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AGRONOMIC YIELD AND POST-HARVEST QUALITY OF BABY CORN UNDER NITROGEN FERTILIZATION

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Abstract – Baby corn is a growing crop in the agricultural setting, however there is still a lack of research in the area of fertilization, especially nitrogen fertilization. The objective of this study was to evaluate the influence of nitrogen fertilization on agronomic yield and quality of baby corn. Outlined in randomized blocks with four replications, the treatments consisted of five levels of nitrogen fertilization (50, 75, 100, 125 and 150%), based on the recommended dose for green corn crop (150 kg ha^{-1} of N). After harvesting, the following agronomic variables were evaluated: Number, productivity, dry matter, length and diameter of commercial and non-commercial spikelets. And the variables of post-harvest quality were: Soluble Solids, Titratable Acidity, Ratio of soluble solids and titratable acidity, Hydrogen-ion potential and firmness. Nitrogen fertilization at 150 kg ha^{-1} resulted in an increase in the total number of spikelets per hectare, around 405,000. There was an increase in productivity due to the increasing levels of nitrogen fertilization, with maximum yield of 4.4 t ha^{-1} at a dose of 165 kg ha^{-1} of N. The soluble solids content presented a maximum of 10.05 ° Brix with the N applied to 222 kg ha^{-1}. Nitrogen fertilization around 150 to 165 kg ha^{-1} increases the agronomic yield of the crop, without affecting its characteristics of quality.

INTRODUCTION

Baby corn is the name given to the female inflorescence of the corn plant, harvested before pollination, two days after the issuance of the stigmas. Its consumption has been growing in recent years, leading canning companies to increase their demand for this vegetable (Melo *et al*., 2014). However, the baby corn cultivation is considered a recent activity in the national agricultural scenario, as such, it lacks information to consolidate the phytotechnical management of the crop (Pereira Filho *et al.,* 2009).

Fertilizer adjustments, emphasizing the balanced use of nutrients, as well as sustainability in cropping systems are one of the main goals of modern agriculture. In this sense, researches related to the use of fertilizers in crops with little scientific investigation are necessary, such as baby corn. The requirement of corn crop by N is characterized by the functions that this nutrient performs, mainly because it is part of organic compounds such as amino acids and proteins. Nitrogen is related to plant growth and yield, mainly due to the development of reproductive drains, and constitution of chlorophyll molecule, with increase in photosynthetic rate, reflecting in higher dry matter contents (Basi *et al*., 2011).

Nitrogen fertilization is a hotly debated topic among growers, as the maize plant is responsive to N addition in the system (Corrêa *et al*., 2014). To set the optimal dose for maximum agronomic performance that is financially viable and sustainable is a determinative point. The mastery area of this management is challenging because the production cycle is shorter, about 60 to 75 days, and the grower objective is not the production of grains or larger ears, but a greater amount of spikelets within commercial quality standards. Thus, the objective of the study was to evaluate the agronomic yield and post-harvest quality of baby corn as a function of nitrogen fertilization.

MATERIALS AND METHODS

The experiment was conducted in the experimental area of Plant Science, on the campus of the State University of Montes Claros - UNIMONTES, located in the city of Janaúba – MG (15 ° 47’40 “S 43 ° 18’05" W, 515 m altitude, climate Aw according to Köppen), from june to august 2014. The soil of the area classified as Fluvic Neossol, it was prepared by plowing and harrowing in order to provide the best condition for root development. Before planting the area was in fallow.

In the initial phase of the study soil samples were collected at a depth of 0 - 0.20 m to characterize the chemical attributes as follows: Organic matter: 2.1 dag kg^{-1}; pH (water): 6.5; P (Mehlich 1): 17.0 mg dm^{-3}; K (Mehlich 1): 123 mg dm^{-3}; Na (Mehlich 1): 0.1 mg dm^{-3}; Ca: 3.6 $cmol_c$ dm^{-3}; Mg: 1.7 $cmol_c$ dm^{-3}; Al (KCl): 0.0 $cmol_c$ dm^{-3}; H + Al: 1.4 $cmol_c$ dm^{-3}; SB: 5.7 $cmol_c$ dm^{-3}; t: 5.7 $cmol_c$ dm^{-3}; base saturation (V%): 81%; B: 0.1 mg dm^{-3}; Cu: 1.9 mg dm^{-3}; Fe: 108.7 mg dm^{-3}; Mn: 54.1 mg dm^{-3}; Zn: 3.4 mg dm^{-3}; Prem: 43.9 mg L^{-1}; EC: 0.4 dS m^{-1}.

