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Growth and yield of baby corn as influenced by nitrogen topdressing

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Baby corn maize (*Zea mays* L.) is a highly profitable alternative to farmers due to its short crop duration, being harvested at the juvenile stage. It demands large amounts of nutrients in a short time, especially nitrogen, which is responsible for the rapid development of crop. This study aimed to evaluate the effect of topdressing application of different doses of nitrogen on the vegetative and spikelet productivity features in the baby corn crop in Janaúba - Minas Gerais. The experiment was laid out in randomized block design with three replications and four treatments. The treatments comprised four doses of nitrogen (0, 40, 80 and 120 kg ha^{-1} N applied as urea) top dressed at the V6 (sixty leave with visible auricle) growth stage, which occurs 30 days after sowing the seed. Nitrogen topdressing doses did not interfere in vegetative characteristics of baby corn cultivar Al Bandeirante, but the productivity of spikelet responded to the increasing doses of nitrogen, being the highest productivity at a dose of 120 kg ha^{-1} N.

Key words: Fertilizer, urea, *Zea mays* L., fertilization, yield components

INTRODUCTION

Maize (*Zea mays* l.) in Brazil is one of the main cereals grown and consumed, being one of the most important crops in the world. The country is the third largest corn producer in the world, with a production of 84,67 million tons of grains in the 2014/2015 crop (CONAB, 2015), being surpassed only by the United States and China (FAO, 2013). These tree countries represent 70.11% of world production.

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Table 1. Results of the chemical analysis of 0-20 cm layer of Fluvisoil, before the crop establishment.

Depth	[1] Ph	MO [2]	P [3]	K [3]	Ca[4]	Mg[4]	Al[4]	H + Al[5]	SB	V	EC	Prem[5]
cm	Dag kg^{-1}		mg dm^{-3}		------------cmol$_c$ dm^{-3}-------------					%	DS m^{-1}	mg L^{-1}
0-20	6.5	2.1	17	123	3.6	1.7	0	1.4	5.7	81	0.4	43.9

[1]pH in water; [2] Colorimetry; [3]: Mehlich Extractor-1; [4] Extractor: 1 mol KCl L^{-1}; [5]SMP, pH [5]Solution equilibrium of Fr. Prof., sample depth; SB, sum of Bases; V, saturation by bases; Prem, remaining Phosphorus; EC electrical conductivity.Dag kg^{-1} =%; mg dm^{-3} = ppm; cmol$_c$ dm^{-3} = meq 100 cm^{-3}.

Corn offers a wide range of colors and formats. Among them, there is the baby corn, which is the "young corn cob" It is a small young corn ear harvested at the stage of silk emergence (Pereira Filho et al., 1998; Almeida et al., 2005). According to Hardoim et al. (2002) the baby corn is a highly profitable alternative for farmers and can generate a net profit of up to 400% of the amount invested, mainly for those framed as family farming.

Studies carried out by Sahoo and Panda (1999), Verma et al. (1998), Thakur et al. (1997), Faiguenbaum and Olivares (1999) and Kotch et al. (1995) showed good yields of commercial baby corn, which depends on the cultivar used and soil fertility conditions.

The factor "mineral nutrition" is important for obtaining high rate of productivity. Despite the higher plant population density of the of baby corn, usually the fertilization is carried out according to the recommendations to regular corn (Fancelli and Dourado Neto, 2007). The maize demand for nitrogen (N) is a result of its structural function, because it is part of molecules of organic compounds, such as amino acids and proteins (Malavolta, 2006).

In a study conducted by Santos et al. (2014), in southern Brazil conditions, the maximum baby corn yield in the summer crop was obtained with the application of 64.35 kg ha^{-1} of nitrogen. In India, Golada et al. (2013) observed that the application of 90 kg ha^{-1} promoted the highest baby corn yields.

As the efficiency of the use of nutrients varies according to the culture and environmental factors, it is necessary to determine the nitrogen doses that promote the maximum baby corn yield in different regions.

This work aimed to evaluate the effects of topdressing application of different doses of nitrogen on the vegetative characteristics and yield of spikelet baby corn crops in Janaúba-MG.

