Original Research Article

Production of Maize Silage is Possible in Integrated Crop-Livestock-Forest Despite the Effects of Shading of the Arboreal Component

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ABSTRACT

Distribution of the intercropped plants determines the production, but is highly dependent on the machinery of the property. Producers, who harvest silage row by row, depend on plantings with greater spacing. This study aimed to evaluate the maize intercropped for cultivated silage in 0.90 m between rows, with grass under shade and full sunlight conditions. Maize with brachiaria grass was tested in four sowing densities (0, 2, 4 and 6 kg of pure and viable seeds per hectare). The treatments in factorial (2x2x4) were distributed in split-split plot design with four repetitions. The maize agronomic characteristics and the silage quality were evaluated. There was a high level of competition when associated with maize, piatã and eucalyptus. The aggressive growth of the grass, with the light restriction, caused that the production of silage was affected in the higher sowing rates. For ruziziensis, this pattern was different, because it is a less aggressive grass in terms of growth. For plantations with 0.90 m of spacing, when there is light restriction, the maize intercropped must be done with lower growth rate grass to reduce competition and maintain the yield.

Keywords: Intercropped, Row spacing, Crop-Livestock-Forest integration, Shadowing.

1. INTRODUCTION

Integrated systems are modes of production that involve agriculture, livestock and trees in the same environment. The association of the components brings several benefits, affecting soil fertility, root system, water and nutrient cycling, greenhouse gas mitigation and production diversification. Despite the benefits, it is necessary to define a break-even point in which all cultures can develop in an adequate way to remain productive. Thus, different arrangements must be tested in the different regions, aiming to identify parameters for the efficient use of the integration. Among the most used crops, maize stands out for its versatility and ease of cultivation.

The maize crop stands out for the high dry matter yield, nutritive value and flexibility of use, being one of the main agricultural crops in the Brazil. An important use of the maize crop is for silage production, aiming the massive supplementation of the herd in the time of pasture shortage. Although many studies have shown the benefits of planting with smaller row spacings [1], there is a considerably high proportion of producers who harvest the crops row by row, which makes the smallest spacings impractical because of machinery.

Based on this assumption, the adjustment of the other cultures when in integrated systems is fundamental. Listing the main cultural aspects of integration is of the utmost importance to strengthen the adoption of these systems [2]. Productive components should be allocated to be sustainable in order to use with maximum efficiency the growth capabilities with less competition among themselves [3].

The use of productive systems that aim at the conservation of natural resources, such as the no-tillage system, is an essential tool to enable greater production by area with reduction of environmental impacts [4].

The area planted to no-tillage system has increased rapidly, corresponding to 50% of the area planted with grain crops [5]. The adoption of no-till improves the sustainability of agricultural activities, but gains are limited by the lack of crop rotation and soil cover. *Urochloa* spp. forages, because they remain in growth throughout the dry season and because of the ease of desiccation, can be well utilized for covering the soil [6]. Brachiaria sowing can be done in several ways, however, simultaneous sowing with maize has been recommended due to greater efficiency and economicity [7].

Migrate from specialized systems to mixed systems, more complex, demand greater managerial capacity, specialized teams and more investments in infrastructure [8]. Integration, since it involves different cultures in a simultaneous productive cycle, has been introduced slowly. The possibility of maximizing soil use for the three distinct activities and with economic return in the short, medium and long term is one of the motivating factors for the implementation of the integrated systems in several rural properties.

However, there is little cultural information in integrated production systems, especially when associated with the forest component.

Thus, aimed to evaluate the yield and bromatological composition of maize for silage production intercropped with ruziziensis and piatã grasses submitted to different sowing rates associated with shade conditions and full sun in the Brazilian Cerrado.

2. MATERIAL AND METHODS

2.1 Location and Characterization of the Study Area

The experiment was implemented at the Experimental Base of Integrated Milk Production Systems of the Brazilian Agricultural Research Corporation (Embrapa Agrossilvipastoril), in the municipality of Sinop – MT, Brazil, latitude 11° 51' 43" South, longitude 55° 35' 27" West and 384 m altitude. The experimental area is situated on a red-yellow Latosol in flat relief. The climate of the region is Aw (tropical climate with dry season) according to Köppen classification.

Table 1. Soil analysis of the Experimental Base of Integrated Milk Production Systems of Embrapa Agrossilvipastoril, Sinop – MT, Brazil.

