Nitrogen fertilizations via leaf on soybean stages and nitrogen released on yield of off season maize

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Abstract. The objective of this study was to evaluate the residual effects of nitrogen (N) fertilization liberation of mulching soybean crop in the yield corn of-season. The sowed was the corn hybrid Land® in date 01/26/2017, of mulching soybean crop experiment, in Sinop-MT, Brazil. The experimental design was a randomized complete block with four replications with teen treatments. The treatments were: control without N application (only inoculated with *Bradyrhizobium japonicum e B. elkanii*) and the other treatments was applied the dose of 10 kg ha^{-1} of N in different phenological stages and modes of application (the cover in the sowing; in V2 the haul in coverage; in V2 via leaf; in V4 the haul in coverage; in V4 via leaf; at R1 the coverage haul; in R1 via leaf; in R2 the cover and R2 in the leaf). The traits components of the yield analyzed were: number of rows of grain, number of grains per rows, the thousand-grain weight and yield grains. The mineralization of the nitrogen provenient of mulch the soybean crop is not sufficiency for corn off-season crop. The application of nitrogen in the stages V2 and R1 in coverage in the soybean predecessor crop provided the highest values to yield grains of the maize off-season crop.
Keywords: *Zea mays.* Mineral Nitrogen. Leaf fertilization. Demand of nitrogen in maize. Mulching of soybean crop.
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Introduction

The State of Mato Grosso stands out in the production of grain corn, under second crop climate environmental conditions ("safrinha") in succession mainly after the early soybean crop. It is the state that has the largest increase in corn production second crop, which was 64% higher than in the 2015/16 crop, from 15 million tons to 24.7 million in the 2016/17 crop, a fact justified by the cultivated area and productivity achieved. Mato Grosso is responsible for almost 40.5% of corn production under second crop conditions in Brazil (CONAB, 2017).

Corn cultivation Second crop in succession early soybean cultivation is a common practice in the state of Mato Grosso, which allows intensive use of soil, labor, farm machinery, and promotes the rotation / succession of legumes with grasses, while maintaining mulch in the soil, with reductions in pests and diseases for crops. In addition to soil conservation, soil mulch has an effect on maintaining / increasing soil organic matter and releasing nutrients from soybean mulch, especially nitrogen (Torres et al., 2005; Torres et al., 2008).

Among the nutrients present in soybean straw used by second crop corn, nitrogen stands out, which is the nutrient most demanded in greater quantity by both crops. The corn crop responds to high doses of this nutrient, and it is recommended to use cover crops such as crotalaria and crotalaria + millet as predecessors associated with the application of 120 kg ha-1 in cover, which increases production costs (Kappes et al., 2013). Thus, in the decision making of the use of nitrogen fertilization should be considered: the cropping system (direct sowing), sowing time (second crop), crop rotation and nitrogen sources, among others, emphasizing that the application recommendations of N should be specific and not generalized (Chagas et al., 2007).

The establishment of cover crops for the formation and maintenance of crop residues on the soil surface, especially in the Cerrado regions, has encountered some obstacles, as climatic conditions in these regions favor the decomposition of plant residues. The maintenance of soybean vegetable

residues on the soil for the use of second crop corn crop is of paramount importance for nutrient cycling. However, depending on the management of these residues, leaving them on the surface or incorporating them into the soil, and depending on the climatic conditions of the region, will result in different rates of decomposition and release of nutrient amounts to the soil (Pacheco et al., 2011).

However in general the crop management of second crop corn should be improved to obtain increases in crop yield and yield. In view of the above, the objective was to verify the effect of nitrogen (N) released by the early soybean straw, inoculated as a function of N rates and application rates on the yield components and grain yield of second crop corn in succession to early soybeans.

Methods

The experiment was carried out in a commercial area cultivated in minimum cultivation system for more than five years, from February to July 2017, in the municipality of Sinop (MT). The experiment site is located at latitude 11º57'05 " S and longitude 55º 23'51 " O and average altitude of 380m with flat topography. The climate according to Koppen is rated Aw, having two well-defined seasons, one rainy between October and April, and another drought from May to September, with low annual temperature ranges from 24 to 27 ° C, the average annual rainfall. of the region is around 2100 mm (GARCIA et al., 2013). The climatological data of the experiment conduction period between January 26, 17 and April 27, 17 are presented in Figure1.

