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Soil chemical properties under a no-tillage system: Forage grass seeding modes of gender *urochloa* intercropped with maize

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Different farming practices and soil management can make changes in the chemical properties of the soil. In this sense, the monitoring of these possible changes is essential for proper soil correction and/or using systems that are more sustainable. The objective of this work was to verify the behavior of the chemical attributes of a Latosol (Oxisol) under a no-tillage system of plantation, by intercropping maize with two species of forage grasses in different methods of sowing. The experiment was conducted in an area of the Laboratory of Agricultural Equipment and Mechanization of Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP, São Paulo State University), in Jaboticabal, Brazil, and the treatments were maize intercropped with two species of grass, of the *Urochloa* gender, namely *Urochloa brizantha* cv and *Urochloa ruziziensis cv*, sown in four modes: maize with *Urochloa* in row seeding (MFL); maize with *Urochloa* between rows, sown on the same day of the sowing of maize (MFE); maize with *Urochloa* sown in rows, covered by fertilizer at the V4 stage (MFC); maize with *Urochloa*, sown by casting, along with fertilizer cover at the V4 stage of maize (MFLA) and maize alone, without any intercropping (control). Composite samples were taken for chemical analysis (P, MO, Ca, Mg, K, H + Al, SB, T, and V) in layers from depths 0.00 to 0.10 m; 0.10 to 0.20 m; and 0.20 to 0.30 m. The experimental design was that of randomized blocks, with nine treatments, in a factorial design (2×4) +1, with four replications. Major changes were observed in the soil chemical attributes in layer 0.10-0.20 m, within modes MFE and MFLA. In the no-till system, *Urochloa brizantha* cv has greater cycling of Ca^{2+} and Mg^{2+} in the layer from 0.10 to 0.20 m.

Key words: Fertilization, soil fertility, sowing mode, crop rotation, nutrient cycling.

INTRODUCTION

The intensive use of areas for agricultural production, coupled with inadequate techniques of soil management and the uneven distribution of rains hamper the implementation of autumn/winter crops for both the

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formation of straw and the production of grain, a fact observed almost wherever in the state of São Paulo as well as in the Brazilian Midwest (Barducci et al., 2009). In tropical regions, the decomposition of organic material is faster and this fact is worthy of greater attention by producers (Liu et al., 2010). In recent decades, with the advancement in research and the use of new technologies, a change is happening in the agricultural sector, which is explained by the incorporation of more intensive processes in production systems (Barcellos et al., 2008). Among planting systems used by producers, the no-till is considered the most conservationist, for recommending the supply of coverage over the soil, rotation and intercropping. In the no-till system, intercropping is an alternative aimed at increasing the sustainability of the agricultural production model, because the consortium of crops changes the physical, chemical and biological soil properties over time, may favor the improvement of the sustainability of agricultural systems as a result of yield diversity (Garcia et al., 2008; Calonego et al., 2011).

The maize crop has excelled in integration with forage grass for providing increased straw provision for the maintenance of tillage, in addition to allowing the use of the dry mass after harvest, used in animal feed during periods of lower supply of pasture. Barducci et al. (2009), claim that the implanted forage grass species in the consortium is crucial for obtaining good yields of both maize grains and accumulation of forage grass dry matter. Various forage grass species stand out in intercropping with maize, but in the literature are found a few that stand out, such as *B. brizantha cv*, *B. ruziziensis cv*, *Panicum maximum cv. Tanzania* and *P. maximum cv. Mombaça*, (Pereira et al. 2014). Forage grasses provide large amount of mass (dry matter), according to Costa et al. (2014) the *Urochloa brizantha cv.* and *Urochloa ruziziensis cv* are good alternatives in the production of straw under no-tillage. Thus, forage grasses protect the soil for longer against erosion and change the physical and chemical properties of soil through nutrient cycling and aggregate stability (Loss et al, 2011; Seidel et al, 2014). It is extremely valuable to understand the dynamics of soil properties, be they of physical, biological or chemical order, in view of the direct influence of these factors in the success of agricultural production. Thus, the monitoring of soil fertility levels is important not only for the correct nutritional supply of crops, but also to allow that adequate management practices of fertilization and soil preparation are performed efficiently, enabling improvements in management practices in order to improve the production and crop management (Tasso Júnior et al., 2010).

The no-tillage improves soil chemical conditions due to the level of organic matter from straw, contributing to soil cover, while maintaining system stability (Chioderoli et al., 2012a). Also, according to Mateus et al. (2012), the simple fact of maintaining straw in the soil, increases the level of organic matter, phosphorus, potassium, calcium, magnesium, pH, effective CEC and micro-nutrients on the soil surface, as well as there is a decrease of exchangeable Al. Freitas et al. (2014) reported that the main chemical changes in cultivated soils compared to the original conditions, are due to the variation of pH and cation levels.The chemical properties of the soil are affected by the removal of natural vegetation and cultivation, mainly on its surface, due to the addition of lime and fertilizers and agricultural operations. According Zanão Junior et al. (2010), in the no-tillage system (SPD), the management itself, such as the surface application of limestone, fertilization, accumulation of crop residues, can alter the soil chemical fertility. Thus, the adoption of certain management practices, such as surface fertilizer; sowing by casting; sowing in rows; crop residues in succession and/or rotation over the years, contribute in the dynamic behavior of the soil chemical properties. In this sense, the evaluation of soil chemical properties is required due to the heterogeneity of these attributes, especially when associated with methods of sowing and intercropping. Therefore, the objective of this study was to evaluate the behavior of soil chemical properties due to the consortium maize-forage grass of the *Urochloa* species under different methods of sowing.