The experimental design was a randomized block, with four replications, the treatments consisted of five levels of nitrogen fertilization (50, 75, 100, 125 and 150% of N), in which the variations occurred around the recommended dose for green corn (150 kg ha-1 of N), considering the permanence of the rest of the plant in the area (Ribeiro *et al*., 1999).

The experimental unit consisted of four planting lines of two meters in length spaced half a meter between them, totaling an area of 4.0 m², with a population density of 200,000 plants per hectare. The useful area was represented by the central lines, with the extremes constituting the border. The seeds were obtained from Hybrid AG 1051, recommended for the local cultivation region.

Due to the chemical characteristics of the soil presented by the analysis, the application of 80 kg ha^{-1} of phosphorus (P_2O_5), 40 kg ha^{-1} of potassium (K_2O) and for nitrogen rates varied according to the treatments. The sources used were Single Superphosphate, Potassium Chloride and Ammonium Sulfate respectively, Phosphorus was applied at planting, and potassium and nitrogen were split into three applications, 20% at planting and the others under cover, when the plant reached five and eight leaves respectively. Micronutrient fertilization was carried out with 50 kg ha^{-1} of FTE BR 12 (3.9% S, 1.8% B, 0.85% Cu, 2% Mn and 9% Zn). Phytosanitary treatments and irrigation were performed according to the need and technical recommendations for the crop.

With the onset of female inflorescence emission (Stage R1), the harvest began, with frequency of two days, picking the spikelets with the red stigmas, defined as field harvest pattern, until no more spikelet emission in the plants.

After harvesting, the spikelets were husked and the agronomic variables evaluated: Total and commercial number of spikelets, total and commercial yield estimated at t ha^{-1}, dry matter of commercial and non-commercial spikelets, commercial and non-commercial diameter of spikelets and length.

To obtain the dry matter data, 10 spikelets were randomly selected from each experimental unit and sent to the forced-air oven at 65 ° C for 72 hours, where the constant dry weight was obtained. In a survey of local canned food companies, it was determined that commercial spikelets should have a median diameter of less than 20 mm, furthermore, these should not be with evidence of fertilization, or physically damaged.

After agronomic evaluations, spikelets were evaluated for post-harvest quality. The soluble solid content was determined by a digital refractometer with a scale from 0 to 45 ° Brix (AOAC, 2005). The acidity was determined by titration and the results were expressed in milliequivalents of citric acid per kg of fresh tissue (AOAC, 2005). The ratio between soluble solids and acidity was determined by the relation between the values obtained for these variables.

The hydrogen-ion potential was determined directly by digital pH meter in the solution containing the fresh tissue of baby corn. The firmness was determined by the maximum penetration force of a flat tip with 4 mm diameter, with a distance of 10 mm from the spikelet, using a Brookfield digital penetrometer model CT3 10 KG in the middle region of the spikelet and, the results expressed in Newton (IAL, 1985).

The data were submitted to the assumptions of adherence to the normality and homoscedasticity of the residues and after to regression analysis. The choice of regression models was based on the significance of the regression coefficients ($p < 0.05$) and on the potential for explanation of the biological factor in question. Statistical analysis was performed using the statistical software R, version 3.5.

RESULTS AND DISCUSSION

Fertilization with N led to the adjustment of the quadratic regression model ($p < 0.05$) for the characteristic number of total and commercial spikelet. It was observed an increase in the total and commercial number of spikelets due to increasing of nitrogen fertilization, with maximum values around 405,000 baby corn spikelets per hectare, harvested with nitrogen fertilization at 150 kg ha^{-1}. The amount of commercial spikelets increases to a dose of 151 kg ha^{-1}, with 390,000 spikelets ha^{-1}, with an increase in non-commercial spikelets after fertilization level (Figure 1).