Soil collection was carried out with the aid of a Dutch auger in the 0 to 20 cm deep layer, and subsequent chemical analysis of the soil in the laboratory. The chemical analysis of the soil obtained the following results: pH (CaCL2) 5.1; M.O .; 18.55 g / dm³; P (Melich); 6.07; K, 52.00 mg / dm³; Mg; 0.93; S; 0.40; Al; 00; H; 2.92; CTC pH 7.0; 6.82 cmol / dm³; V% = 57.2; Ca / Mg relation; 3.05; Ca / K; 21.85; Mg / K; 7.16. The micronutrient values in mg dm³ were: Zn; 5.51; Ass; 0.44; Faith; 199.16; Mn; 11.25; B; 0.15. The physical analysis of the soil obtained the values: Sand; 497; Silt; 125; Clay; 378, in g dm-³ respectively.

With the result of soil analysis, it was observed that the base saturation is in accordance with the crop requirement and liming was not necessary. In pre-planting, fertilization was carried out with 500 kg ha-1 of the formulated 00:18:18, according to the producer's management, supplying phosphorus and potassium to soybean. The soil of the region is classified as Red Yellow Latosol (SANTOS et al., 2013).

The experimental design was a randomized block design (DBC) with four replications and ten treatments, totaling 40 plots. The treatments were: control without N application (only inoculated with Bradyrhizobium japonicum and B. elkanii). For the

other treatments, the dose of 10 kg ha-1 of N (Urea 45% N) was applied, corresponding to 22.5 kg ha-1 of urea at different times (phenological stages) and methods of application: the haul in coverage at sowing; in V2 at hedging; in V2 via leaf; in V4 at hedging; in V4 via leaf; in R1 at hedging; in R1 via leaf; in R2 to cover and in R2 via leaf.

The experimental plots consisted of four cultivation lines and five meters in length, totaling 10m². We considered the useful area of the plot for the two central lines and four meters in length, totaling 4 m². As a border, half a meter was discarded at each end of the plots and the two lateral lines (border). The soybean cultivar sown before the second crop corn crop was TMG 132 RR, at a density of 15 seeds per meter, aiming to obtain an average population of 260,000 plants ha-1. Prior to sowing of soybean, seed treatment (TS) was performed by applying Fipronil-based insecticide of the pyrazole group, and the fungicides Piraclostrobin of the strubirulin group and Methyl Thiophanate of the benzimidazole group at a dose of 2 mL kg. [-1] seed. Cobalt and molybdenum micronutrients were also applied in the proportion of 5 g Co and 42 g Mo to increase nodulation efficiency (Almeida, 2011). Prior to sowing the seeds were inoculated with Bradyrhizobium japonicum peat inoculum, strain SEMIA 5079 and 5080, minimum rhizobia concentration 7 x 109 cells / g, dose 200 g ha-1, and in liquid form, dose 200 mL ha-1 with 5 x 10 9 cells/mL rhizobia concentration of Bradyrhizobium elkanii, strain SEMIA 587 and 5019. Mixing was performed in polyethylene bags until complete inoculant was mixed in the seed.

The cultural treatments followed the recommendations and were performed by the producer according to the soybean crop requirement. To control the rust four fungicide applications of the chemical group (Strobirulina and Triazol) and (Trifloxystrobin and Protioconazole) were applied, along with the second fungicide application, the micronutrients Mn, Mo were applied via leaf.

Before sowing, weed desiccation was carried out with 1.5 kg ha-1 glyphosate (granulated) and after emergence, at 30 DAE an additional 1.5 kg ha-1 glyphosate was applied, with 100 L ha-1 spray volume with the aid of a tractor-mounted drag sprayer. Weed control occurred within the recommended period, from germination up to thirty days after planting, considered a critical period of competition between the crop and the weeds.