MATERIALS AND METHODS

The experiment was conducted in the experimental area of the Laboratory of Machines and Agricultural Mechanization of UNESP, in Jaboticabal, São Paulo state, Brazil, located in the following geodetic coordinates: latitude 21°14 'S and longitude 48°16' W, featuring local altitude of 560 m, with a 4% slope. The soil of the experimental area was classified as Latossolo Vermelho eutroférrico típico (according to the Brazilian System of Soil Classification of the Brazilian Agricultural Research Corporation, (Embrapa, 2006), or “Ferralsol”, according to the FAO Soil Classification, aka “Oxisol”), with a particle distribution of 200 g/kg sand, 290 g/kg silt and 510 g/kg clay. The experimental area was being treated in the SPD for over ten years. The climate, according to Koeppen classification is Aw, defined as tropical humid, with a rainy season in summer and a dry winter, with an average annual rainfall of 1,425 mm and an average temperature of 22°C. The precipitation, maximum temperature, minimum and average (°C) during the experiment are shown in Figure 1.

The treatments consisted of two species of *Urochloa* (*U. brizantha cv* and *U. ruzizienses cv*) and four modes of intercropping of urochloas with maize, namely: maize with *Urochloa* at sowing line (MFL); maize with *Urochloa* between rows, sown on the same day of the sowing of maize (MFE); maize with *Urochloa* sown between rows, covered by fertilizer at the V4 stage of maize (MFC); maize with *Urochloa* sown by casting, with surface fertilization at the V4 stage of maize (MFLA), and maize without intercropping (control). Maize received basic fertilization in two growing years, of 300 kg/ha of the commercial formula (08-28-16) with supplementary cover fertilization at the V4 stage, corresponding to 120 kg/ha of potassium chloride and 300 kg/ha urea, while for soy, the basic fertilizer was 250 kg/ha commercial formula (04-20-20), and for *Urochloas*, we used 20 kg/ha commercial formula (08-28 -16) for forage grass seeding between rows (MFE) and at the time of the maize crop at the V4 stage (MFC), being the fertilizer used only as a vehicle for distribution of seeds. The experimental design was a randomized block design, with nine treatments in a factorial scheme (2×4) +1. Two forages of the genus Urochloa (Urochloa brizantha

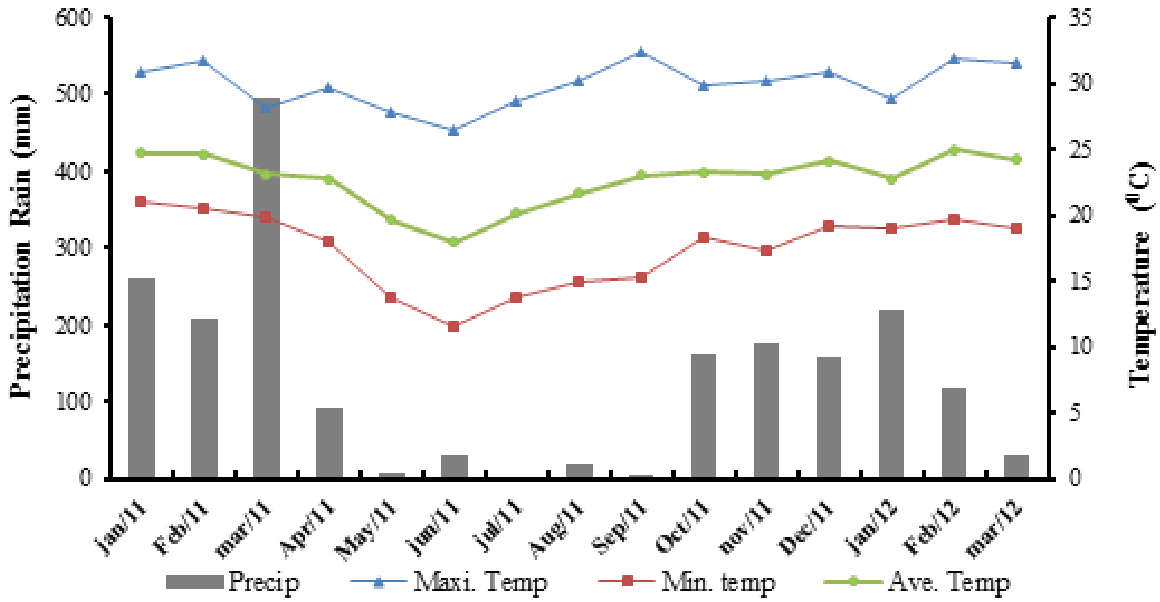

Figure 1. Rainfall (mm), average maximum temperature, minimum and average (° C) during the experiment.

cv and Urochloa ruziziensis cv), sown in four sowing modalities, Maize with urochloa in the sowing line (MFL); Maize with urochloa in the interweave, sown on the same day as maize sowing (MFE); Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage (MFC); Maize with urochloa on the haul along with maize V4 maize mulch (MFLA) and maize without intercropping (control).

Each experimental plot consisted of eight maize lines (DKB 390) for a population of 60 thousand ha^{-1} plants, with 0.90 m row spacing, sowing density of 5.4 m^{-1} seeds and 14 Soybean cultivar Valiosa Roundup Ready, spaced at 0.45 m. The plots were 25 m long, 15 m haulers for machine and equipment maneuvers, useful area corresponding to the two maize lines and three soybean rows with five meters each, discounting the ten meter border in each end. Soil samples were collected from depths of 0.0-0.10; 0.10-0.20; 0.20-0.30 m for subsequent chemical analysis (P, MO, Ca, Mg, K, H + Al, SB, T, and V), following the method proposed by Raij et al. (2001). Data were submitted to analysis of variance by the F test ($p<0.05$) and when significant, factorially compared to the control group (maize, only) and this comparison performed by applying Dunnett's test ($p<0.05$). Statistical analyzes were performed by using a statistical software, *Assistat*, version 7.7 (beta) Silva and Azevedo (2016).