CHEMICAL CHARACTERISTICS											
[1]pH	**[2]P**	**[3]K**	**[4]Ca+Mg**	**[5]Ca**	**[6]Mg**	**[7]Al**	**[8]H**	**[9]OM**	**[10]S**	**[11]CEC**	**[12]V**
H_2O	mg dm^{-3}		cmol$_c$ dm^{-3}					g dm^{-3}	cmol$_c$ dm^{-3}		%
5.7	6.2	55	2.5	2.0	0.5	0.2	3.5	24.8	2.7	6.3	42.1
PHYSICAL CHARACTERISTICS											
SAND				**SILT**				**CLAY**			
g kg^{-1}											
266				134				601			

[1]Potential of Hydrogen; [2]Phosphorus; [3]Potassium; [4]Calcium+Magnesium; [5]Calcium; [6]Magnesium; [7]Aluminium; [8] Hydrogen; [9]Organic Matter; [10] Sulfur; [11]Cation Exchange Capacity; [12]Base saturation.

2.2 Experimental Design

The experimental design was a randomized split-split plot, using a 4x2x2 factorial arrangement, with four seeding densities of the grass (0, 2, 4 and 6 kg of pure and viable seeds ha^{-1}), two forages (ruziziensis and piatã) and two conditions of luminosity (shade and full sun), totaling 16 treatments with four repetitions.

2.3 Area Management

The experimental base was composed of four quadrants subdivided in treatments of shade and full sun with 10 hectare each where the cultures were rotating. The shading was provided by the presence of Eucalyptus (*Eucalyptus urograndis* H-13 clone), with four triple tree row every 15 m in spacing 3 x 2 m to promote rapid shading of the tree. At the implantation of the experiment, the trees were 23 months and approximately 10 m high.

Maize sowing was performed with 0.90 m line spacing to simulate mechanized harvest row by row, however for the experiment, the harvest was done manually. It was carried out by planning a stand of 60,000 plants ha^{-1}.

The hybrid used was Herculex I, transgenic to caterpillar due to the great pest pressure that occurs in Mato Grosso in the harvest period. The sowing was done with fertilizer sowing and the plots were divided and staked after sowing of maize.

The seeds of the grasses presented 50% of cultural value. The sowing was done manually every 0.45 m between the furrows, regardless of the maize spacing being 0.90 m.

In the formation fertilization of maize, 350 kg ha^{-1} of the formulated fertilizer 04-30-16 was applied. For the establishment fertilization of the grass, 130 kg ha^{-1} was applied to the haul and 500 kg ha^{-1} of the 20-00-20 formulation in the cover, performed 30 days after sowing, when the maize plants were in the phenological stage of six fully developed leaves.

Post-emergence dicotyledonous weed control was performed 16 days after emergence (DAE), with the herbicide atrazine at the dose of 1000 g ha^{-1} of the active ingredient. The application was carried out using a tratorized bar sprayer, adjusted to the system, equipped with fan nozzles and regulated to apply 200 L ha^{-1} of syrup.

Each plot measures 86.4 m^2, with the central rows being discounted from the borders. The maize harvesting point was monitored, starting when maize presented 33 to 35% dry matter.

At the time of harvest, the booth was counted, the plants being harvested, grouped and weighed to determine the green mass production (GMP) per hectare. The plant height (m) and insertion of the ear height (m) were determined with graduated ruler, stem diameter (mm) was determined with digital pachymeter and the green leaves number in relation to the total leaves number were determined, determining the stay green of all plants collected for production. Three plants were sampled to evaluate the morphological composition of maize. The plants were separated into dry leaves, green leaves, stems, bracts, cobs and ears. After drying, it was done the separation of the ears in grain and cob and later weighing. The samples were dried in a forced air circulation oven at 65 °C for 72 hours. The dry mass (DM) yield of maize was obtained by weighing the plants harvested within the useful area of each plot and extrapolated to hectare. The plants were harvested in all the rows sown, being collected the plants in 1 m per row, totaling 14 m of rows per plot. The living area ensured that the shade effect was portrayed throughout the plot.

The yield of the grasses in kg of DM per hectare was determined, being collected 2 m of row in each plot. The samples were placed in an air circulating oven at 55 °C for 72 hours. The total dry mass production was obtained by adding the mass yield of maize and grasses. The production of the different components of the plant was calculated as a function of the proportion generated by the weighings multiplied by the dry mass of the maize and expressed in kg DM ha^{-1}. The monitoring of the light to determine the level of shading was carried out with the LI-250 device of the LICOR.