The Land® corn hybrid was shown on January 26, 2017 in succession and after the early soybean harvest, in order to evaluate the residual N from the treatments after its early soybean harvest. In the fertilization of sowing of corn second crop, the dose of 30 kg ha-1 of N was used; 98.4 kg ha-1 P2O5 and 52.5 kg ha-1 K2O, according to the results of soil analysis and the expectation of good yield of corn

crop. Nitrogen was applied by hand and the source used was urea (45% N) at a dose of 30 kg ha-1.

The harvest was done manually, on 06/25/2017, where the ears were threshed with the help of a manual thresher. After harvesting, the number of rows of grains, number of grains per row and the mass of one thousand grains obtained from six representative ears of the plants of each useful portion of the treatments were counted. At harvest the grains were with approximately 180 g kg-1 of water, the samples were placed in bags, made to the markings of the treatments and taken to the UFMT campus Sinop Soil Laboratory, where they were threshed with the help of a manual thresher. After threshing, samples of approximately 200

grams of grains placed in properly identified paper bags were collected from the grain mass. The grain moisture was then corrected to 130 g kg-1 water in a forced air oven at 60 ° C.

Grain yield was quantified by weighing the grains of the useful area of each plot on a Fillizola® precision scale with subsequent moisture correction to 13% and was converted to the kg ha-1 unit.

The data obtained were submitted to analysis of variance (ANAVA) at the 5% probability level by the F test, with the aid of the SISVAR statistical program (Ferreira, 2011). The means were compared by the Skott-Knott test at 5% probability.
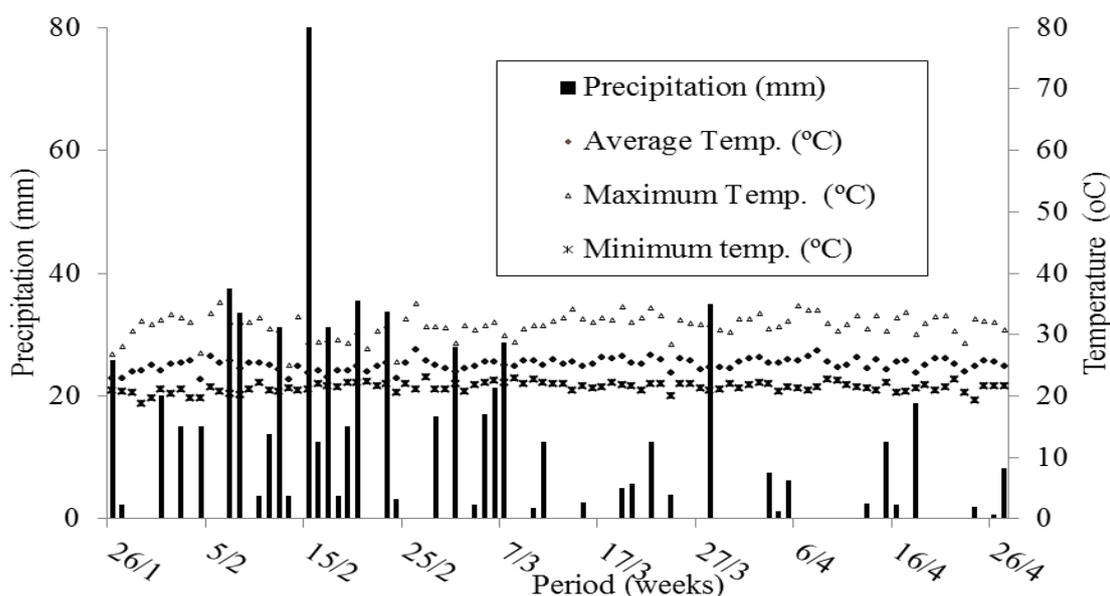

Figure 1. Rainfall (mm) and minimum, average and maximum temperatures (ºC) per week during the experiment period. 2016/2017 Harvest. Sinop - MT.

Results and discussion

The application of treatments of N modes and application in the predecessor soybean crop did not statistically influence yield component characteristics such as number of grain rows, number of grains per row, weight of one thousand seeds and corn off season crop yield second crop (Table 1).