RESULTS AND DISCUSSION

In general, the soil chemical attributes in the layer from 0.0 to 0.10 m do not differ statistically among themselves by Dunnett test ($p<0.05$) presented in Table 1. The non-significant difference among the soil chemical properties in the layer from 0.0 to 0.10 m, may possibly be explained by the short development period of the study, which lasted one agricultural years. However, the phosphorus levels were higher and significantly different within modes, MFLA (Casting V4) and MFL (Rows), and possibly these results may be due to the process of decomposition of the roots of *Brachiaria*, releasing nutrients, together with the colloids present in latosols, as kaolinite clays, Fe and Al oxides, favoring greater fixation of phosphorus.

Another factor that may be contributing to the higher phosphorus values within modes (sown by casting in V4 stage) and (in the maize planting row), is the pH, since as it rose there was an increase in the phosphorus level, and this may be due to competition between the OH^- anions (from the rising pH) and $H_2PO_4^-$ and HPO_4^{2-} from the surface of colloids. With regard to the detailing for the phosphorus level, forage grasses within the modes, as well as modes within forage grasses (Figure 2) , it is noticed that there was an increase in the phosphorus level within modes MFL (Rows) and MFLA (Casting V4) for forage grasses *U. ruzizienses* cv and *U. brizantha cv* respectively. Means followed by same letter do not differ at Tukey test 5% probability. Forages: U .B – (*Urochloa brizantha); U.R – (*Urochloa ruziziensis); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). These results may be due to continuous fertilization in rows and between rows (Ciotta et al., 2002; Costa et al., 2009), in addition to biopores formed by the roots and soil fauna (Adiscott, 1995), promoting redistribution of P in the profile and by its low mobility in the soil. Furthermore, the soils in the tropical regions have clays with high fixation

Table 1. Average values of the chemical soil parameters, evaluated in the layer from 0.0 to 0.10 m, according to seeding mode and forage grass species.

Causes for variation		P	MO	pH	K	Ca	Mg	H +Al	SB	T	V
Forage grass species	**Modes**	**(mg dm^{-3})**	**(g dm^{-3})**	**($CaCl_2$)**	**---------mmol$_c$ dm^{-3}---------**						**(%)**
U. Brizantha	Rows	38.0^{b}	21.6	5.4	4.4	33.3	15.0	28.0	52.7	80.7	64,6
U. Brizantha	Between Rows	61.3^{b}	30.6	5.5	4.7	47.0	18.6	32.3	70.4	102.7	66,3
U. Brizantha	Cover	38.7^{b}	29.0	5.2	4.0	38.5	16.2	31.7	58.8	90.5	64,4
U. Brizantha	Casting V_4	83.0^{a}	26.5	5.6	5.2	45.5	21.0	23.5	71.7	95.2	70,8
U. Ruziziensis	Rows	86.3^{a}	29.3	5.8	5.9	54.3	23.6	18.0	83.9	101.9	81,7
U. Ruziziensis	Between Rows	62.3^{b}	30.6	6.0	5.3	61.6	27.3	17.3	94.3	111.6	84,3
U. Ruziziensis	Cover	62.6^{b}	24.6	5.3	4.0	34.0	17.3	31.3	55.4	86.7	61,5
U. Ruziziensis	Casting V_4	52.0^{b}	26.3	5.3	3.6	33.3	15.6	31.3	52.6	84.0	62,1
Control		33.5^{b}	26.6	5.6	4.5	40.3	21.0	24.0	65.9	89.9	66.5
FxT		5.6*	0.1^{ns}	0.1^{ns}	0.6^{ns}	0.1^{ns}	0.2^{ns}	1.0^{ns}	0.1^{ns}	0.0^{ns}	0.1^{ns}
DMS		39.7	6.4	0.7	2.8	27.1	10.4	17.2	38.5	25.8	25.0
CV%		34.0	11.7	6.5	30.3	31.4	26.4	32.6	26.9	13.7	18.0

*Significant at 5% probability level ($p<0.05$); NS (not significant). Averages followed by the same letter and no letters in columns do not differ by the Dunnett test ($p <0.05$). F - Forage grass; T - Control; U. Brizantha - Urochloa brizantha; U. Ruziziensis - Urochloa ruziziensis; Rows - Maize with Urochoa in planting rows; Between Rows - Maize with Urochoa between rows; Cover - Maize with Urochoa sown in rows cover fertilizer in maize V4 stage; Casting V4 - Maize with Urochoa sown by casting in the V4 stage of maize; Control - maize only.