The forage collected in the row was ground, homogenized and stored in mini silos. After the 45 days of incubation period, the material was removed from each silo, oven dried at 55 °C to obtain constant mass, ground in Willey mills with a 1 mm sieve, followed by the bromatological analyzes. Analyzes of pH and titratable acidity were performed.

The contents of neutral detergent insoluble fiber (NDF), acid (ADF) and lignin were determined according to the methodologies by [9], using Ankon (Ankon 200 Fiber Analyser Technology Corporation) equipment, being added sodium sulphite in order to solubilize the protein adhered to the cell wall [10] and the thermostable alpha-amylase enzyme for solubilizing the starch [9]. The lignin was analyzed with the addition of 72% sulfuric acid in the insoluble residue of the ADF determination [9]. *In vitro* dry matter digestibility (IVDMD) analyzes and organic matter (IVOMD) were performed with Daisy Incubator II (Ankon). The total nitrogen was determined by dry combustion of the sample at 1400 ° C using the CHNS elemental analysis method [11] on the automatic element analyzer Macrocube (Elementar, Germany).

2.4 Statistical analysis

The data were analyzed using the MIXED procedure of SAS 9.2, and the means comparison was performed by the PDIFF test at 5% significance after analysis of variance.

3. RESULTS AND DISCUSSION

3.1 Agronomic Characteristics

Although the height of the maize plants was higher in the shade (10%) ($P < .0001$), there was a significant effect of the intercropped species on this maize variable. In the intercrop with ruziziensis grass, maize plants grew more in the shade (2.11 m) relative to the full sun (1.82 m), while intercropped with piatã grass, this behavior was inversely, that is, in the shade, maize plants were lower (1.91 m) than full sun (2.01 m) ($P < .0001$) (Table 2).

When comparing the cultivation under shade and full sun, shading was expected to modify the leaf architecture of the plants as a whole, presenting an increase of canopy area and plant height according to the increase of the shade level. This would be a typical response of species under low light conditions, which would compensate for the light limitation with an increase of the catchment area [12]. The same response pattern of ruziziensis grass was also described for maize shaded with eucalyptus, where the more shaded the higher maize the plant presented [13].

Table 2. Maize Plant Height (MPH), Stem Diameter (SD), Ear Insertion Height (EIH), Green Leaves Number (GLN) and Plant Population (PP) intercropped with brachiaria grass and trees in integrated systems of production in conditions of shade and full sun.

MPH (m)	Full Sun	Shade	Mean
Maize/Ruziziensis	1.82 bB	2.11 aA	1.97
Maize/Piatã	2.01 aA	1.91 bB	1.96
Mean	1.92 b	2.01 a	
SD (mm)			
Maize/Ruziziensis	16.3 aB	15.6 bA	16.0 A
Maize/Piatã	17.6 aA	13.4 bB	15.5 B
Mean	17.0 a	14.5 b	
EIH (m)			
Maize/Ruziziensis	0.86 bB	1.11 aA	0.99
Maize/Piatã	1.02 aA	0.93 bB	1.98
Mean	0.98 b	1.02 a	
GLN (unit)			
Maize/Ruziziensis	10.1 aA	9.5 aA	9.8 A
Maize/Piatã	7.6 aB	6.0 bB	6.8 B
Mean	8.9 a	7.7 b	
PP (plants ha^{-1})			
Maize/Ruziziensis	41,643 bA	46,930 aA	44,286 A
Maize/Piatã	40,078 aA	39,323 aB	39,700 B
Mean	40,861 b	43,126 a	

Means followed by the same letter, uppercase in the row and lowercase in the column, do not differ statistically between them by the PDIFF test (P > .0050).

However, stem diameter decreased as light restriction occurred. The intercrop with ruziziensis grass provided finer maize plants (5%) in the shade (15.6 mm) in relation to the full sun (16.3 mm) (P < .0001), while this difference was greater for the intercrop with piatã grass (24%) (Table 2). There was a large reduction of stem diameter, from 17.6 mm to full sun, to 13.4 mm in shade in this intercrop. The competition for growth factors in denser plantations may lead to less accumulation of dry mass by maize and, consequently, thinner stems [14].