MATERIALS AND METHODS

The experiment was conducted at the Department of Agricultural Sciences, of the State University of Montes Claros, Janaúba, which is situated a 15°49'48,05'' S and 43° 16 ' 7.48''. According to Köppen (1948), the climate in the region is semiarid is tropical with dry winter, classified as AW. The mean annual precipitation is 900 mm and the mean temperature is 25°C. The soil of the experimental area is classified as a Fluvisoil (EMBRAPA, 2013). The results of the chemical analysis of soil samples conducted at EPAMIG in Nova Porteirinha prior to the installation of the experiments can be found in Table 1.

The corn cultivar used was Al Bandeirante, originated from random crossing of cultivars of normal cycle. The experiment was conducted during the period March/June 2014, being the lines arranged every two and four meters between microsprinklers with flow rate of 100 Lh^{-1}.

The experiment was laid out in randomized block design with three replications and four treatments. The treatments comprised four doses of nitrogen (0, 40, 80 and 120 kg N ha^{-1} applied as urea, with 48% of N) top dressed at the V6 growth stage, which occurs 30 days after sowing the seed.

The experimental plots were composed of three lines of planting spaced 0.8 m among themselves and 3.0 m in length, totaling 7.2 m^2. In data collection were discarded both sidelines and 1.0 m from each side in the direction of its length, totaling 0.8 m^2 of useful area. The seeding was done manually at a density of 15 plants m^{-1} totaling 186567 plants ha^{-1}.

Synthetic fertilizer potassium topdressing application was performed at the V6 growth stage, calculated in accordance with the chemical characteristics of the soil and taking into account the recommendations of Ribeiro et al. (1999) for corn growing. It was applied 13 g m^{-1} of potassium chloride (KCl) in all different treatments. During the crop development, the mechanical control of weeds was performed with hoe between rows, an manually between plants.

The harvests were carried out in the late afternoon, to avoid possible moisture loss of the spikelet. The first one was held seven days after the appearance of the tassels, defaulting as the harvesting point when the spikelets present between 4 to 10 cm long and the diameter of 1.0 to 1.5 cm, cylindrical shape and coloration ranging from pearly white to cream, according to Ritchie et al. (2003) and Hardoim et al. (2002). Generally, this occurs two to three days after exposure of styles-stigmata that have around 2.5 cm long. Thus, the harvest began 63 days after sowing, totaling five harvests every three days. Once harvested, the spikelet were placed in plastic bags, and subsequently forwarded to the Laboratory of Hydraulics and Hydrology of the State University of Montes Claros *Campus* Janaúba- Minas Gerais, where corn mass with and without straw straw was measured. The vegetative and reproductive variables evaluated were:

Height of plants: verified on the occasion of the full flowering, when 90% of the plants have issued tassel, measured through the culm length (the surface of the ground to the base of the male inflorescence-"tassel").

Culm Diameter: the determination was done on the occasion of full flowering. It was determined at 10 cm height, being the soil as a baseline, from the five plants, which were measured through the use of an electronic caliper.

Number of sheets per plant: obtained in full bloom by the count of all the leaves fully expanded and deployed, being considered five plants per plot.

Internodes number: obtained in full bloom by the count of all

Table 2. Summary of the analysis of variance for the effect of doses of nitrogen topdressing on the plants height variables (AP), culm diameter (DC), number of leaves (NC), internodes number (NIT), transverse diameter (DT), SPAD reading (SPAD), straw (PP) productivity, productivity without straw (PS), baby corn yield (RD).