For the number of grains rows (NGR), there was no significant effect for the tested treatments, and the average values obtained ranged from 18.50 in the control (Without N applied in soy) to 21.25 rows of grains (N applied in R1 via soybean leaf).

Biscaro et al. (2011) also observed no difference in number of rows evaluating N rates for off-season corn. The same fact occurred for the number of grains per row, where the values ranged from 23.75 in the control (No N applied in soybean) to 28.50 grains per row (N applied in V2 coverage), where there was no also statistical differences between treatments of soybean nitrogen fertilization in second crop corn.

Results obtained by Cadore et al. 2016, where the nitrogen rates in the cover generated significant increases in relation to the non application of N, but there was no significant difference in the number of grains per row. These ear-related data do not corroborate only with Carmo et al. (2012), who described positive linear equations in response to increasing nitrogen doses and verified increases in ear length and grain number per row.

Among the nutrients required by corn crop, nitrogen (N) is the one that most limits its growth, besides being required in greater quantity. N is a constituent of proteins, nucleic acids and other cellular constituents, as well as membranes and various plant hormones. Thus, its deficiency can cause widespread chlorosis of the older leaves and decrease in plant growth. Its most common absorption by corn is in the form of nitrate (NO_3^-), due to the nitrification process of N that occurs in the soil (Souza & Fernandes, 2006).

For the number of grains per row (NGPR), there was no significant effect for the tested treatments, and the average values obtained ranged from 23.75 in the control (Without N applied in soy) to 28.50 of grains per row (N V2 coverage).

According to Malavolta (2006), N is an element involved in the synthesis of chlorophylls and protein compounds, presenting potential to increase the ability of plants to produce reproductive buds. In the present study, the low N rate applied in different soybean stages 10 kg ha^{-1} N was not sufficient to generate increases in characteristics number of grain rows (NGR) and number of grains per row (NGPR) compared to control without N.

Table 1. Means of variables analyzed at harvest at physiological maturity: number of grain rows (NGR), number of grains per row (NGPR), one thousand seed weight (OTSW) and grain yield (GY), under different forms and times of application of 10 kg ha-1 of nitrogen. UFMT. 2016/2017 Harvest, Sinop - MT.

Treatments:	Traits			
	NGR	NGPR	OTSW (g)	GY (kg ha^{-1})
Without N	18.50 a	23.75 a	230.15 a	5224.00 a
N sowing	19.00 a	26.00 a	236.83 a	5858.00 a
N V2 cover	19.75 a	28.50 a	261.11 a	7019.00 a
N V2 leaf	20.25 a	28.12 a	288.38 a	7299.00 a
N V4 cover	19.25 a	27.50 a	255.86 a	6598.00 a
N V4 leaf	18.75 a	27.75 a	240.35 a	5678.00 a
N R1 cover	20.75 a	28.12 a	260.90 a	6912.00 a
N R1 leaf	21.25 a	28.37 a	280.03 a	7491.00 a
N R2 cover	19.50 a	26.00 a	254.40 a	5904.00 a
N R2 leaf	19.75 a	26.25 a	254.55 a	5924.00 a
Means	19.67	27.04	256.25	6390.70
C.V.	8.14	12.64	10.01	19.95

* Means followed by the same letters do not differ from each other at the 5% probability level by the Scott-Knott test.

For the variable of one thousand weight seeds (OTSW), it was found that the application of N in different modes and forms in the previous soybean crop ranged from 230.15 (No N applied to soybean) to 288.38 grams (N applied in soybean leaf V2) with an average of 256.25 grams and there were no statistical differences between treatments in different modes and forms of N fertilization in the previous soybean crop over the variable in the second crop corn crop.

Similar results that collaborate with the results obtained in the present study where there were no differences between the control without N and the evaluated treatments were obtained by other authors such as Chagas et al. (2018) did not find differences for the mass of one thousand grains in the N rates under cover in the two-year experiments with late sowing in December and January, respectively, even in the highest at 180 grams. Although there were no statistical differences, numerically between the values for the weight of one thousand grains in the tested hybrids, they were observed within each N dose (high and low), where the heaviest grains were obtained with

the highest nitrogen doses in both hybrids harvests evaluated. The one thousand weights of seeds is considered one of the maize yield components, and it is expected that in plants submitted to adequate nitrogen doses, this variable will be higher.