This information allied to the height gives an indication that maize was losing competition when associated with a more aggressive growth forage (piatã grass) when it was still influenced by tree shade. Due to this aggressiveness, of the piatã grass, it was observed that there were no changes in stem diameter up to 4 kg of PVS ha^{-1} of grass seeds in a intercrop (15.6 mm), but with 6 kg of PVS ha^{-1} seed there was a reduction of stem diameter (14.9 mm). For ruziziensis grass, a maximum stem diameter was reached with 4 kg of PVS ha^{-1} of grass seed (16.7 mm) (P = .0233) (Table 2). According to [15], stem diameter is more affected by intense competition than the height of the maize plant.

Regarding ear insertion height, it was verified that taller plants had higher ear height. The intercrop with ruziziensis showed maize plants with ear 30% higher in the shade (1.11 m) in relation to the full sun (0.86 m), while in intercrop with piatã grass the ears were 8% higher (0.93 m) relative to the full sun (1.02 m) (P < .0001) (Table 2).

An indicative that reinforces the high level of competition between plants damaging the maize in the condition of shade with piatã grass was the low green leaves number (6 leaves) while the other treatments maintained from 8 to 10 green leaves per plant (P = .0512) (Table 2). Consequently, the number of dry leaves and the stay green were lower for maize plants intercropped with piatã grass (20%) than with ruziziensis grass (P < .0050). The green leaves number in the maize plant showed to be very sensitive to competition also in the experiments carried out by [15].

The intercrop with ruziziensis grass in the shade provided a greater survival of maize plants (47,000 plants) (P = .0002) (Table 2), probably due to lower effects of competition. The plant population presented a correlation of 50% with height, that is, other factors influenced the height of plants such as the environment or interspecific competition. Accordind to [16], the intercropping of maize with the brachiaria in the row and between row provided a smaller plant stand in both spacings (0.45 and 0.90 m) as well as the intercrop in the row in the spacing of 0.45 m, probably due to the greater competition between species during the initial development of maize.

Regarding grain yield, the intercrop with ruziziensis grass was superior (210%) to the intercrop with piatã grass (Table 3). This mean was influenced mainly by the low yield in the piatã grass intercrop under shade conditions. [17] had a negative effect of the increase in sowing density of brachiaria on grain yield maize, an effect not verified in the present experiment (P > .05), which corroborated with the results of [18].

Table 3. Grain Yield (GY), Grass Dry Mass (GDMY), Maize Dry Mass (MDMY) and Maize Total Mass (MTMY) intercrop with brachiaria grass and trees in integrated systems of production in conditions of shade and full sun.

GY (kg ha^{-1})	Full Sun	Shade	Mean
Maize/Ruziziensis	8,000 bA	9,300 aA	8,650 A
Maize/Piatã	6,060 aB	2,350 bB	4,200 B
Mean	7,030 a	5,830 b	
GDMY (kg ha^{-1})			
Maize/Ruziziensis	1,350 aB	575 bB	960 B
Maize/Piatã	1,700 aA	1,710 aB	1,705 A
Mean	1,525 a	1,140 b	
MDMY (kg ha^{-1})			
Maize/Ruziziensis	8,006 Ab	12,240 Aa	10,123 A
Maize/Piatã	9,303 Aa	5,949 Bb	7,626 B
Mean	8,655	9,095	
MTMY (kg ha^{-1})			
Maize/Ruziziensis	9,358 aB	9,879 aA	9,618 B
Maize/Piatã	13,943 aA	7,656 bB	10,800 A
Mean	11,653 a	8,767 b	

Means followed by the same letter, uppercase in the row and lowercase in the column, do not differ statistically between them by the PDIFF test (P > .0050).