Features	Medium squares of treatments		Average	CV_{and} (%)	Accuracy	Accuracy (%)
AP	439.73	NS	167.92	9.89	0.61	37.27
DC	0.90	NS	12.91	7.15	0.23	5.44
NF	1.59	*	12.68	4.74	0.88	77.32
NIT	1.59	*	12.68	4.74	0.88	77.32
DT	21.14	NS	92.87	4.66	0.34	11.29
SPAD	156.50	**	37.51	9.35	0.96	92.14
PP	12660020.80	**	5792.27	20.16	0.94	89.23
PS	2841682.06	**	2050.67	22.22	0.96	92.70
RD	76.40	**	34.70	8.56	0.94	88.44

(*Significant 5%), (**) 1% and significant (^{ns}) is not significant, for the F-test; AP (cm), DC (mm), NF (und), NIT (und), DT (cm), SPAD (g.cm μ^{-2}), PP (kg/ha), PS (kg/ha), RD (%).

internodes or stalk present in a plant, being considered five plants per plot.

Cross-section: verified on the full flowering, measured by the ends of the plant towards the rows, using measuring tape, being considered five plants per plot.

SPAD reading: when the plants were in full bloom, readings were performed using the portable meter of chlorophyll SPAD-502 (Soil-Plant Analysis Development (SPAD) Section, Minolta Camera Co., Ltd, Japan). Measurements with the SPAD were performed at the fifth corn leaf downwards. Evaluations were carried out in five plants per plot, being three readings by leaves.

Mass of spikelet with straw: obtained by weighing on digital scale semi analytical of all commercial spikelet with diameter ranging between 0.8 and 1.8 cm and length between 4 and 12 cm, cylindrical shape and spikelet non-fertilized in the parcel. Every spikelet harvested in useful areas was weighted with straw. The data of commercial spikelet weight were transformed into kg ha^{-1}.

Mass of spikelet commercials without straw: The same process used for mass of spikelet with straw was performed. Every spikelet harvested in useful areas was weighted without straw. The data of commercial spikelet weight were transformed into kg ha^{-1}.

Baby corn yield: Obtained by the equation: (PS * 100)/PP

PS = productivity without straw
PP = productivity with straw

Experimental accuracy was evaluated by estimation of the accuracy by Resende and Duarte (2007), given by the estimator:

$$\hat{r}_{\hat{g}g} = \left[\frac{1}{1+\left(\frac{CVe^2}{CVg^2}\right)/r}\right]^{\frac{1}{2}}$$

Where, $\hat{r}_{\hat{g}g}$ is the experimente accuracy; CVe^2 is the square of the experimental variation coefficient; CVg^2 is the square of the coefficient of genetic variation e r corresponds to the number of repetitions.

The data were subjected to analysis of variance using the statistical program GENES ® (Cruz, 2013) and, when the F was significant to the level of 5%. For the variables that presented significance, a regression analysis was performed according to the nitrogen doses used.

RESULTS AND DISCUSSION

The quality of an experiment is usually measured by experimental Coefficient of Variation (CV_{and}). The values of CV_{and} in all the variables (Table 2) were within the limits reported in the literature (Pizolato Neto et al., 2016; Silva et al., 2013, 2016; Souza et al., 2016), what guarantees a good accuracy in the experiment.

However, the CV_{and} is not best suited to assess the accuracy of a study, since its estimates considers only the residual variance as a proportion of the average of the experiment (Resende and Duarte, 2007). The measurement of accuracy ($\hat{r}_{\hat{g}g}$) is best suited to determine the accuracy of an experiment, since the accuracy depends on the magnitude of the residual variation in the number of repetitions, the proportion between the variations of residual nature and the treatments associated with the character in evaluation (Resende and Duarte, 2007). The accuracy is estimated to be between 0 to 1, the closer to 1 the more accurate is the experiment.

In the present work, except for the variables height, diameter and transverse diameter culm, the accuracies estimated ranged from high (> 0.70) to very high (> 0.90) (Table 2) showing that there is a good experimental precision, according to the values recommended by Raj and Duarte (2007). The good accuracy presented in this work leads to the conclusion that the casualization of the blocks and the number of repetitions allowed the reduction of environmental heterogeneity in the study, and verify the influence of doses of nitrogen topdressing on the agronomic performance of baby corn.