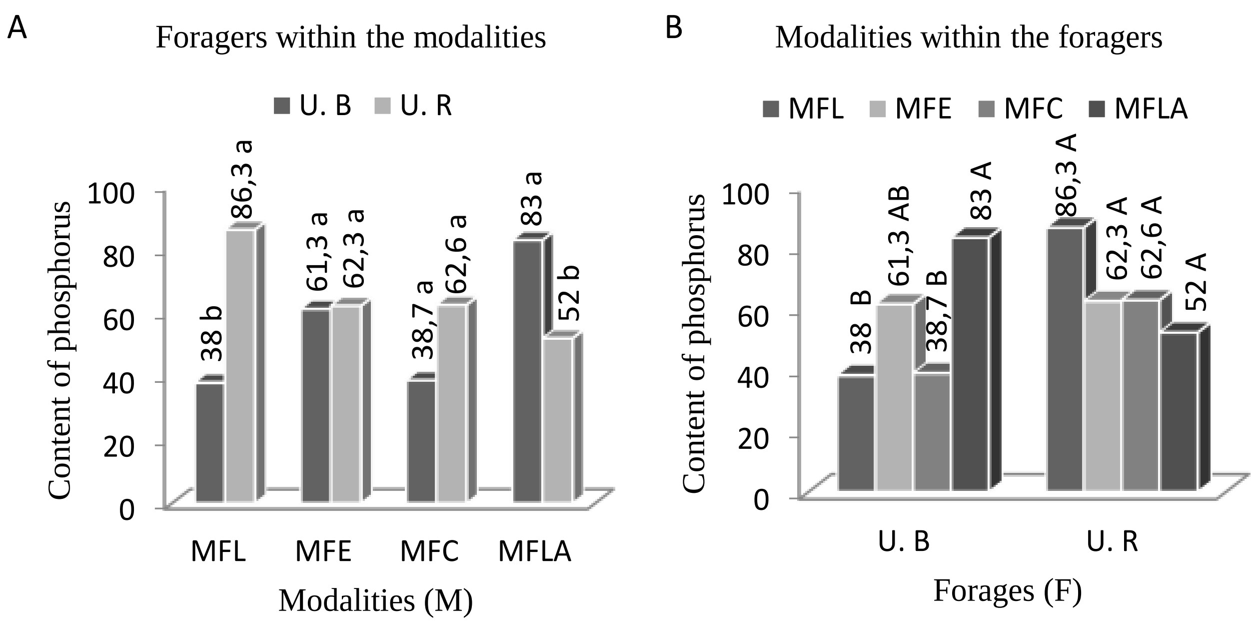

Figure 2. Ramifications of interaction between factors, sowing modalides and fodder for the variable phosphorus.

capacity of phosphorus (Ferreira et al., 2014). For the values of chemical parameters of the soil in depth from 0.10 to 0.20 cm (Table 2), in general, significant differences in the interaction between grasses and modes for the pH, Mg, H + Al, SB and V, as detailed in Figures 3, 4, 5, 6 and 7 respectively.

Nascente et al. (2014), by studying the chemical attributes of an Oxisol under no-tillage affected by soil management and crop rotation, concluded that chemical attributes Ca, Mg, organic matter, P, K, concentrated in the most superficial layer, regardless of rotation used in managements with lesser soil revolving.With the exception of phosphorus, which is found in the between rows mode for *Urochloa ruziziens*, the other attributes (pH, Mg, SB, T and V) had higher values observed in mode Casting V4 for *Urochloa brizantha cv*, (Table 2).

Table 2. Average values of the chemical soil parameters evaluated in the layer from 0.10 to 0.20 m, according to seeding mode and forage grass species.

Causes for variation		P	MO	pH	K	Ca	Mg	H +Al	SB	T	V
Forage grass species	Modes	(mg dm^{-3})	(g dm^{-3})	($CaCl_2$)	----------mmol$_c$ dm^{-3}----------						(%)
U. Brizantha	Row	29.6^b	22.0	5.3^a	4.0	27.6^a	12.6^b	27.0^b	44.3^a	71.3	62.1^a
U. Brizantha	Between Rows	39.3^b	21.6	4.9^b	3.1	24.3^a	11.0^b	40.0^a	38.5^a	78.5	48.7^b
U. Brizantha	Cover	57.0^b	22.2	5.0^a	3.9	24.7^a	10.2^b	35.5^b	38.9^a	74.4	52.0^a
U. Brizantha	Casting V_4	50.0^b	27.5	5.6^a	5.5	38.5^a	19.6^a	23.5^b	63.0^a	86.7	72.2^a
U. Ruziziensis	Row	32.0^b	21.6	5.3^a	3.7	33.3^a	14.6^a	29.0^b	51.7^a	80.7	63.2^a
U. Ruziziensis	Between Rows	80.3^a	24.6	5.5^a	4.2	37.3^a	19.0^a	24.3^b	60.6^a	84.9	70.6^a
U. Ruziziensis	Cover	29.0^b	20.6	4.8^b	3.5	16.6^b	8.6^c	41.6^a	28.8^b	70.5	40.1^b
U. Ruziziensis	Casting V_4	30.0^b	26.3	5.3^a	3.3	32.0^a	15.6^a	30.3^b	50.9^a	81.3	60.6^a
Control		27.6^b	23.6	5.5^a	4.1	38.3a	19.0^b	24.3^b	62.1^a	86.5	69.9^a
FxT		2.3^{ns}	0.03^{ns}	4.5*	0.1^{ns}	3.4^{ns}	10.1**	5.3*	4.8*	2.6^{ns}	4.6*
DMS		38.5	6.6	0.5	2.5	18.3	6.8	11.5	25.9	18.4	19.5
CV%		46.0	14.1	5.5	32.1	30.1	23.6	18.8	26.5	11.5	16.2

**Significant at 1% probability level ($p < 0.01$); *Significant at 5% probability level ($p<0.05$); NS (not significant). Averages followed by the same letter and no letters in columns do not differ by the Dunnett test ($p < 0.05$). F - Forage grass; T - Control; U. Brizantha - Urochloa brizantha; U. Ruziziensis - Urochloa ruziziensis; Rows - Maize with Urochoa in planting rows; Between Rows - Maize with Urochoa between rows; Cover - Maize with Urochoa sown in rows cover fertilizer in maize V4 stage; Casting V4 - Maize with Urochoa sown by casting in the V4 stage of maize; Control - maize only.

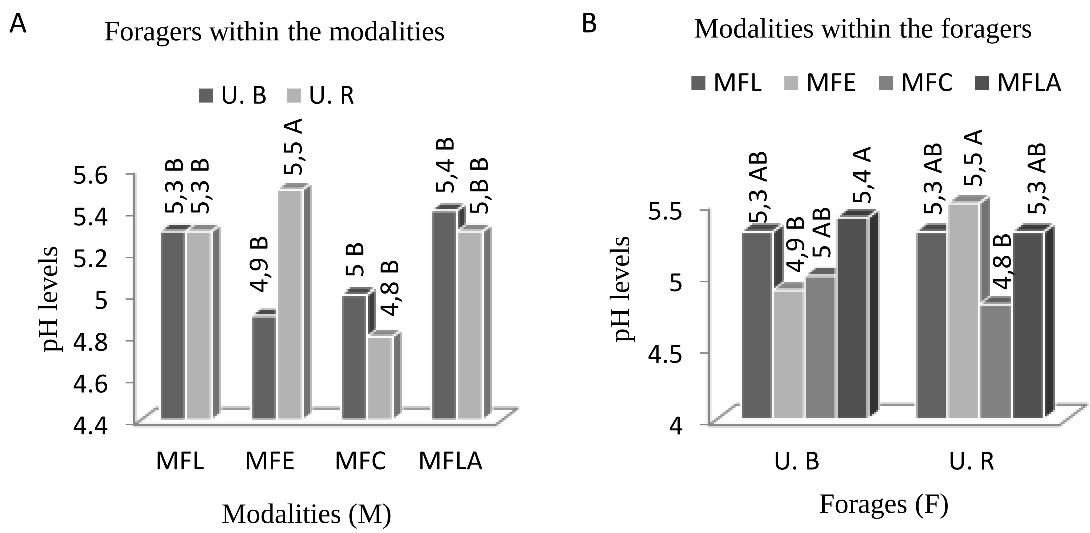

Figure 3. Ramifications of interaction between factors, sowing modalides and fodder for the variable pH.