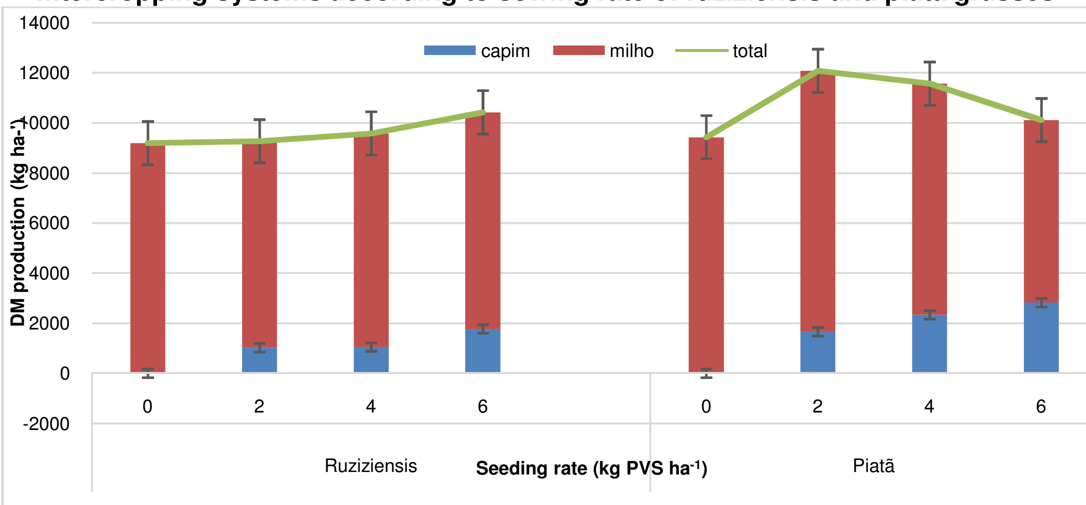
Another significant difference in response to shading was the sensitivity of forage species to shading. The piatã grass did not present any type of interference in its accumulation of DM due to the shade, but the ruziziensis grass had its yield affected drastically (Table 3).

Even with the change in DM production of grass, the maize intercrop with ruziziensis showed the same total forage yield when harvested at the silage point. The more drastic competition suffered by maize intercrop with piatã grass and trees caused the total production to be reduced (45%) (Table 3). Although total dry mass yield in the sun was higher than in the shade, this response was true only for the most productive (piatã grass). On the other hand, ruziziensis grass presented a lower growth potential, reducing the cumulative effect of competition. The mean yield of total dry mass (maize + grass) in a system intercropped with *Uroclhoa brizantha* was 14 ton ha^{-1}, while in monoculture it was 12 ton ha^{-1} [19].

As for sowing density, the values of total DM production were increasing and positive the higher the sowing density of ruziziensis grass, thus increasing the mass of grass and maize

(Figure 1). For the intercrop with piatã grass, the highest yields were obtained with the rates of 2 to 4 kg of PVS ha^{-1}, with 0 and 6 kg ha^{-1} being the lowest yields due to no mass aggregation by the grass or when no had grass, by high competition at the highest rate.

Figure 1. Production of total and compartmental dry matter of maize for silage in intercropping systems according to sowing rate of ruziziensis and piatã grasses.



The differences obtained in maize yield (Table 3) highlight the effect of shade on forage mass yield to be ensiled, mainly in relation to the piatã grass that presented mean total dry mass yield of 13.94 ton ha^{-1} in full sun and 7.65 ton ha^{-1} in the shade [19].

3.2 Silage Composition

The mean pH of the ensiled material was 3.69 (Table 4) and it was considered satisfactory in terms of fermentation standard [20], since there was an efficient fall from a forage mass with pH of 5.5 before ensiling.

The titratable acidity is considered as a more appropriate concept to judge the fermentation, being more important than the pH itself [21]. The determination of the titratable acidity has a high correlation with the lactic acid content of the silage, which only with the pH of the silage is not properly related [22]. There was no effect of the treatments on the titratable acidity of the silages produced, obtaining the mean of 20.13 being considered adequate [23].

Table 4. Neutral detergent fiber (NDF), *in vitro* dry matter digestibility (IVDMD), acid detergent fiber (ADF), lignin (LIG) of maize silage in Brachiaria intercrop and trees in integrated production systems under shade and full sun.

NDF (%)	Full Sun	Shade	Mean
Maize/Ruziziensis	42.06 aA	41.75 aA	41.90 A
Maize/Piatã	37.77 aA	43.19 aA	40.48 B
Mean	39.91 b	42.47 a	
IVDMD (%)			
Maize/Ruziziensis	72.95 aA	72.35 aA	72.65 A
Maize/Piatã	73.22 aA	68.71 bB	70.96 B
Mean	73.08 a	70.53 b	
LIG (%)	1.96 b	2.20 a	

ADF (%)	21.65 b	23.10 a
pH	3.67 b	3.71 a

Means followed by the same letter, uppercase in the row and lowercase in the column, do not differ statistically between them by the PDIFF test (P > .0050).

