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Assessment of *Urochloa ruziziensis* in different sowing seasons intercropping with late corn cultivars

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Abstract

Background: The cultivation in intercropping between maize and forage brings numerous benefits, among them is the possibility of maintaining maize production and the formation of straw, aiming at improvements in the characteristics of the productive environment.
Objective: This work had as objective to evaluate the performance of the forage *Urochloa ruziziensis* in different sowing dates in intercropping with corn crop.
Results: *U. ruziziensis* was sown in-between the maize rows. It was evaluated soil coverage percentage, plants height, chlorophyll content, density of tillers, leaf area index and biomass production. *U. ruziziensis* showed no significant difference for biomass production, however there was no interaction between cultivar and date for the other variables.
Conclusion: The intercropping between maize and *U. ruziziensis* must be carried out with the sowing of the same occurring at the same time and preferably with an early cycle and low size cultivar.

Key words: Crop-livestock integration, Poaceae, *Zea mays*, intercropping, yield.

INTRODUCTION

Maize (*Zea mays* L.) is one monocotyledon from the family Poaceae of great economic importance for Brazil as well as for the whole world. In recent years, Brazil increased significantly its production and export. In the states in the Midwest region of Brazil, agriculture is based in succession between soybean and corn. However, in most of the crops, soon after the corn harvest, the soil is maintained with little coverage of straw, leaving it thus exposed and consequently more vulnerable to degradation.

Important changes in the system of production of these crops have occurred in recent years and had as a result the expansion in direct sowing system (SSD) and also in the integration of crop breeding (CLI). This latter system, the CLI, consists of the deployment of the implantation of the intercropping of annual cultivations with fodder species, being that the grass *Urochloa* genus (formerly called *Brachiaria*) is the forage species more used, being a kind that presents a good competitiveness with weeds, tolerance to shading, soil high protection, tolerance to drought and also presents a wide adaptability climate change, as well as forming dense pastures, when submitted to favorable conditions.

The corn intercropping with *Brachiaria* is an important alternative to increase and keep the straw on the soil surface, with quality and quantity sufficient to express the maximum potential of SSD, since it increases the inflow of the vegetable waste and provides higher economic return in the cultures that will be sown in succession (Ceccon *et al.*, 2008).

Due to the climate conditions of the West, the SSD Center along with the rotation of crops and pastures, is pointed out as the form of soil management more adequate to reconcile productivity with sustainability. The agriculture, however, presents high vulnerability to climate conditions and variations in market price quotations. To alleviate these problems, it is recommended to use the appropriate practices of soil management, as the SSD and the diversification of activities.

The crop-livestock integration (CLI) becomes an alternative to manage, in the conditions previously cited, a more viable and competitive agricultural activity. According to Carvalho (2005), the cereals cultivation, such as soy and corn system intercropping with fodder species, mainly of the genus *Brachiaria*, can provide, in a single rainy season, high grain production and also of good quality forage.

There are many questions about the conditions that enhance the employment of this intercropping as the sowing seasons of *Urochloa ruziziensis*, whose delay will imply in greater climatic risk for its development. Tsumanuma *et al.* (2012) and Jakelaitis *et al.* (2006) found that the intercropping can be implanted simultaneously to the seeding of annual crop or approximately 10 to 20 days after the emergence of these, corresponding to the stages V3 - V4 maize, aiming at the preservation of the cereal productivity. According to these authors, the sowing season of the forage in the interrow companion can be considered a determinant factor in competition for water, nutrient and mainly light. This competition between the cultivated species could result in potential loss in productivity, being necessary the knowledge about the best sowing times of *U. ruziziensis* to minimize competition and prevent losses in productivity of corn crop.

The aim of this work was to evaluate the performance of the forage *U. ruziziensis* in different sowing dates in intercropping with late corn crop, aiming at the production of straw for the sowing of the soybean in no tillage.

MATERIALS AND METHODS

The experiment was conducted between the months of February and October of the year of 2014, in the geographical coordinates 9˚51'44.86' S, 56˚04'03.55"; at an altitude of 283 m, within the municipality of Alta Floresta - MT, in no-tillage system on straw of soybean. The soil of the experimental area is classified as Dystrophic Red-yellow Latosol, sandy clay texture (EMBRAPA, 2013) and the predominant climate in the region is of type equatorial hot and humid with defined dry station and according to the classification of Köppen is Type Am, with average rainfall of 2,800 mm.