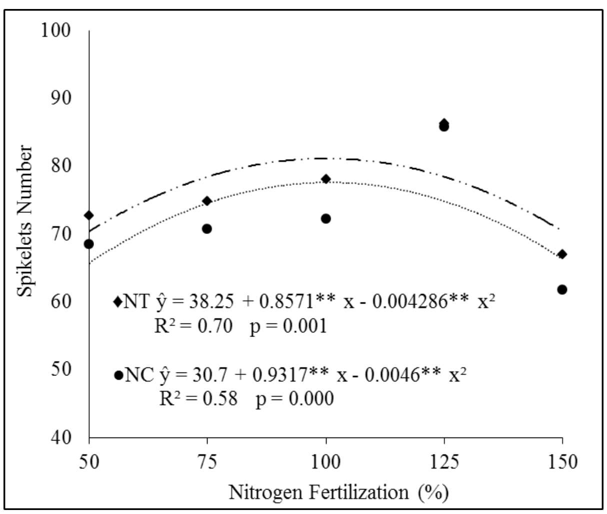

Fig. 1. Total (TN) and commercial number (CN) of baby corn spikelets as a function of nitrogen fertilization. Janaúba-MG, UNIMONTES, 2019.

Santos *et al.* (2014) also found an increase in the number of spikelets harvested with the addition of N in the fertilization of the crop. Nitrogen, for baby corn production, is one of the most important nutrients and constitutes important molecules for plant development, such as amino acids, protein molecules, enzymes, alkaloids, nucleotides, chlorophyll and others, thus increasing crop yield (Kumar *et al.*, 2017).

A properly fertilized plant with N, has the ability to increase its leaf area, resulting in a higher photosynthetic rate and production. However excess of this nutrient in plant predisposes to exaggerated increase in biomass of all organs, including those of economic interest, thus causing spikelets larger diameter, discarded for commercial purposes, as observed in the highest N doses of the present study, in which there was increase in non-commercial spikelets.

The baby corn showed an increase in productivity ($p < 0.05$) with increasing levels of nitrogen fertilization, presenting the maximum total yield, 4.4 t ha^{-1}, at a dose of 165 kg ha^{-1}. The yield of commercial spikelet was observed to increase to the same fertilization with N reaching 3.9 t ha^{-1} of spikelet, and from this level of fertilization there is a decrease in productivity and increase of non-commercial spikelets (Figure 2).

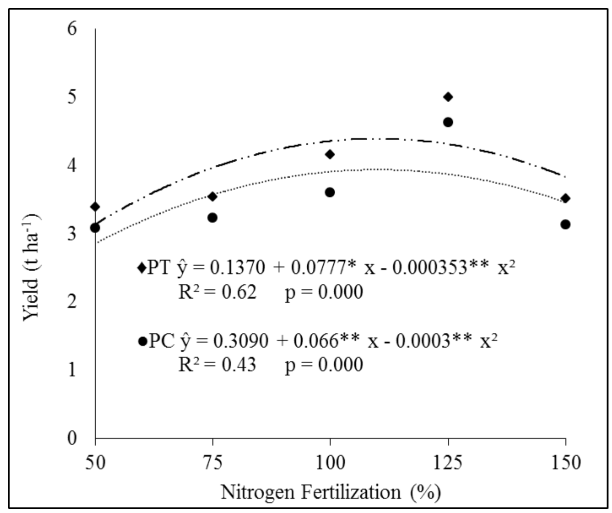

Fig. 2. Total (TY) and commercial (CY) yield of baby corn as a function of nitrogen fertilization. Janaúba-MG, UNIMONTES, 2019.

Baby corn yield is directly related to the amount of spikelets produced per plant, the higher the number of spikelets harvested, the higher the yield. In the present study, this relation was observed between 150 and 165 kg ha^{-1} of N. Nitrogen is the nutrient that provides the highest yield increases, however overdosing of this nutrient can cause soil and plant imbalance, negatively affecting the crop agronomic performance (Meneghetti *et al.* 2012).