There was no significant difference (P > 0.05) for the

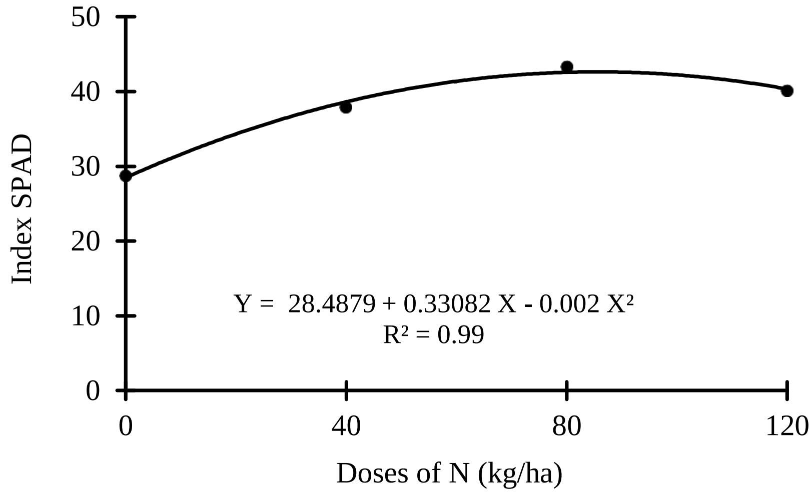

Figure 1. SPAD index in baby corn submitted to different doses of nitrogen topdressing. **significant at the 1% level, by t.

variables, height of plants, culm diameter and cross-section for the different doses of nitrogen (N) (Table 2).

The plant height considered great for easy harvest of baby corn varies between 1.9 and 2.5 m (Rodrigues et al., 2004). In the culture of baby corn, the largest height of plants combined with the use of high densities is considered a negative factor on productivity, because it favors plant bedding The average height of the plants in this experiment was 1.68 m. This low height of plants can be related to the density of the experiment (186567 ha^{-1}plants) and/or cultivar Al Bandeirante for being a rustic breed from random breeding of cultivars of normal cycle after several generations of mass selection and recombination between families of half-siblings.

This work corroborates with Pereira Filho et al. (2005), which did not observe significant differences in culm diameter with increasing nitrogen doses. The culm diameter is a very important variable, as it is directly related to plant bedding, an undesirable process in baby corn crops.

There was significant effects between doses of N topdressing for SPAD index (Table 2), and with quadratic effect according to the doses of N (Figure 1). 82 dose, by ha^{-1} N provided the highest SPAD which corresponded to 42.17 µ g cm^{-2} sheet.

The chlorophyllmeter does not detect the luxury consumption of N (Blackmer and Schepers, 1994), that is, when working with high doses of N, the index SPAD on the sheet tends to increase up to a point, called a photosynthetic maturity point (Costa et al., 2001), from which remains invariant, while the N content continues to increase with increasing doses of this nutrient (Schepers et al., 1992). This can be attributed to the fact the device detects, indirectly, increasing N only when being incorporated into molecules of chlorophyll and not free, nor incorporated ($N^{-}in_3^{-}$), in which the N accumulates when there is luxury consumption (Larcher, 2005).

In full bloom, the chlorophyllmeter reading values were lower than those considered appropriate µ g 58.0 cm^{-2}. In all treatments, results reflect the insufficient level of N in plants. However, the application of N in this growth stages very efficient, because the greatest demand for this nutrient occurs about two to three weeks before flowering, that is, usually 95% of period total N of the plant had already been absorbed (Plénet and Cruz, 1997).

Argenta et al. (2002) highlighted the possibility of inferring on the nutritional status of N on corn from chlorophyllmeter readings. The feasibility of using this equipment for diagnosing nutrient deficiency and need for nitrogen fertilization is effective, especially when there is greater variation in the supply of N, whether in dose, installments and nitrogenous sources. Thus, with the use of the SPAD in the present study it was possible to verify the variation of the doses tested. In the Figure 1, one can verify that in the dose above 82, by ha^{-1} N, there was a decrease of N in foliage.