Before the installation of the experiment, it was performed the soil sampling for the determination of the chemical and granulometric characteristiscs at the layer 0-0.20 m whose results were: 23.0 g dm^{-3} of organic matter; pH ($CaCl_2$) 5.22; 1.22 mg dm^{-3} of P; 0.14 $cmol_c$ dm^{-3} of K; 1.79 $cmol_c$ dm^{-3} of Ca; 0.67 $cmol_c$ dm^{-3} of Mg; 3.89 $cmol_c$ dm^{-3} H + Al; CTC 8.0 $cmol_c$ dm^{-3} and 52.2% of saturation through bases. The granulometric characteristics were: 386 g kg^{-1} of clay; 140 g kg^{-1} of silt and 474 g kg^{-1} of sand fraction.

The experimental design used was randomized blocks, in factorial scheme 3 x 2, being that the treatments were constituted by the combination of three sowing dates of *U. ruziziensis* (0, 7 and 14 days after corn seeding) and two cultivars of hybrid maize, with four repetitions each. Each plot had the size of 5 x 5 m, corresponding to 25 m^2.

Corn was sown in the tillage system on straw of soybean, on 22 March 2014 in the spacing of 0.70m between rows, being used 4.0 seeds per linear meter, aiming to obtain a population of 50,000 to 55,000 plants ha^{-1}. In seeding fertilization, it was used 400 kg ha^{-1}, of the formulated 04-30-20 and in coverage it was applied 140 kg $ha^{-1}$of N (urea - 45% of N) according to the recommendations of Ribeiro *et al.* (1999). The phytosanitary treatments were performed to meet the needs of the corn crop.

The *U. ruziziensis* was sown in-between the maize rows, using seeds with 55% of cultural value, being performed simultaneously to the corn seeding, and in times of 7 days and 14 days after the culture implantation. The corn has been harvested in the month of July 2014, keeping the *U. ruziziensis* in the field until the month of October, when the following characteristics were performed: The percentage of soil coverage (twine method); plant height (measurement of the soil surface to the apex of the branches); the chlorophyll content (chlorophyllometer SPAD 502 MINOLTA - readings in the middle third of five blades of leaves located in the median region of theplant); density of tillers (counting of tillers present in the area of the rectangle of iron useful for 50 x 50 cm); leaf area index (leaf area meter LICOR LI-3100 - sub-samples of Leaves present in the square of 0.25 m^2). The leaf area index (IAF) was calculated by the ratio between the area of leaf blades and collection area (IAF= leaf area in m^2 / pickup area in m^2). The biomass productivity was determined by collecting randomly three samples from 0.25m^2 in each plot. The cutting plants contained inside the sample unit was performed manually using scissors, being that the plants have been mown down at the height of 0.15 m from the surface of the soil and packed in plastic bags duly identified. The samples collected from each plot were subjected to separation of stem and leaf, being the material wrapped in paper bags and weighted later in precision balances, obtaining, the fresh mass of the culm (MVC) and LEAF (MVF) in kg h^{-1}. The samples present in paper bags were then, sent for drying in forced ventilation at 65 °C until constant mass was reached. After drying, the samples were again weighed in precision balances, for obtaining the culm dry mass (MSC) and the leaf (MSF) in kg ha^{-1}.

The data obtained for the components of the *U. ruziziensis* were submitted to variance analysis. In the case of significant F test, the variables were submitted to the Tukey test at 5% probability, using the SISVAR program (Ferreira, 2011).

RESULTS

It was not observed difference ($p > 0.05$) among cultivars and sowing seasons of the forage, as well as the interaction between these factors for dry mass of culms, dry mass of leaves, stem and leaf ratio density of tillers. To the percentage of the soil cover by the forage, it was observed difference ($p \leq 0.05$) among the cultivars of maize and also between the times of sowing the forage (Table 1).

Table 1. F values, coefficient of variation (CV), minimum significant difference (MSD) and average values for leaf/stem dry mass, leaf/stem ratio, tiller population density and percentage of soil coverage for *Urochloa ruziziensis* cultivated in different sowing dates intercropping with two cultivars of maize.

	Stem dry mass (Kg ha^{-1})	Leaf dry mass (Kg ha^{-1})	Leaf/stem ratio	Tiller population density (tiller m^{-2})	Percentage of soil coverage (%)
Cultivar (C)					
Riber	342	596	1.85	67.25	70.44 a
Dekalb	257	482	2.35	69.25	57.44 b
F values	4.11 ns	3.66 ns	0.78 ns	0.21 ns	8.19 *
MSD (Tukey 5%)	89	126	1.21	9.53	9.68
Data (D)					
0	310	568	2.16	72.75	73.50 a
7	286	529	2.33	64.25	58.00 b
14	303	520	1.81	57.75	50.33 b
F values	0.15 ns	0.24 ns	0.29 ns	1.27 ns	4.51 *
MSD (Tukey 5%)	132	189	1.81	13.92	14.45
C*D Valor de F	4.02 ns	1.74 ns	0.59 ns	3.28 ns	1.85 ns
CV (%)	24.07	26.98	26.11	15.69	17.40

Obs. *$p < 0.05$; **$p < 0.01$; ns not significant at $p < 0.05$. Means within each column followed by the same letter are not significantly different ($p = 0.05$) as determined by Tukey's test.