These results can be explained by the low competition occurring between maize and forage grasses in the vegetative stage V4 of maize, together with supplementary surface fertilization and a higher pH value, where higher pH values contributed directly in the reduction of potential acidity levels (H + Al) and increased levels of Mg, SB and V (Strojaki et al., 2013).

Also with respect to the pH, when it is increased, there is also an increased mineralization of organic matter, and this process is favored in soils of pH values between 5.0 and 6.0, freeing N, P and S, as well as macro and micronutrients in smaller amounts (Cardoso et al., 2014). For the detailing of pH (Figure 3), the *Urochloa ruziziensis cv* showed higher pH levels in the MFE mode differing from the others. For Portugal et al. (2010), the forage grass *Urochloa ruzizienses* cv has a positive effect on the increase of cations in the soil, which can positively affect crop productivity in the short and long run

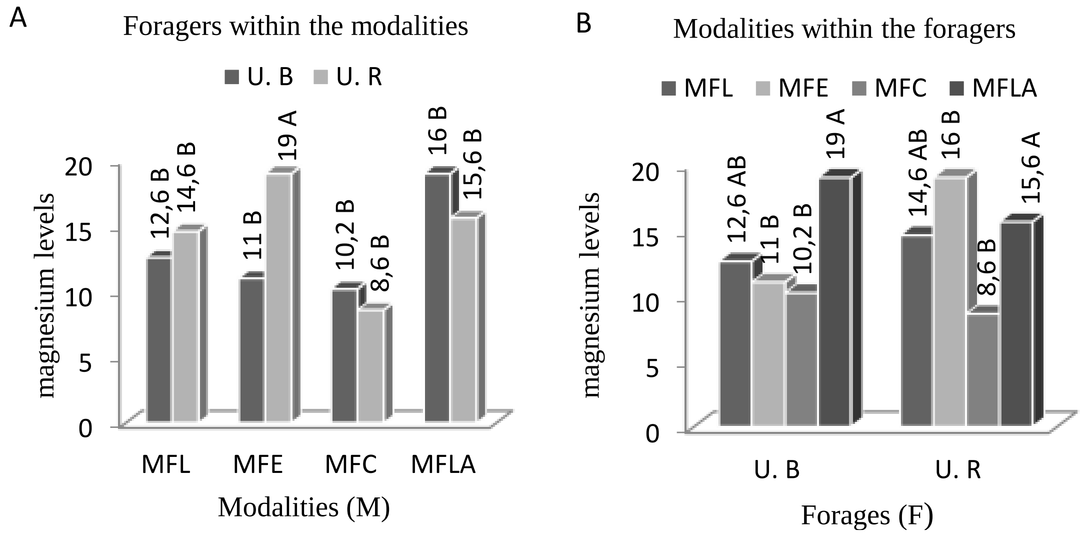

Figure 4. Ramifications of interaction between factors, sowing modalides and fodder for the variable magnesium.

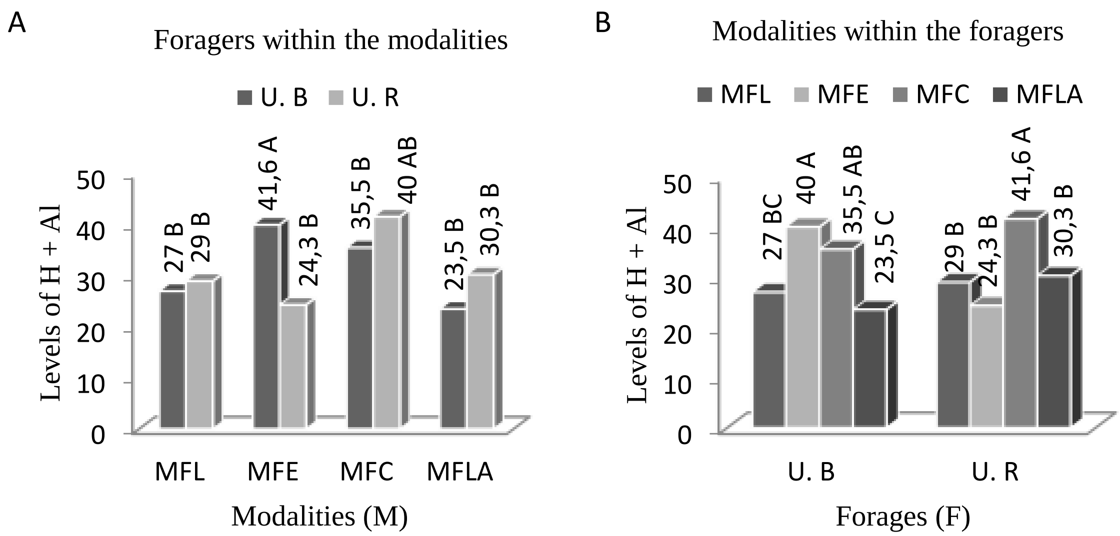

Figure 5 . Ramifications of interaction between factors, sowing modalides and fodder for the variable H + Al.