The productivity of baby corn with and without fall-winter crop straw was influenced by the application of N. There was increased productivity with high doses (Figure 2), being the highest productivity achieved at a dose of 120 kg N ha^{-1} , with 7815.06 and 3244.06 kg ha^{-1} of baby corn with straw and no straw, respectively. These results corroborate with Thakur et al. (1997) who, evaluating the effect of 4 doses (0, 40, 80 and 120 kg ha^{-1} of Nitrogen) in the culture of baby corn, observed that there was an yield increase at doses above 100 kg ha^{-1} N.

However, to decide the dose to be used it is interesting to note the economic feasibility, since the same varies throughout the year, depending on the market prices of baby corn and nitrogen fertilizer.

Significant yields of baby corn in India were obtained by Thakur and Sharma (1999) with the dose of 200 kg ha^{-1} of

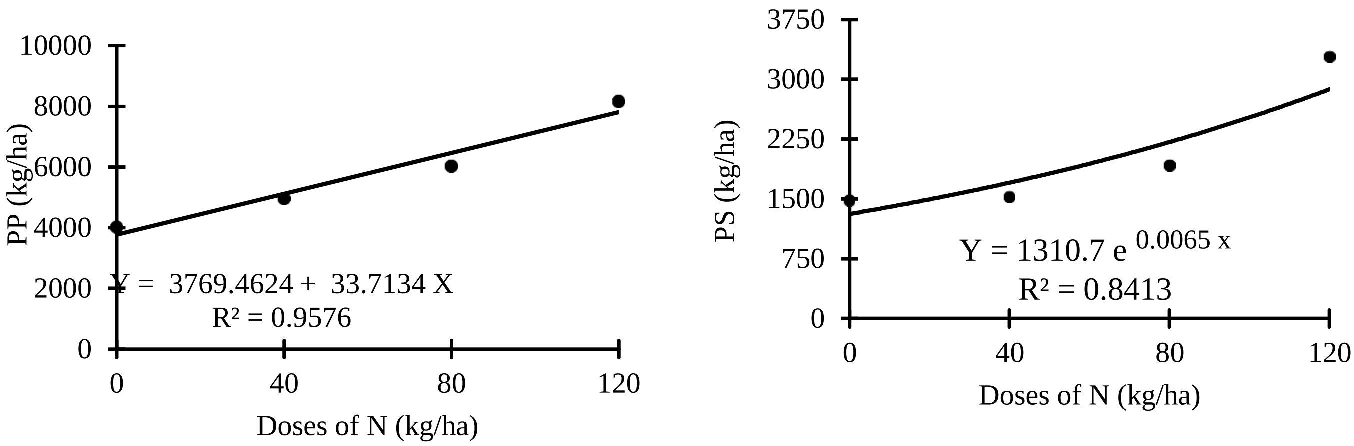

Figure 2. Productivity with straw (PP) and productivity without straw (PS) subjected to different doses of nitrogen topdressing.

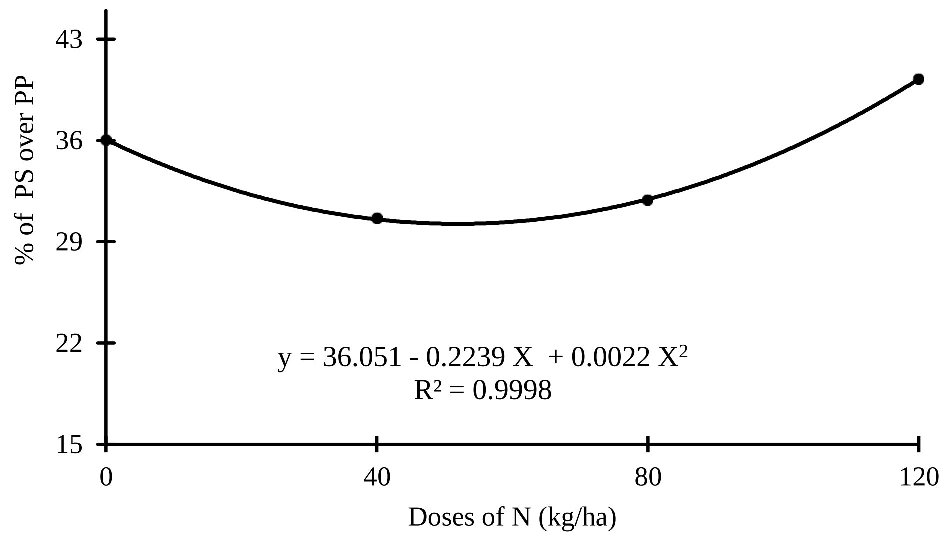

Figure 3. Baby corn yield, percentage of productivity without straw versus productivity with straw, subjected to different doses of nitrogen topdressing.

