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NITROGEN SIDEDRESS ON SILAGE MAIZE INTERCROPPED WITH MARANDU GRASS

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ABSTRACT - The method used for the establishment of an intercropping system may interfere in the optimal timing of nitrogen sidedress fertilization on maize for silage. Due to this, the aim of this study was to evaluate the effects of nitrogen sidedress timing on the development and yield of silage maize and Marandu grass grown under irrigation in an intercropping. A split plot randomized blocks design with four replications was used. The plots corresponded to the nitrogen sidedress timing on silage maize (0, 15, 30, 45 and 60 days after sowing, corresponding to the phenological stages V3, V5, V7 and R1, respectively). The subplots consisted of two consortium establishment methods, Marandu Grass simultaneously sowed with the maize crop and 30 days after. The simultaneous sowing of silage maize and Marandu grass intercropped, and irrigated favors the grass development and dry mass yield, reducing the yield of maize ear green mass and maize total dry mass. The nitrogen fertilization after corn sowing reduced maize silage yield and favored the forage production of the intercropped Marandu grass.

Keywords: *Zea mays*; *Urochloa brizantha* cv. Marandu; interspecific competition; integration crop-livestock.

ADUBAÇÃO NITROGENADA DE COBERTURA PARA O MILHO SILAGEM CULTIVADO EM CONSÓRCIO COM CAPIM MARANDU

RESUMO - O método de introdução da forrageira no sistema de consórcio pode interferir no momento ideal para a realização da adubação nitrogenada em cobertura na cultura do milho silagem. Em função disto, objetivou-se avaliar os efeitos de diferentes épocas de adubação nitrogenada em cobertura no desenvolvimento e produtividade da cultura do milho silagem e do Capim Marandu, cultivados em consórcio sob irrigação. Utilizou-se delineamento experimental de blocos ao acaso em parcelas subdivididas, com quatro repetições. As parcelas corresponderam à época de adubação nitrogenada em cobertura no milho silagem (0, 15, 30, 45 e 60 dias após semeadura do milho, equivalendo à semeadura, V3, V5, V7 e R1, respectivamente). Nas subparcela, foram testados dois métodos de implantação do consórcio: Capim Marandu semeado simultaneamente à cultura do milho e 30 dias após. A semeadura simultânea do milho silagem e do Capim Marandu, em sistema de consórcio, favoreceu o desenvolvimento e a produção de massa seca do capim, reduzindo a produtividade de massa verde de espigas de milho e massa seca total de plantas. A adubação nitrogenada de cobertura realizada após a semeadura prejudicou a produção de milho silagem e beneficiou o desenvolvimento do capim Marandu cultivado em consórcio.

Palavras-chave: *Zea mays*; *Urochloa brizantha* cv. Maradu; competição interespecífica; integração lavoura-pecuária.

The silage maize crop intercropped with forage is becoming a viable option for agribusiness in the Cerrado region due to its profitability (Garcia et al., 2012).

This system is also a technology for crops integration,, enabling diversification of production systems and reducing soil compaction, especially in irrigated areas due to increased soil coverage at the silage harvest time. Besides this, their root system restores the physical properties, changed as the result of heavy harvesting and transportation machines traffic and provides forage for the period after harvest or straw to the following cultivation (Agnes et al., 2004).

Diversifications such as the Crop-Livestock Integration System (CLIS) offer some advantages over conventional systems, due to the benefits from crop and livestock activities. So, silage corn cultivation intercropped with forages is an option to improve soil conditions and silage production in order to provide supplemental feeding for cattle during the dry season, when a decrease in food quantity and quality is observed.

The CLIS aims to maximize land use and agricultural supplies, with consequent increase in yields and improvements in chemical and physical attributes of the soil. The use of CLIS has been increasing in recent years, especially for the Midwest region of Brazil, where the intercropping of corn and forages, mainly of the genus *Urochloa,* has emerged as the main option. This system has greatly contributed to increasing on the animals food supply (Panichi et al., 2010). The productivity of a forage plant is genetically determined. However, is influenced by environmental variables such as nutrient availability (Fagundes et al., 2005).