The percentage of soil covered by the forage *U. ruziziensis* (Table 1) was influenced by cultivar used, where the cultivar Riber provided greater coverage in relation to Dekalb.

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For fresh mass of culm (Table 2), no difference was observed between the cultivars in the sowings seasons studied, however, it was observed difference between the seasons when it was used the Riber cultivar. The largest productions were verified in simultaneous seeding and after seven days of maize sowing.
With relation to the fresh mass of leaves and total dry mass (Table 2), it is noted the difference between the cultivars only in the sowing of the forage to 14 days after corn seeding, where the cultivar Dekalb provided greater production of leaves. Only with the use of the cultivar Riber occurred difference between the sowing dates, where simultaneous sowing provided greater production of leaves.

Table 2. Unfolding of significant interaction between cultivar and sowing times (DASM - days after the sowing of maize) for fresh mass of culm, fresh mass of leaf, total dry mass, average daily gain of dry weight, plant height, chlorophyll content and leaf area index for *Urochloa ruziziensis* cultivated in different sowing dates in itntercropping with two cultivars of maize.

Cultivar (C)	Days after the sowing of maize (DASM)		
	0	7	14
	Fresh mass of culm (kg ha^{-1})		
Riber	1,860 a A	1,214 a AB	1,059 a B
Dekalb	1,533 a A	1,161 a A	1,295 a A
MSD Tukey (5%) - C(DASM) = 597; DASM(C) = 704			
	Fresh mass of leaf (kg ha^{-1})		
Riber	2,979 a A	1,861 a B	1,680 a B
Dekalb	1,856 a A	1,580 a A	1,886 b A
MSD Tukey (5%) - C(DASM) = 489; DASM(C) = 596			
	Total dry mass (kg ha^{-1})		
Riber	1,132.10 a A	879.20 a B	804.20 a B
Dekalb	844.40 a A	751.90 a A	624.20 b A
MSD Tukey (5%) - C(DASM) = 206.78; DASM(C) = 252,12			
	Plant height (cm)		
Riber	39.25 a A	29.25 a B	26.00 a B
Dekalb	33.75 b A	30.50 a A	24.00 a B
MSD Tukey (5%) - C(DASM) = 3.5; DASM(C) = 4.27			
	Chlorophyll content (spad index)		
Riber	46.07 a A	42.80 a B	35.67 a C
Dekalb	40.35 b A	35.72 b B	34.95 a B
MSD Tukey (5%) - C(DASM) = 1.71; DASM(C) = 2.09			
	Leaf area index (m^2 m^{-2})		
Riber	0.55 a A	0.34 a B	0.34 a B
Dekalb	0.43 b A	0.32 a B	0.32 a B
MSD Tukey (5%) - C(DASM) = 0.07; DASM(C) = 0.08			

Means followed by the same lower-case letter in the column and upper-case letter in the row are part of the same group according to the Tukey's test ($p < 0.05$).

With relation to the height of plants of the forage (Table 2), there was difference among the cultivars only in simultaneous seeding with the corn, where the cultivar Riber provided higher plants of *U. ruzizienis*. For the two cultivars of maize, it was verified differences in height of plants of *U. ruziziensis,* being that for the cultivarRiber, the largest height was observed in simultaneous seeding. Now in the cultivar Dekalb, there was no difference between the simultaneous seeding and the one held seven days after the maize.

For the two cultivars of maize, the highest contents of chlorophyll (spad index) were verified when seeding occurred simultaneously with the *U. ruziziensis*, indicating once again the best performance of the forage in this condition (Table 2). *U. ruziziensis* intercropped with the cultivar Riber obtained higher contents of chlorophyll when sown simultaneously with the corn and at seven days. This is due to the morphological differences and genetic of each hybrid. The hybrid Riber presents 770 days degrees and super early cycle, allowing the shading shorter in relation to another cultivar (Dekalb), which has 870 days degrees and early cycle. This way, the latter takes a little longer to reach the time of harvesting in condition of intercropping, reducing the light gathering by Brachiaria.