Several authors (Thakur *et al*., 1997; Thakur and Sharma 1999; Rajendran and Singh 1999; Banarjee *et al*., 2004; Maurya *et al*., 2005; Jeet *et al*., 2017) indicates that the optimum baby corn yield is associated with the range of 150 to 180 kg ha^{-1} N, which corroborate the present study. Carvalho, *et al*. (2003) found low yields (1.2 t ha^{-1}) for the crop at doses of 152 kg ha^{-1} N, but using lower planting density and a different hybrid than that used in this study.

The dry matter of the baby corn commercial spikelets increased linearly ($p < 0.05$) 6.21 milligrams for each percentage point increased in fertilization (Figure 3). According to France, *et al*. (2011) the accumulation of dry matter in corn is highly dependent of the N available. Raghuveer, *et al*. (2017) evaluating in their studies the influence of fertility levels, N levels and organic sources on corn crop, observed a significant increase of baby corn dry matter with the application of 187.5 kg ha^{-1} of N. This was observed in the present study, in which the dry matter of commercial spikelet increased as N applied.

The dry matter of non-commercial spikelets increased ($p < 0.05$) with the addition of N, with mass elevation up to 5.59 g when applied to the soil 136.5 kg ha^{-1} N, with reduction of dry mass with upper doses. (Figure 3). When fertilization occurs, spikelets are considered non-commercial, as they increase their diameter and weight due to the higher requirement of photoassimilates for grain formation. Higher N rates caused, in non-commercial spikelets, abnormal development and small spikelets, which reflected in the lower accumulation of dry matter.

The length of baby corn spikelets increased ($p < 0.05$) 0.0161 cm for each percentage point of N applied to the soil, reaching maximum values of 10.15 cm with 150% of nitrogen fertilization, corresponding to 225 kg ha^{-1} of N (Figure 4).

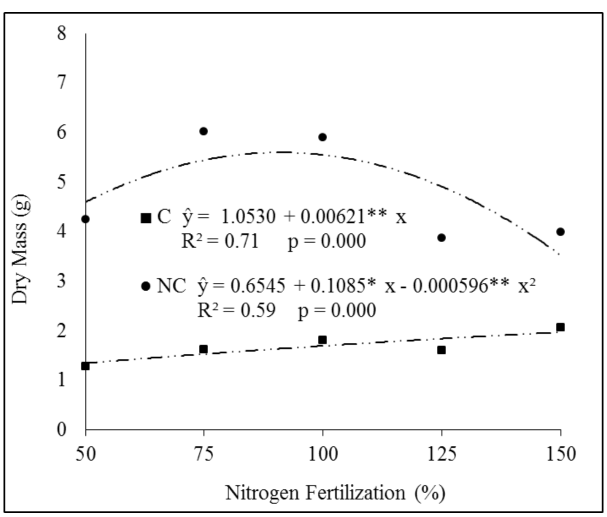

Fig. 3. Dry matter of baby corn commercial (C) and non-commercial (NC) spikelets as a function of nitrogen fertilization. Janaúba - MG, UNIMONTES, 2019.

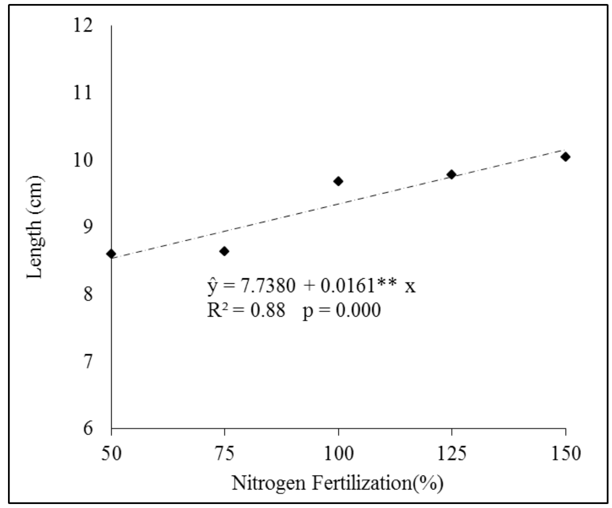

Fig. 4. Length of baby corn spikelet as a function of nitrogen fertilization. Janaúba-MG, UNIMONTES, 2019.