Maize is a crop that removes large amounts of nitrogen and usually requires supplementation with sidedress nitrogen (Coelho, 2006), since the crop high productivity is dependent on the expressive use of nitrogen fertilizers (Araújo et al., 2004). However, there are large losses of applied nitrogen and a way to minimize this is parceling nitrogen fertilization.

In integrated production systems, for example, with crop and pasture grown intercropped, there will be competition between plants which might change the nitrogen fertilizer management in every crop. The anticipation or delay of nitrogen fertilization may favor one crop over another, since the time of application of nutrients in the soil must coincide with the higher demand by the crop, especially for highly mobilized elements in soil and high soluble fertilizers (Cruz et al., 2008).

In Brazil, the sidedress nitrogen recommendations for maize present regional variations, with doses ranging from 20 to 180 kg ha^{-1} (Sousa & Lobato, 2004) and timing ranging mostly from 15 to 45 days after emergence of corn seedlings in field (Cruz et al., 2008). Thus, it becomes fundamental the search for more accurate information on needs of crops cultivated intercropped, as well as their response to different times of nitrogen sidedress application.

Considering the hypothesis that the establishment method of *Urochloa brizantha* on the intercropped system can affect the ideal time of maize sidedress nitrogen fertilization, this research was developed with the aim of evaluating the effect of different nitrogen sidedress timing in the development and yield of irrigated silage corn and *Marandu grass* grown intercropped.

Materials and Methods

The experiment was carried out at Buritis farm in Palmeiras de Goiás, GO, with coordinates

16°50’42” S and 49°58’30” W and 562 m altitude, in an area irrigated by center pivot during the growing season 2012/2013. The climate in the region is Aw, according to the Köppen classification, characteristic of savannah with two distinct seasons: a dry and cold (autumn and winter) and another hot and wet (spring and summer).

The soil was classified as Latossolo Vermelho distroférrico (Brazilian Soil Classification System) with 420, 100 and 480 g kg^{-1} of clay, silt and sand, respectively. The soil sample collected (0-20 cm) and subjected to chemical analysis as described in Silva (2009) showed the following results: pH (H_2O) of 5.6, OM of 29.5 g dm^{-3}, P (Mehlich) of 96.3 mg dm^{-3}, K, Ca, Mg, H+Al and CTC, of: 0.3, 3.5, 1.5, 3.8 and 9.1; $cmol_c$ dm^{-3}, respectively, S, Fe, Mn, Zn, B and Cu, of: 6.5, 123.0, 31.2, 14.2, 0.4 and 9.2; mg dm^{-3}, respectively. The experiment consisted of 10 treatments established in a split plot randomized block design with four replications and an area of 16 m² (2 x 8 m) as subplot. Plots corresponded to nitrogen sidedress timing (0, 15, 30, 45 and 60 days after sowing, corresponding to the phenological stages sowing, V3, V5, V7 and R1) using the hybrid Pioneer 30F53H. The treatment “0” represents all the nitrogen fertilization at the time of corn sowing. The subplots consisted of two consortium establishment methods with Marandu Grass (*Urochloa brizantha*. cv. Marandu) sowed simultaneously (subplot 1) and 30 days after corn sowing (subplot 2).

Corn sowing was held under soybean crop residues cultivated in the summer season without tilling using a thirteen rows tractor seeder, distance of 0.5 meters between rows, placing 3.8 corn seeds per meter, aiming a population of 70,000 plants per hectare. Sowing in the subplot 1 was held on March 7, 2013, with the Marandu grass seeds mixed with the corn recommended fertilizer, in the amount of 10 kg ha^{-1} of seeds with cultivation value of 50%. The sowing of grass Marandu in the subplot 2 was manually held on April 6, 2013, placing 10 kg ha^{-1} of seeds, incorporated with a range of two to four centimeters deep, in a single row between the corn lines.