There was a small increase in the NDF content (Table 4) when the maize intercropped with the piatã grass was produced in the shade (43.2%) in relation to the full sun (37.8%) (P = .0021). For the intercrop with ruziziensis grass, the NDF content was unchanged (41.9%). Despite this small variation, it is observed that the NDF content of this experiment was close to those found in the literature (41%), on mean, in an experiment with eleven maize cultivars at four sites for three years [24].

There was a small increase in the ADF content (Table 4) when maize was produced in the shade (23.1%) in relation to full sun (21.7%) (P = .0355). Nevertheless, the ADF contents were below those cited in the literature as satisfactory values for maize silage of 24 to 28% [24].

The lignin content in the silage mass did not change (Table 4), being very low (2.08%) and lower than those reported in the literature (3-4%) [24]. Thus, the fiber quality of this silage can be considered high because the most digestible portion (hemicellulose) is higher due to the low levels of ADF. This confirmation is made by means of the high values of *in vitro* dry matter digestibility (71.80%, on mean), while in the above mentioned silages, the mean digestibility obtained was 60% [24].

However, the higher fiber content in the maize, piatã grass and tree intergrated provide a slight reduction in silage digestibility (68.7%) (Table 4) in relation to the full sun integration (73.2%) (P = .0002). The maize intercropped with ruziziensis grass did not affect the digestibility of silage. According to [25], maizd silage produced with xaraés grass ensures higher yield, however, with ruziziensis grass, silage presented better bromatological composition with lower fiber, crude protein, total digestible nutrients, and higher dry matter digestibility.

There were no significant variations in mineral content (3.2%) despite some statistical differences. The crude protein content was 8%, on mean, being lower content in the silage with piatã grass, probably because there is a greater proportion of grass in the mass. The maize silage of the intercrop with ruziziensis grass had a CP content of 8.3% and of 7.6% in the intercrop with piatã grass (P < .0001). Also considered adequate when comparing the silages used as reference (6 to 7% CP) [23].

4. CONCLUSION

The production of maize silage with high participation of grains in the mass and of quality is possible in integrated systems, as long as the level of competition between the plants is controlled.

When sowing is carried out in shaded environments, preference must be given to grasses with slower growth or lower sowing rates.

REFERENCES

1. Demétrio CS, Fornasieri Filho D, Cazetta JO, Cazetta DA. Performance of maize hybrids submitted to different row spacing and population densities. Brazilian Journal of Agricultural Research, v. 43, n. 12, p. 1691-1697, 2008. Portuguese.

2. Balbino LC, Cordeiro LAM, Porfírio da Silva V, Moraes A, Martinez GB, Alvarenga RC, Kichel NA, Fontaneli RS, Santos HP, Franchini JC, Galerani PR. Technological evolution and productive arrangements of crop-livestock-forest integration systems in Brazil. Brazilian Journal of Agricultural Research, v.46, n.10, p.1-12, 2011. Portuguese.

3. Oliveira Neto SN, Reis GG, Reis MGF, Leite HG. Structural arrangements of the tree component in an agroforestry system and its management by raking and thinning. Agricultural Report, Belo Horizonte, v. 31, n. 257, p. 3, 2010. Portuguese.

4. Macedo MCM. Crop and livestock integration: the state of the art and the near future. Campo Grande. Brazilian Journal of Animal Science, v. 38, p. 133-146, 2009. Portuguese.

5. Monquero PA, Milan B, Silva PV, Hirata ACS. Desiccation Timings of Soil Cover Crop Before Soybean Sowing. Planta Daninha, v.28, n.3, p.561-573, 2010. Portuguese.

6. Machado LAZ, Assis PGG. Straw and forage production of annual and perennial species in succession to soybean. Brazilian Journal of Agricultural Research, v.45, n.4, p.415-422, April 2010. Portuguese.

7. Garcia CMP, Andreotti M, Tarsitano MAA, Teixeira Filho MCM, Lima AES, Buzetti S. Agronomic performance of corn and forages species in Crop-Livestock Integration system in the Cerrado. Ciência Rural, v. 43, n. 4, p. 589-595, 2013. Portuguese.

8. Vilela L, Martha Junior GB, Macedo MCM, Marchão RL, Guimarães Júnior R, Pulrolnik K, Maciel GA. Integrated crop-livestock systems in the Cerrado region. Brazilian Journal of Agricultural Research, Brasília, v. 46, n. 10, p. 1127-1138, 2011. Portuguese.