(Chioderoli et al., 2012b). Means followed by same letter do not differ at Tukey test 5% probability. Forages: U.B – (*Urochloa brizantha); U.R – (*Urochloa ruziziensis); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). As for the magnesium levels (figure 4), the highest values were found in the MFE mode for *Urochloa ruzizienses cv*, differing from the others. This result can be explained by the nutrient cycling capacity that have the *Urochloa ruzizienses cv*, together with the fertilization carried out between rows. Dalchiavon et al. (2012), by evaluating the spatial variability of fertility of an oxisol under no-tillage system, report that high Mg^{2+} levels, layered from 0.10 to 0.20 m, occured by providing considerable amounts of exchangeable bases during liming.

Means followed by same letter do not differ at Tukey test 5% probability. Forages: U .B – (*Urochloa brizantha); U.R – (*Urochloa ruziziensis); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize

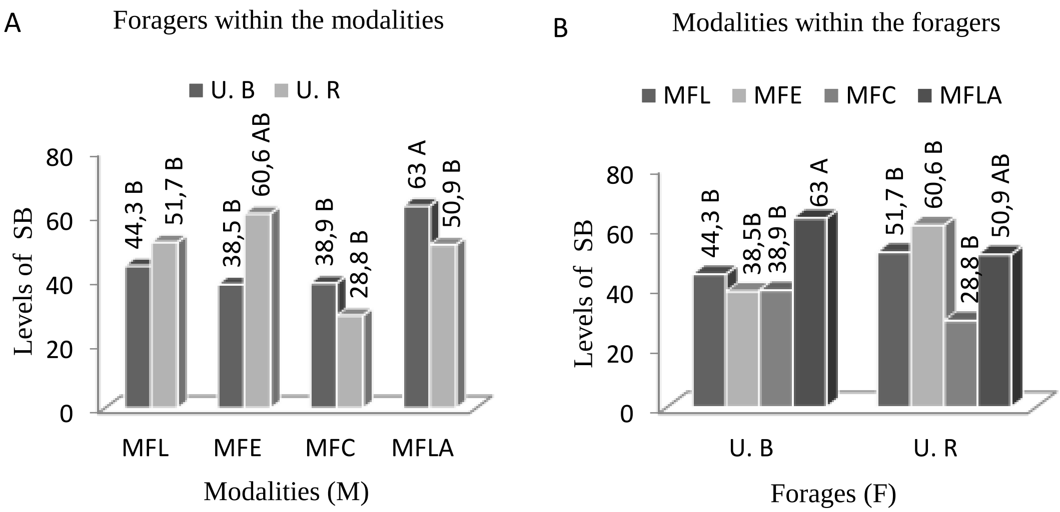

Figure 6. Ramifications of interaction between factors, sowing modalides and fodder for the variable SB.

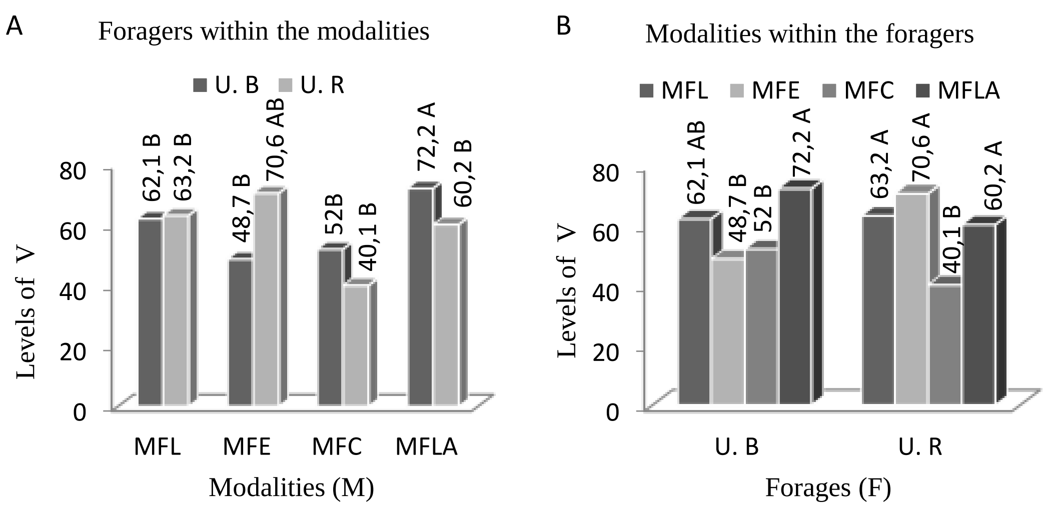

Figure 7. Ramifications of interaction between factors, sowing modalides and fodder for the variable V.

with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). To have the contents of H + Al (figure 5), higher values within the MFE mode were found, as a greater value for *Urochloa brizantha cv*. This result is explained by the pH increase in the same mode (figure 3). According to Steiner et al. (2011), the potential acidity has a behavior opposite to that of the pH, therefore, as the pH is raised, the potential acidity tends to decrease. The author comments that when the pH is increased in depth it is due to the downward movement of Ca^{2+} and Mg^{2+} to deeper soil layers. However, Oliveira et al. (2002) observed that in the no-tillage system the higher pH values are found in the surface layer up to 0.10 m.

Means followed by same letter do not differ at Tukey test 5% probability. Forages: U.B – (*Urochloa brizantha); U.R – (*Urochloa ruziziensis); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). For SB levels (figure 6) the highest values were found in the MFLA mode for *Urochloa brizantha cv*, both for forage grasses within the modes and to the modes within the forage grasses. This result can be explained by higher values of Ca^{2+}, Mg^{2+}

Table 3. Average values of the soil chemical parameters, evaluated in the layer from 0.20 to 0.30 m, according to the sowing mode and forage grass species.