The sowing fertilizer was 230 kg ha^{-1} of formulated NPK 08-28-20, incorporated into the sowing furrow at approximately 7 centimeters deep. The sidedress fertilization was performed at the timing established in the treatments, with the application of 150 kg ha^{-1} of nitrogen in the form of urea. The fertilizer was superficially distributed at approximately 20 centimeters from the corn plants and incorporated into the soil by irrigation.

Potassium sidedress in a dose of 100 kg ha^{-1} of potassium chloride was performed in all treatments, broadcasted with tractor powered equipment. All cultivation practices and pesticides used followed the recommendations for maize in the region. Before the crops sowing, desiccation of the area with 4 L ha^{-1} of glyphosate was performed. After corn sowing there was no more herbicide application in the area.

The height of 10 corn plants per subplot was measured at the flowering stage, starting from the ground level to the tassel first branch insertion, with the aid of a measuring tape. To determine the maize leaf area (cm^2), a high resolution leaf area meter system (LI - 3100C) was used, collecting all the leaves with more than 75% of the green leaf blade of five plants per subplot.

When the grains were among the stages of milky grain and pasty, 96 days after sowing, corn was harvest for silage. All plants located on six meters of the two central lines were removed by manual cutting at approximately 10 cm from the soil surface.

On this occasion, the green ear yield, the total green mass (weight of all plants plus the weight of the ears) and total dry mass were evaluated and the results extrapolated to Mg per hectare. The ear number per rows was also evaluated.

Thirty days after the corn harvest the number of tillers per plant and the dry matter of forage were evaluated. Tiller number was determined by counting in 10 plants of each subplot. To dry mass determination two meters of green mass of each subplot were cut close to the ground. The cut material was weighed and submitted to forced air circulation stove at 65°C temperature until constant weight.

All data were subjected to variance analysis at 5% and 1% probability by F test and the treatment means were compared by Tukey test. The data relating to nitrogen fertilization timing were subjected to regression analysis, using linear and quadratic equations and the significant equations were accepted up to 5% of probability by F test with the highest determination coefficient (R^2).

Results and Discussion

The interaction between the consortium establishment methods and nitrogen sidedress times in maize was not significant (P> 0.05) for the studied variables. The consortium establishment methods did not affect the maize morphological components, indicating that the forage sown simultaneously or 30 days after corn sowing did not impair the annual crop vegetative development. However, for the ears green mass and total dry mass, statistical difference was noticed between the consortium establishment methods (Table 1).

The highest green ear yield and total dry mass were observed in subplots with intercropping established 30 days after corn sowing, demonstrating that the competition carried out by the forage sown simultaneously negatively affected the ears production and total dry mass accumulation. This result differs from that presented by Pequeno et al. (2006) which did not observe significant effect of different sowing

Table 1. Means of variables evaluated in silage corn and Marandu grass, with two consortium establishment methods.

Consortium Establishment methods	Maize						Marandu Grass	
	Plant height	Plant foliar area	Ear number of rows	Ear green mass	Total green mass	Total dry mass	Plant number of tillers	Dry mass 30 days after corn harvest
	cm	cm^2	——	Mg ha^{-1}	Mg ha^{-1}	Mg ha $^{-1}$	——	Mg ha^{-1}
Simultaneously	220.6	4695.8	16.0	21.9	49.1	9.2	30.5	2.9
30 DAS*	220.8	4872.3	16.1	23.6	51.2	9.7	13.4	0.3
DMS	4.1	250.1	0.4	1.2	2.3	0.4	2.4	0.1
CV%	2.8	7.7	4.0	7.9	6.7	7.11	16.6	13.3

Means followed by the same letter do not differ statistically by Tukey test at 5% probability. * DAS = days after corn sowing.

dates of Grass Marandu intercropped with corn on green ear yield under rainfed conditions. Richard et al. (2010) studied different seeding times of *Brachiaria ruziziensis* intercropped with corn under rainfed conditions and also found no significant difference for the yield components evaluated, asserting that the sowing dates did not exert depressing effect on corn yield.