However, Floss (2004) observed for most of the evaluated hybrids that the nitrogen rates used in the study did not influence the mass of one thousand grains. According to the author, hybrids differ in nutritional requirement and genetic characteristics. The weight of one thousand grains depends on the genetic potential of each cultivar, which determines the functioning of the photosynthetic apparatus of the upper parts of the plant, the transferability of the assimilated photos to the grains during the grain filling period, the climatic conditions that occurred during the grain filling phase (humidity and temperature) and the occurrence of diseases (especially in the leaves and ears / tassels) and pests.

Regarding grain yield (GY) of corn, it was found that although treatments with N fertilization in soybean obtained higher values in this variable compared to control without N in soybean, there were no significant differences between treatments that varied from 6858 (control without N) at 7491 kg ha^{-1}, with an average of 6390.7 kg ha^{-1}. These values are considered high for the region where the experiment was conducted considering the second crop weather conditions and the average yield of second crop corn in Brazil (CONAB, 2017).

These yield values of second crop maize grains may be due to adequate rainfall during the critical period of grain yield (grain filling), soil fertility conditions that had good nutrient levels and maize planting and mulching, as well as residual N from soybean mulch.

According to Fumagalli et al. (2017), when defining the number of eggs and ear size (stage V12), moisture and nutrient deficiencies can seriously reduce the potential number of seeds and ear size harvested, which explains the shorter length of ears and lower yields of second crop maize compared to first crop maize.

Although no significant differences occurred, the application of nitrogen at stages V2 and R1 in cover or via leaf in the predecessor soybean crop provided the highest yield values of second crop corn. The results of the present study corroborate those obtained by other authors such as Souza et al. (2003), who also had no response in corn grain yield to the application of 0 to 120 kg ha of N in cover.

However, Rezende et al. (2003) observed that the increase in grain yield, both for row spacing and / or better plant density, depends on the climatic conditions of the crop year. The spacing of 0.80 m between rows, the population density of 40.000 plants ha and without nitrogen fertilization led to lower grain yield (6.048 kg ha^{-1}). Caione et al. (2016) found that the maximum corn yield occurred with application of 180 kg ha-1 of N. In a study of

nitrogen fertilization in corn crop, Araújo et al. (2004) observed a 28% increase in grain production and 37% in dry phytomass production compared to non-application of nitrogen, with the highest productivity and phytomass achieved at 240 kg ha-1.

Although no significant differences occurred, the application of nitrogen in the predecessor of soybean to second crop corn, obtained higher values in the characteristics evaluated compared to the control without N. Probably the low doses of mineral nitrogen generated by the modes and forms of nitrogen fertilization of the crop. soybean and N release by their straw, but the low N rates used in the second crop maize and planting fertilizers were not enough to generate second crop corn yield responses.

Fornasieri Filho (1992) reported that, in soils with adequate availability of organic matter and under the favorable occurrence of rainfall, the effects of nitrogen fertilization are, as a rule, little pronounced.

Research results in the country show that second crop corn has yield potential greater than 7000 kg ha^{-1} grown or not in succession to soybean (Duarte, 2013; Sichocki et al., 2014; Silva et al., 2015; Fiorini et al. 2015). Further studies on the effect of residual N from soybean fertilization on second crop maize production in different locations, climate conditions, soil types with different hybrids, and N rates on predecessor soybean crop are needed.

Conclusions

The application of nitrogen fertilization with 10 kg ha^{-1} of N under different modes and forms of application in the predecessor soybean crop was not sufficient to generate increases in the component characteristics of second crop corn yield (number of grain rows, number of grains per row, one thousand seed weight and grain yield).

Fertilization with nitrogen application in the predecessor soybean crop obtained higher values in the yield characteristics of second crop corn compared to control without N.

Nitrogen fertilization in soybean predecessor crop at V2 and R1 stages under cover or via leaf in soybean predecessor crop yielded the highest yield values for second crop corn.

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