Causes for variation		**P**	**MO**	**pH**	**K**	**Ca**	**Mg**	**H +Al**	**SB**	**T**	**V**
Forage grass species	**Modes**	**(mg dm^{-3})**	**(g dm^{-3})**	**($CaCl_2$)**	----------------------**mmol$_c$ dm^{-3}**					----------------------	**(%)**
U. Brizantha	Row	66.3	27.0	5.3	4.7	38.0^a	16.0	30.3	58.7	89.0	62,0
U. Brizantha	Between Rows	28.6	20.0	5.1	3.4	22.6^b	10.6	32.0	36.7	68.7	53,3
U. Brizantha	Cover	47.0	22.0	5.1	4.0	26.6^b	12.6	33.6	43.4	77.0	56,2
U. Brizantha	Casting V_4	36.3	21.0	5.1	3.9	21.3^b	12.0	1.0	37.2	68.2	54,2
U. Ruziziensis	Row	32.3	19.6	5.2	4.3	29.3^b	14.3	27.0	48.0	75.0	62,7
U. Ruziziensis	Between Rows	53.3	24.6	5.4	4.3	33.0^b	18.3	23.0	55.6	85.6	64,5
U. Ruziziensis	Cover	37.0	22.0	4.8	3.7	16.3^b	8.3	40.3	28.4	68.7	41,4
U. Ruziziensis	Casting V_4	32.6	21.0	5.1	3.2	23.0^b	14.0	32.3	40.2	72.6	55,4
Control		33,3	21.0	5.1	3.6	21.0^b	12.3	33.0	37.0	70.0	52.2
FxT		$0,5^{ns}$	0.2^{ns}	0.3^{ns}	0.2^{ns}	1.4^{ns}	0.2^{ns}	0.1^{ns}	0.9^{ns}	0.9^{ns}	0.9^{ns}
DMS		41,5	9.0	0.4	2.2	16.8	7.1	10.7	24.8	21.9	15.8
CV%		50,8	20.3	4.0	28.3	32.7	26.9	16.6	28.9	14.5	14.1

NS (not significant). Averages followed by the same letter and no letters in columns do not differ by the Dunnett test (p <0.05). F - Forage grass; T - Control; U. Brizantha - Urochloa brizantha; U. Ruziziensis - Urochloa ruziziensis; Rows - Maize with Urochoa in planting rows; Between Rows - Maize with Urochoa between rows; Cover - Maize with Urochoa sown in rows cover fertilizer in maize V4 stage; Casting V4 - Maize with Urochoa sown by casting in the V4 stage of maize; Control - maize only.

and K^+ found in Table 2, in mode Casting V4, as well as the base saturation Figure 6.

Means followed by same letter do not differ at Tukey test 5% probability. Forages: U.B – (*Urochloa brizantha); U.R – (Urochloa ruziziensis*); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). These results corroborate Sarto et al. (2014), in which working with soil chemical properties depending on the silicon fertilization, found higher SB levels because of cations Ca^{2+}, Mg^{2+} and K^+. Means followed by same letter do not differ at Tukey test 5% probability. Forages: U.B – (*Urochloa brizantha); U.R – (Urochloa ruziziensis*); sowing modalities: MFL – (Maize with urochloa in the sowing line), MFE – (Maize with urochloa in the interweave, sown on the same day as maize sowing), MFC – (Maize with urochloa in the seeded line together with the cover fertilizer in the V4 stage), MFLA – (Maize with urochloa on the haul along with maize V4 maize mulch). For layer 0.20 to 0.30 m (Table 3), there were no significant differences at the 5% probability level (p<0.05). Several studies show that in a no-till system there is a tendency in accumulation of surface nutrients after four to six years of cultivation. It is explained by the lack of tillage, liming and fertilization on the surface, by casting or in rows, which favors the formation of gradient concentration, according to Júnior et al. (2010).

Although this work has been developed in a no-till system, established more than ten years ago, there is a trend towards lower levels of exchangeable bases in soil, with increasing depth, given that the effects of liming in these regions tend to be smaller (Bayer et al., 1997; Souza et al, 2003; Cavalcante et al., 2007).

Conclusions

The intercropping of forage grasses with maize, in different modes, promotes changes in the soil chemical attributes, mainly in the layer from 0.10 to 0.20 m. The intercropping of maize with *Urochloa brizantha cv* presents a higher nutrient recycling. Both modes maize with *Urochoa* between rows (MFE) and maize with *Urochoa* sown by casting in the V4 stage of maize (MFLA) presented higher values of chemical changes.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Adiscott AGC, Cogo NP, Levien R (1995). Relações da erosão do solo com a persistência da cobertura vegetal morta. Rev. Bras. Cienc. Solo 19:127-32.

Barcellos AO, Ramos AKB, Vilela L, Martha júnior GB (2008). Sustentabilidade da produção animal baseada em pastagens consorciadas e no emprego de leguminosas exclusivas, na forma de banco de proteína, nos trópicos brasileiros. Rev Bras Zootec. 37:51-67.

Barducci RS, Costa C, Crusciol CAC, Borghi É, Putarov T, Sarti, Celmn (2009). Produção de Brachiariae Panicum maximum com milho e adubação nitrogenada. Rev. Arch. Zootec 58:211-22.

Bayer C, Mielniczuk J (1997). Nitrogênio total de um solo submetido a diferentes métodos de preparo e sistemas de cultura. Rev. Bras. Cienc. Solo 21:235-9.

Calonego JC, Borghi E, Crusciol CAC (2010). Intervalo hídrico ótimo e compactação do solo com cultivo consorciado de milho e braquiária. Rev. Bras. Cienc. Solo 35:2183-90.

Cardoso AAS, Santos JZL, Tucci CAF, Barbosa TMB. (2014). Acúmulo de nutrientes e crescimento da pimenta-de-cheiro em função de doses de calcário. Rev. Agro@mb. On-line 8:165-74.

Cavalcante EGS, Alves MC, Souza ZM, Pereira GT (2007). Variabilidade espacial de atributos químicos do solo sob diferentes usos e manejos. Rev Bras Cienc Solo 31:1329-1339.

Chioderoli CA, Mello LMM, Holanda HV, Furlani CEA, Grigolli PJ, Silva JOR, Cesarin AL (2012). Consórcio de *Urochloas* com milho em sistema plantio direto. Cienc. Rural 42:1804-1810.