Considering the evaluations performed in the forage, the number of tillers and the Marandu grass dry mass 30 days after corn harvest showed higher values when the forage was seeded at the same time as corn (Table 1). This can be explained due to less competition, mainly for light, which occurred in the early development of the crops sowed simultaneously. In treatments where forage sowing occurred 30 days after corn, the already established annual crop impaired the forage growth. Similar results were found by Richard et al. (2010) that observed 30 days after corn harvest, 3555 kg ha^{-1} of *Brachiaria ruziziensis* dry mass that was simultaneously sowed with corn. On the other hand, when the forage was sowed 30 days after corn, a dry mass production of 474 kg ha^{-1} was observed.

For corn plant height and leaf area there was a linear decrease in the values with the increase of days after sowing for nitrogen sidedress application (Figures 1A and 1B). The results found in this study were similar to those obtained by Silva et al. (2005), where the plant height highest values were assessed for nitrogen fertilization at sowing time and fifteen days after annual crop emergence. Nitrogen fertilization in a single dose in corn sowing time has provided yield increase when compared with split applications late in V6 or V8 (Duarte et al., 2003; Cruz et al., 2008). Plants with higher nitrogen content in the early stages provided greater growth and development and consequently higher leaf area, and gave greater synthesis of carbohydrates by photosynthesis (Santos & Pereira, 1994).

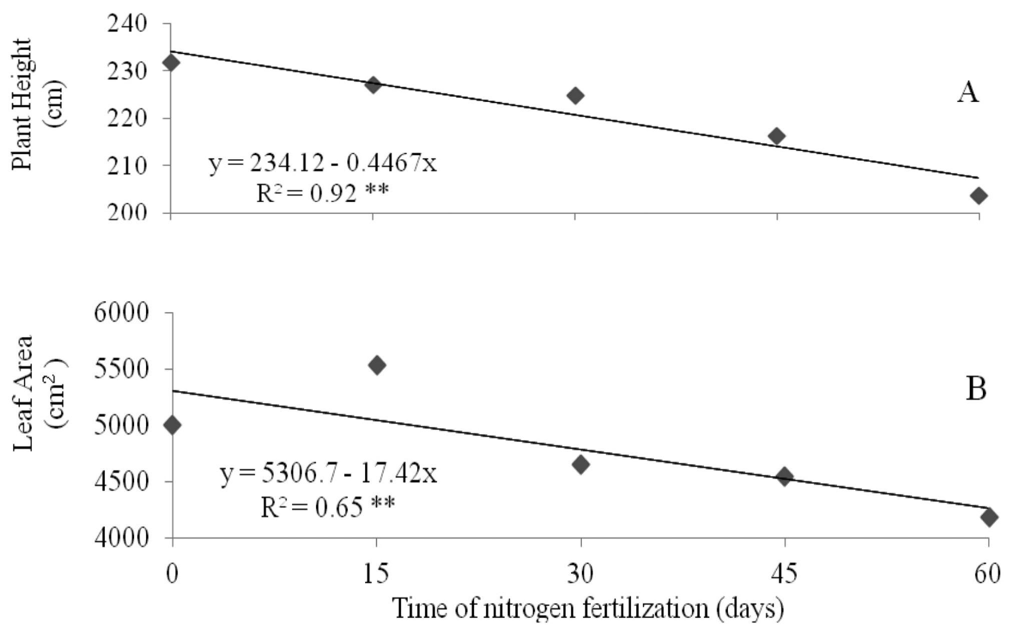

Figure 1. Plant height (A) and leaf area (B) as affected by timing of nitrogen fertilization, Palmeiras de Goiás, GO, 2013. (** significant at 1% level of probability).

Concerning the number of kernels per row, green mass of ears and total dry mass, there was also a negative linear regression adjustment in function of days after sowing for nitrogen sidedress application (Figures 2A, 2B and 2D). These results are probably associated with the nitrogen availability in the maize early stages, resulting in the highest means of the yield components evaluated. The later the nitrogen sidedress in relation to maize sowing, the higher reduction of these components was observed, indicating that deficiency occurred when the productive potential was being defined.