With relation to the leaf area index (Table 2), there was no difference among the cultivars only when the seeding of *U. ruziziensis* was performed simultaneously with the corn. The cultivar Riber provided higher leaf area index to the forage.

DISCUSSIONS

Although there were differences between cultivars and of sowing seasons of the forage for the tiller population density (Table 1) it can be verified that this was above average observed by Gazola *et al.* (2014), who found values between 36.58 and 52.70 tillers m^{-2} for *U. ruziziensis*. The highest density of tillers favors the soil cover and the rapid canopy closure and is determinant for the increased production of grass (Fagundes *et al.*, 2005).

Barros & Broch (2012) commented that the size or final stature of corn cultivar presents effects on the greater or lesser incidence of light, which will be available for the forage during the crop cycle. Thus, cultivars of superior size can even cause the elimination of the forage intercropped. The sowing of the forage on the same date that the maize provided the greatest soil coverage, confirming the one observed by Richart *et al.* (2010). These authors comment that late sowing dates harm the initial development of the forage. This fact can be explained by the effectiveness of the corn crop in competition for water, light and nutrient, as it is delayed the forage sowing.

Although there were no differences in the production of dry mass of leaves and culms among the cultivars tested and also between the times of sowing of the forage, it is noted a low production compared to data reported in the literature as to Richart *et al.* (2010), which can be due to climatic conditions which occurred (low precipitation) after the corn harvest (Figure 1). According to Fagundes *et al.* (2005), the low availability of water and light and low temperatures are unfavorable conditions for the development of forage. Despite of the low production of dry mass, it is noted the values of leaf: stem ratio higher than those recorded by Paciullo *et al.* (2003) and Richart *et al.* (2010), who found values between 0.71 to 0.95 and 0.94 to 1.38 respectively. High values of leaf: stem ratio indicate forage of high content of protein and better animal gain.

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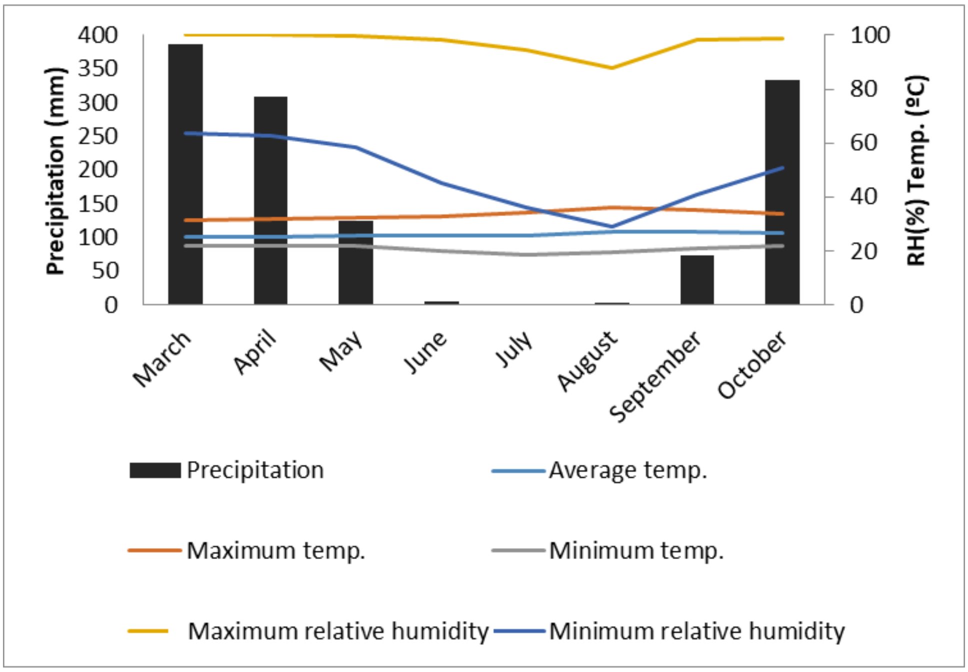

Figure 1. Monthly averages of minimum, mean and maximum temperature, maximum and minimum relative humidity and monthly rainfall occurring in the months of conduction of the survey in the municipality of Alta Floresta - MT. Source: Unemat / AF Meteorological Station.

Thus, the results of this study corroborate with Ceccon *et al.* (2009), who also found in the intercropping of forage *U. ruziziensis* with the corn of different sizes, that the cultivar AG 9010, super early cycle, and BRS 1010, early cycle, presented for *U. ruziziensis* greater production of culms. However, for maize DOW 2B710, due to greater shading caused by high size of this, there was a reduction in the production of culms.