Ciotta MN, Bayer C, Ernani PR, Fontoura SMV, Albuquerque JA, Wobeto C (2002). Acidificação de um Latossolo sob plantio direto. Rev. Bras. Cienc. Solo 26:1055-1064.

Costa KAP, Assis R L, Barros LB (2009). Composição bromatológica de cultivares de milheto e híbridos de sorgo manejados em diferentes estádios de desenvolvimento. In: Anais Reunião Anual da Sociedade Brasileira de Zootecnia; 2009; Manaus. Manaus: Universidade Estadual Manaus pp. 1-4.

Costa NR, Andreotti M, Fernandes JC, Cavasano FA, Ulian NA, Pariz CM, Santos FG (2014). Acúmulo de nutrientes e decomposição da palhada de braquiárias em função do manejo de corte e produção do milho em sucessão. Rev Bras Cienc Agron 9:166-173.

Dalchiavon FC, Carvalho MP, Andreotti M, Montanari R (2012). Variabilidade espacial de atributos da fertilidade de um Latossolo Vermelho Distroférrico sob Sistema Plantio Direto. Rev. Cienc. Agron. 43:453-461.

Empresa Brasileira de Pesquisa Agropecuária - Embrapa (2006). Sistema brasileiro de classificação dos solos. 2ª ed. Rio de Janeiro: Centro Nacional de Pesquisa em Solos.

Ferreira JPT, Ferreira EP, Silva CW, Rocha MTI (2014). Atributos Químicos e Físicos do Solo sob diferentes manejos na microrregião Serrana dos Quilombos. Rev. Agron. Acad. 1:89-101.

Freitas L, Casagrande C J, Oliveira AI, Júnior SR, Campos CCM (2014). Análises multivariadas de atributos químicos do solo para caracterização de ambientes. Rev Agro@mbi. On-line 8:155-64.

Garcia RA, Crusciol CAC, Calonego JC, Rosolem CA (2008). Potassium cycling in a corn-brachiaria cropping system. Eur. J. Agron. 28:579-585.

Júnior LAZ, Lana RMQ, Guimarães EC, Pereira JMA (2010). Variabilidade Espacial dos Teores de Macronutrientes em Latossolos sob sistema plantio direto. Rev. Bras. Cienc. Solo 34:389-400.

Júnior LAZ, Lana RMQ, Zanão MPC, Guimarães EC (2010). Variabilidade espacial de atributos químicos em diferentes profundidades em um latossolo em sistema de plantio direto. Rev. Ceres. 57:429-438.

Liu J, You L, Amini M, Obertsteiner M, Herrero M, Zehnder AJB, YANG H (2010). A hight-resolution assessment on global nitrogen flows in cropland. Rev Proc Natl Acad Sci of USA 107:8035-40.

Loss A, Pereira MG, Giácomo SG, Perin A, Anjos LHC (2011). Agregação, carbono e nitrogênio em agregados do solo sob plantio direto com integração lavoura-pecuária. Pesq. Agropec. Bras. 46:1269-1276.

Mateus GP, Santos NCB. (2012). Sistema plantio direto e a conservação dos recursos naturais. Rev. Pesq. Technol. 9: 1-5.

Nascente AS, Silveira PM, Junior ML, Santos GG, Cunha PCR (2014). Atributos químicos de latossolo sob plantio direto afetados pelo manejo do solo e rotação de culturas. Rev. Caatinga 27:153-163.

Oliveira FHT, Alvarez VVH (2002). Fertilidade do solo no sistema plantio direto. Tópic Cienc. Solo 2:393-486.

Pereira FCBL, Mendonça VZ, Leal ST, Rossetto J É (2014). Avaliação econômica e do desempenho técnico do milho consorciado com duas espécies forrageiras dos gêneros *panicum* e *brachiaria* em sistema de integração lavoura-pecuária. Rev. Agric. 7:157-65.

Portugal AF, Costa ODV, Costa LM (2010). Propriedades físicas e químicas do solo em áreas com sistemas produtivos e mata na região da zona da mata mineira. Rev. Bras. Cienc. Solo 34:575-85.

Raij Bvan, Andrade JC, Cantarella H, Quaggio JA (2001). Análise química para avaliação da fertilidade de solos tropicais. Campinas: Instituto Agronômico.

Sarto MMV, Rampim L, Clana M, Rosset SJ, Ecco M, Wobeto RJ (2014). Atributos químicos do solo e desenvolvimento da cultura do trigo em função da adubação silicatada. Rev. Agron. 7:390-400.

Seidel PE, Gerhardt SFI, Castagnara, Neres ADM (2014). Efeito da época e sistema de semeadura da *Brachiaria brizantha* em consórcio com o milho, sobre os componentes de produção e propriedades físicas do solo. Rev. Cienc. Agron. 35:55-66.

Silva FAS, Azevedo CAV (2016). The Assistat Software Version 7.7 and its use in the analysis of experimental data. Afr. J. Agric. Res. 11(39):3733-3740.

Souza ZM, Alves MC (2003). Propriedades químicas de um Latossolo Vermelho distrófico de cerrado sob diferentes usos e manejos. Rev. Bras. Cienc. Solo 27:133-139.

Steiner F, Costa SM, Costa MAL, Pivetta LA (2011), Castoldi G. Atributos químicos do solo em diferentes sistemas de culturas e fontes de adubação. Gl Sci. Technol. 4:16-28.

Strojaki TV, Silva RV, Somavilla A, Ros CO, Moraes MT (2013). Atributos químicos do solo e produtividade de girassol e milho em função da aplicação de composto de lixo urbano. Rev Pesq Agron Trop 43:278-285.

Tasso Júnior LC, Silva Neto HF, Silva JDR (2010). Marques D, Camilotti F. Variação na fertilidade de solo ao l ongo da safra 2008/2009, para cultivares precoces de cana-de-açúcar. Encicl Biosfera 6:1-9.