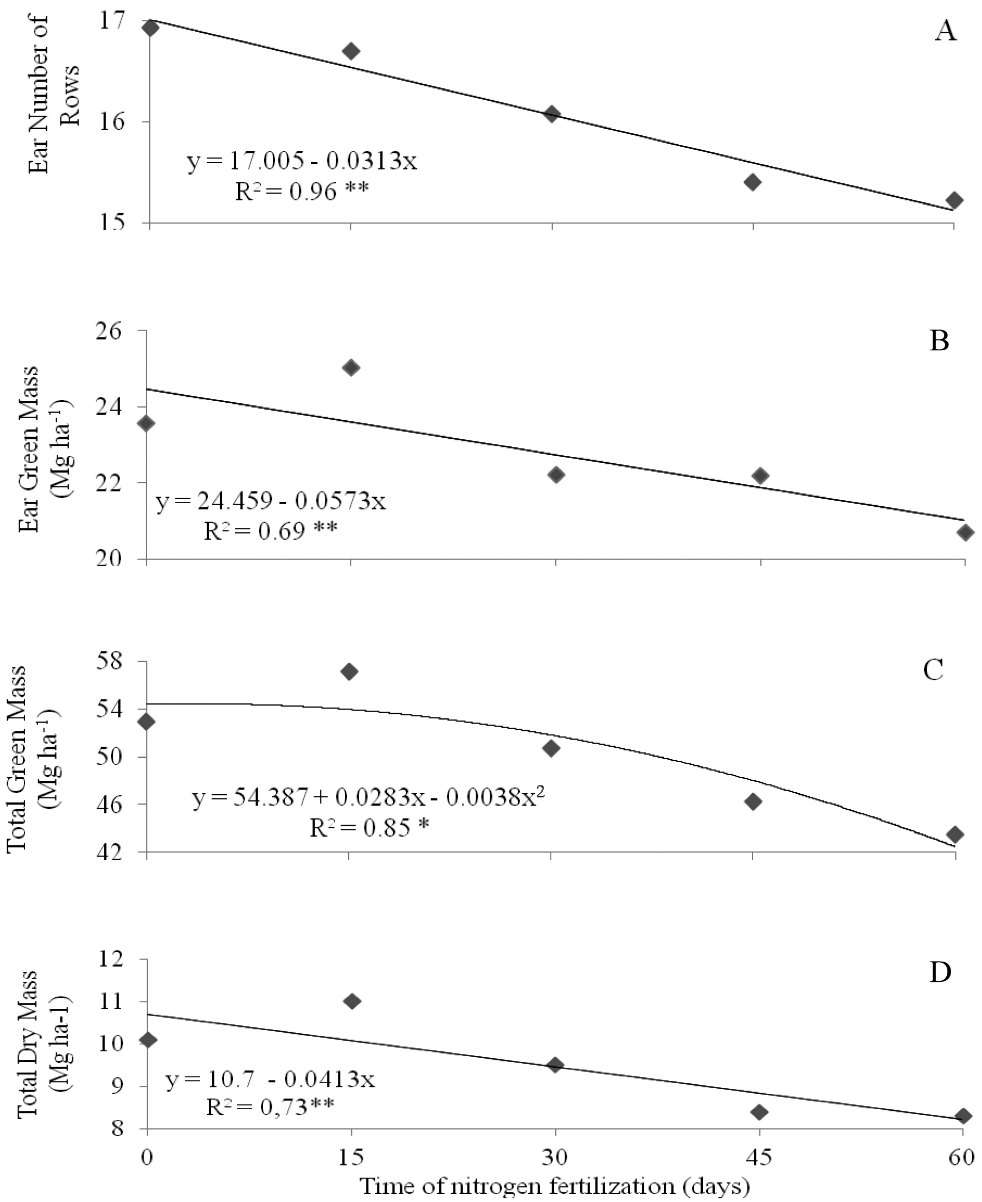

Figure 2. Number of rows per ear (A), ear green mass (B), total green mass (C) and total dry mass (D) as affected by timing of nitrogen fertilization. Palmeiras de Goiás, GO, 2013. (** and * significant at 1% and 5% level of probability, respectively).