Portes *et al.* (2000) affirm that the corn shading is a factor for supression of the forage in intercropping. The pace of foliar growth decreased in favor of the growth of the culms, in an evidence that in the partition of photoassimilated from photosynthesis, the culms are being benefited. Still according to the authors, the benefit in the development of the culms in detriment of the leaves is a strategy of the plant to accumulate mass, since that the excess of leaves causes self shading, reducing the total plant photosynthesiss. Thus, it becomes clear the behavior variation of the forage in function of the cultivars used.

The differential response among the maize cultivars may have occurred due to genetic characteristics of each cultivar, which have vegetative development and accumulation of different plant mass, as well as differences in its lifecycle. Thus, it is important to the knowledge of the differential behavior between the materials available in the market, to be able to position, in production areas, the forage species more responsive in function of different cultivars of maize (Guareschi *et al.*, 2010). The cultivar Riber has a super early cycle, however there are genetic differences and morphological between the maize cultivars, which may allow the forage to have an increase in production of culms in relation to maize Dekalb, thus favoring, its development. This allows a light incidence over the Brachiaria, that will be less late in relation to the cycle of maize Dekalb, causing the brachiaria return to normal process of total photosynthesis and photoassimilated, favoring a higher production of culms.

With relation to the fresh mass of leaves and total dry mass (Table 2), similar results were observed by Tsumanuma et al. (2012) that, evaluating three species of *Urochloa* in different sowing periods, it was observed that the best time for the formation of pastures and of mass production was the same date to maize sowing.

The height of plants of the forage is related to the smaller size of this cultivar and consequently there will be a greater incidence of light on the canopy, favoring the development of the forage. The differences in height of plants of *U. ruziziensis* indicates that this specie presented a decrease in their average height when subjected to a stress condition (reduction of luminous intensity by the presence of shading), condition caused by the competition with the two maize hybrids. During the days in which the maize develops, there is a reduction of the intensity of light, thus hindering the growth and formation of U. *ruziziensis*, demonstrating clearly the interspecific competition between species. Portes *et al.* (2000) observed in their study that, since the beginning of the collections of forage for growth analysis, there was competition in greater or lesser intensity of the cereals with the brachiaria. *U. ruziziensis* is a plant metabolism C_4 of fixation of CO_2. For this reason, they are plants that need large quantity of light for their development. Thus, when cultivated in intercropping with the corn, a shading occurs, causing growth damage.

Pariz *et al.* (2011) studying production, bromatologic composition and chlorophyll index of brachiarias after the intercropping with corn due to nitrogen fertilization, found values for the leaf chlorophyll index ranging between 26.20 and 50.45. These values are similar to those observed in the present study.

The larger leaf area index of the cultivar Riber can be attributed to the difference of the cycle and size existing between the cultivars. For the sowing dates of the forage, it is noted that by virtue of the competition offered by intercropping system, the leaf area index (IAF) for conversion of light trap in the accumulation of biomass, was undermined from the seeding after seven days to maize sowing. This is because when the emergency of the *U. Ruziziensis* occurred, the corn was in the moment of photosynthetic high yield, occurring thus greater competition within the first few days of emergency of brachiaria, causing stress in the first days.

According to Gobbi *et al.* (2009), the shading leads to a reduction of photosynthetic rate per unit of leaf area, which occurs because of greater resistance imposed by the stomata and leaf mesophyll to the absorption of CO_2, mainly for possessing metabolism C_4 of fixation of CO_2, characteristics that are demanding in light (Portes *et al.*, 2000).

It is noted low values of leaf area index (IAF) in this work if compared to those observed by Fagundes *et al.* (2005). This may have occurred due to climatic conditions verified after corn harvest, where there was a low rainfall and high temperatures (Figure 1). According to these authors, the low values of LAI were verified in winter in function of the adverse weather conditions, with low rates of rain water and temperature which, allied to the lowest number of leaves per tiller vivid and the final leaf length contributed to the low IAF.

CONCLUSIONS

The intercropping between corn and *Urochloa ruziziensis* must be carried out with sowing occurring at the same time. Preference should be given to the use of a maize cultivar with low size and super early cycle, because, in this way, the intercropping will allow the production of this crop, without compromising *U. ruziziensis*, thus favoring a better production of straw on the soil and / or animal fodder.

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FUTURE WORKS

Results of this research are very important for the establishment of agricultural practices aiming at the application of different sowing densities. The promising results of this species (*U. ruziziensis*) may generate interest for the research and future use of other forage species in consortium with maize.

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'Not applicable' for that section.

Conflict of Interest

Authors declare no conflict of interest

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