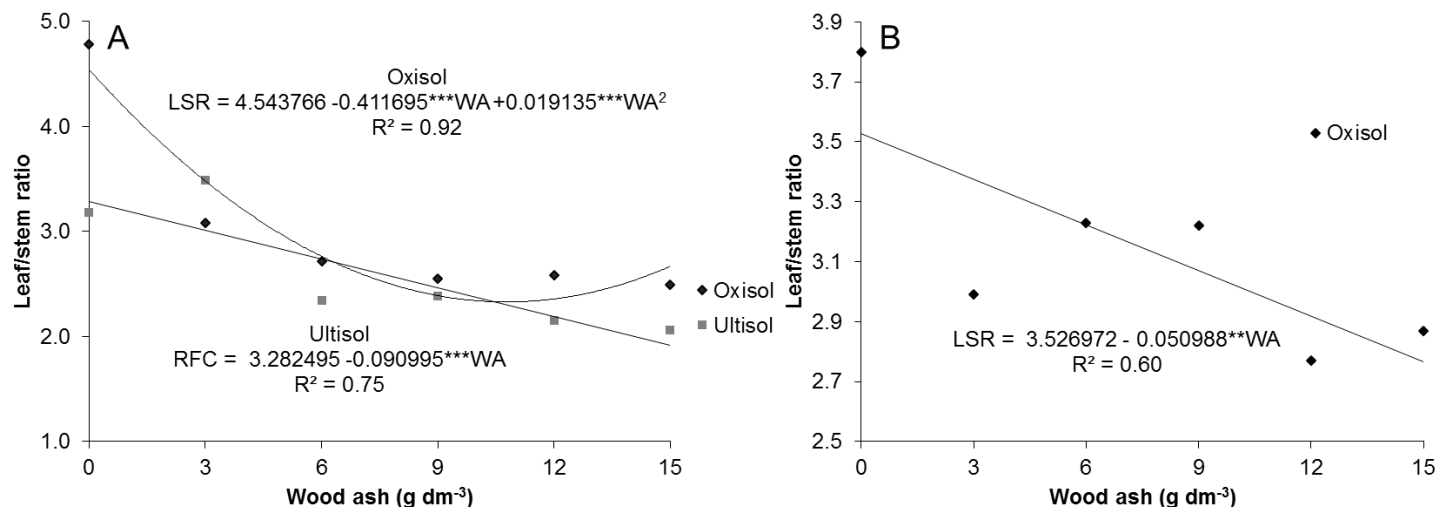


Figure 4. Leaf/stem ratio of marandu grass subjected to wood ash doses in Oxisol and Ultisol in the first cut (A) and in Oxisol in the second cut (B). LSR = leaf/stem ratio. WA = wood ash. ** and *** significant at 1 and 0.1% probability, respectively.

1970; Pinto et al., 1994).

Despite this decrease in the leaf/stem ratio, the results of this study are above the ideal critical threshold, which is equal to 1.00. This critical level regards the quantity and the quality of the produced forage (Pinto et al., 1994; Andrade, 1997). The marandu grass, in general, had higher growth and yield when grown in Ultisol fertilized with the wood ash dose of 15 g dm⁻³. The maximum yields of marandu grass grown in Oxisol were obtained in the wood ash doses range of 9 to 15 g dm⁻³.

Conclusion

The wood ash as fertilizer provides greater growth and dry matter production of marandu grass grown in Oxisol and Ultisol. The use of wood ash as fertilizer may be an alternative for the destination of this waste, and it can provide a reduction of mineral fertilizer and consequently of pasture production costs in the Brazilian Cerrado.

Conflict of Interest

The authors have not declared any conflict of interest.

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