Yield components help to identify conditions that may have hindered the proper plant development, especially when they occur in plant stages where its productive potential is being defined. Maize potential production is set in the early stages of plant development, which corresponds to approximately 15 days (Magalhães & Durães, 2006). According to the quadratic equation fitted to the data of the total green mass of plants (Figure 2C), the critical period for realization of nitrogen fertilization for irrigated silage corn intercropped with Marandu grass is four days after sowing.

There was a linear increase in the development and production of Marandu grass grown in consortium with later application of corn nitrogen fertilization (Figure 3B). Possibly, the lower development of corn plants provided by the late application of sidedress nitrogen favored the light incidence between the maize lines and resulted in higher rates of forage growth, intensifying the competition between intercropped species. The combination of higher light incidence and nitrogen availability with established forage root system was probably important to the linear increase on the number of plant tillers (Figure 3A) and consequently greater dry mass production of Marandu Grass (Figure 3B), depressing the silage corn yield potential even under irrigation.

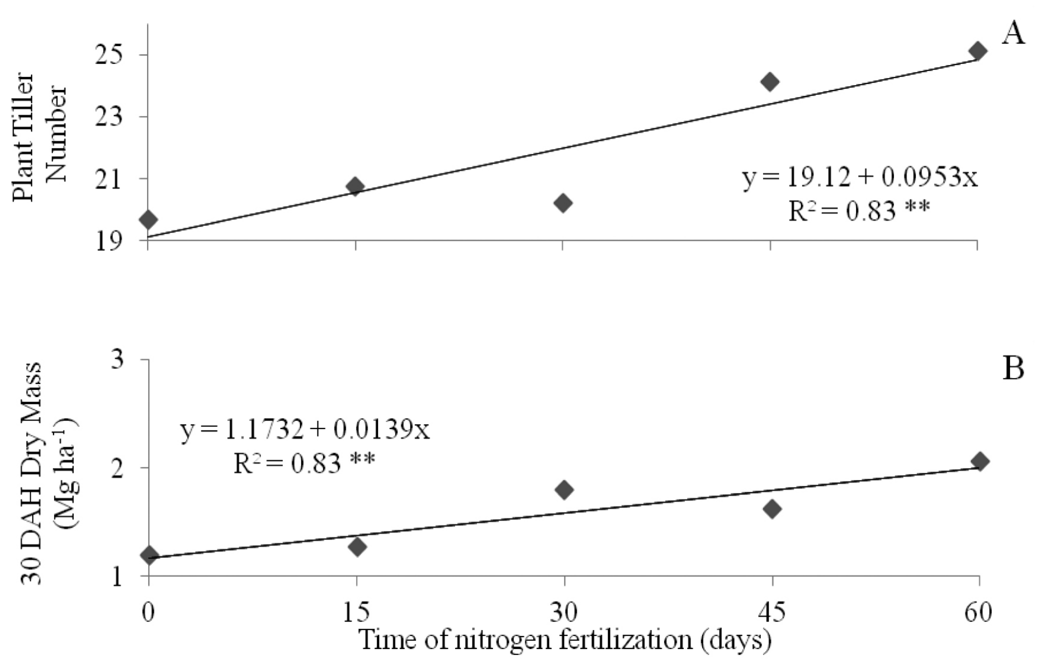

Figure 3. Plant tiller number (A) and 30 days after corn harvest (DAH) Marandu Grass dry (B) according to the timings of nitrogen fertilization. Palmeiras de Goiás, GO, 2013. (**significant at 1% level of probability).

Conclusions

Considering the conditions in which this research was carried out can be concluded that:

The simultaneous sowing of silage maize and Marandu grass intercropped, in irrigated system, favors the grass development and dry mass yield, reducing the yield of corn ear green mass and corn total dry mass.

The nitrogen fertilization after corn sowing reduces corn silage yield and favors the forage production of the intercropped Marandu grass.

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