N applied in three equal installments, being one part when planting and the other two at 25 and 40 days after sowing. According to these authors, the increase of 100 to 200 kg ha^{-1} N promoted increase in yield of 10.26%, and between 100 and 150 kg ha-[1], there was no significant difference. Sahoo and Panda (1999), working with N doses 80, 120 and 160 kg ha^{-1} and three spaces, verified higher income at a dose of 120 kg ha^{-1} and density 125,000 plants per hectare.

High doses of N in baby corn crops, according to Miles and Zens (1997), are not necessary, since the baby corn is harvested before the processes of growth and grain filling. Such authors stress that doses of 30 to 50 kg ha^{-1} N plus phosphorus and potassium (K) are sufficient to obtain a good production, and that N plus K must not exceed 90 kg ha^{-1} in the planting furrows. Unlike that work, it was possible to observe a better yield with higher doses, because the plants, when grown in high densities, promote greater competition for nutrients in function of its rapid growth.

The baby corn yield response (percentage ratio of spikelet without straw production/spikelet with straw production) can be verified in Figure 3. The dose corresponding to the lowest yield was 50.89 kg ha^{-1} of N. From that dose there was yield increase, allied to yield without straw (Figure 2), and the highest proportion of spikelet without straw, 40.26% was obtained with the application of 120 kg ha^{-1} of N.

Silva et al. (2013) studying the effects of the application of doses of N on baby corn yield, obtained the best

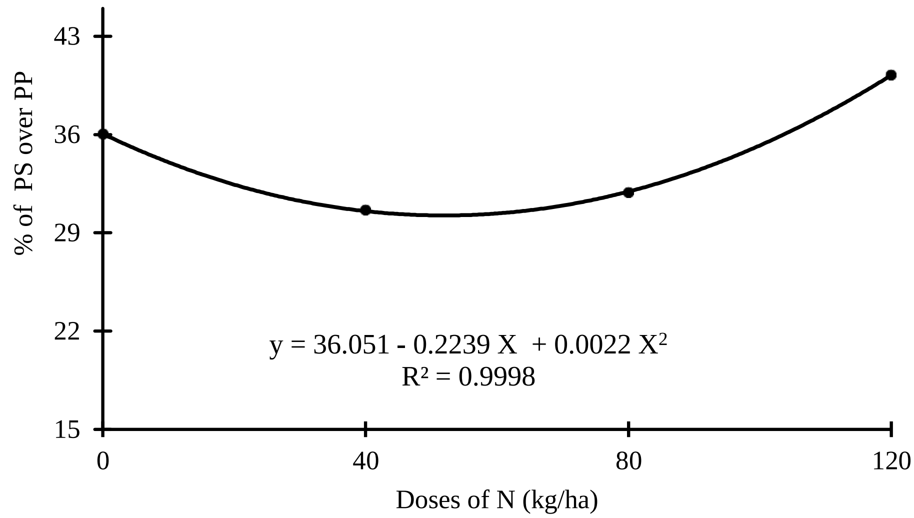

Figure 3. Baby corn yield, percentage of productivity without straw versus productivity with straw, subjected to different doses of nitrogen topdressing.

productive response and economic yield with the maximum dose of nitrogen (160 kg ha^{-1} N).

Conclusions

Nitrogen topdressing doses do not interfere in vegetative characteristics of baby corn cultivar Al Bandeirante, aside from the number of leaves and internodes, in Janaúba-MG.

The spikelet productivity baby corn crops responded to the increasing doses of nitrogen, being the highest productivity and yield of baby corn found at the dose of 120 kg ha^{-1} N.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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