9. Van Soest PJ, Robertson JB, Lewis BA. Methods for dietary neutral detergent fiber and no starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, v.74, p.3583-3597, 1991.

10. Mertens DR. NDF: fiber composition and value of forages with different NDF concentrations. In: Southwest Nutritional Ecology Management Conference, 1988, Phoenix. Proceedings... Phoenix: Arizona State University, 1998. p.85-99.

11. Association of Official Analytical Chemists (AOAC). Official methods of analysis. 15.ed. Washington, D.C., 1298p. 1990.

12. Gobbi KF, Garcia R, Garcez Neto AF, Pereira OG, Ventrella MC, Rocha GC. Morphological and structural characteristics and productivity of Brachiaria grass and forage peanut submitted to shading. Brazilian Journal of Animal Science, v. 38, n. 9, p. 1645-1654, 2009. Portuguese.

13. Fontes LD, Oliveira FLR, Santos MV, Fonseca DM, Galvão JCC, Leli DL. Height of maize hybrids at different distances of eucalyptus trees in agroforestry systems. Mineiro Symposium of Animal Production, 3., 2015, Diamantina. Annals. Diamantina: UFVJM, 2015. p. 194-196. Portuguese.

14. Gimenes MJR, Victoria Filho R, Prado EP, Dal Pogetto MHFA, Christovam RS. Interference of forage species with maize. Journal of the Faculty of Animal Science, Veterinary Medicine and Agronomy, Uruguaiana, v.15, n.2, p.61-76, 2008. Portuguese.

15. Busato C, Busato CCM. Initial growth of corn crop intercropped. Enciclopédia Biosfera, v. 7, 307-316, 2011. Portuguese.

16. Borghi E, Crusciol CAC. Corn yield, spacing and intercropping modalities with *Brachiaria brizantha* in no-tillage system. Brazilian Journal of Agricultural Research, v.42, n.2, p.163-171, 2007. Portuguese.

17. Silva DV, Pereira GAM, Freitas MAM, Silva AA, Seiyama T, Ferreira LR, Cecon PR. Nutritional efficiency of maize in intercropping with signalgrass. Ciência Rural, v. 38, n. 9, p. 1645-1654, 2015. Portuguese.

18. Seidel EP, Gerhardt IFS, Castagnara DD, Neres MA. Effect of time of sowing and system Brachiaria brizantha intercropped with maize on yield components and soilphysical properties. Semina Ciencias Agrarias, v. 35, n. 1, p. 55-66, 2014. Portuguese.
19. Freitas FCL, Ferreira LR, Ferreira FA, Santos MV, Agnes EL, Cardoso AA, Jakelaitis A. Implantation of Pastures via Consortium of *Brachiaria brizantha* with Corn for Silage under No-Tillage System. Planta Daninha, v. 23, n. 1, p. 49-58, 2005. Portuguese.
20. Rodrigues PHM, Ruzante JM, Senatore AL, Lima FR, Melotti L, Meyer PM. Evaluation of Microbial Inoculation on Nutritional and Fermentative Quality of Corn Silage. Brazilian Journal of Animal Science, v.33, n.3, p.538-545, 2004. Portuguese.
21. Jobim CC, Nussio LG, Reis AR, Schmidt P. Methodological advances in evaluation of preserved forage quality. Brazilian Journal of Animal Science, v.36, p.101-119, 2007 (supplement). Portuguese.
22. Melo MJAF, Backes AA, Fagundes JL, Silva GP, Freire APL. Fermentation characteristics and chemical composition of Tanzania grass silage containing additives. Bulletin of Animal Husbandry, v. 73, p.189-197, 2016. Portuguese.
23. Pegoraro PL, Krahl G, Mantovani. Bromatological composition of corn silage during the period of use at different technological levels. Unoesc & Ciência, v. 7, n. 1, p. 39-46, 2016. Portuguese.
24. Nussio LG, Campos FP, Dias FN. Importance of the quality of the vegetative portion in the food value of corn silage. Symposium about Production and Use of Preserved Forage, 2001. Annals... UEM: SFC, 2001. p. 127-145. Portuguese.
25. Costa NR, Andreotti ML, Keny SM, Santos FG, Pariz CM. Nitrogen fertilization of *Urochloa* grasses intercropped with corn. Brazilian Journal of Agricultural Research, v.9, 2014. Portuguese.