The length observed in the present study is within the range defined as a commercial quality standard, which requires spikelets to be between 4.0 and 12.0 centimeters (Rodrigues *et al*., 2004). Santos, *et al.* (2014) observed in their studies a similar effect, in which the increase in spikelet length was proportional to the increase of N in fertilization, with values within the standard quality range.

The diameter of commercial spikelets was influenced ($p > 0.05$) by nitrogen fertilization, with values around 16.7 mm. However, for non-commercial spikelets, the N doses provided ($p < 0.05$) distinct answers regarding their diameter, where there is an increase up to the 150 kg ha^{-1} N dose, reaching values in the order of 25.85 mm, with a subsequent decrease after this fertilization (Figure 5).

This feature is one of the most important in terms of the commercial character of this vegetable, as large diameter spikelets are not well accepted by the final consumer, being discarded because they fall below the standard required by the agricultural industries of food.

DoVale, *et al*. (2011), in their studies, found values of commercial diameters close to those referenced in this study, both for the hybrid AG 1051 and for others studied. This fact may be attributed to the phenological state established for the harvest, as

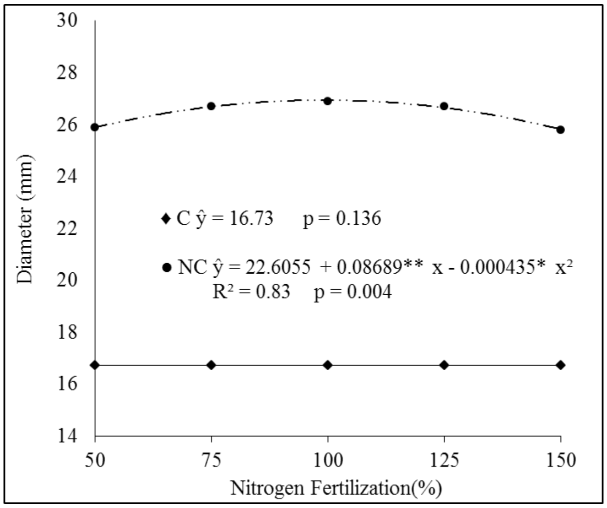

Fig. 5. Diameter of commercial (C) and non-commercial (NC) baby corn spikelets as a function of nitrogen fertilization. Janaúba-MG, UNIMONTES, 2019.

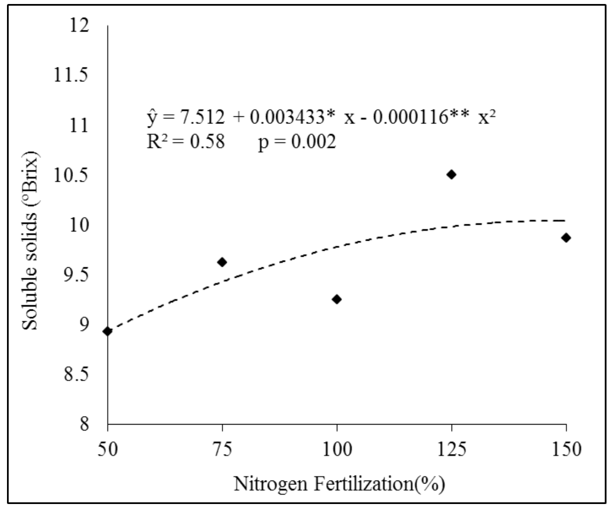

Fig. 6. Soluble solids of baby corn spikelet as a function of nitrogen fertilization. Janaúba-MG, UNIMONTES, 2019.

well as the pre-established commercial patterns, which is why nitrogen doses did not influence this variable.

Non-commercial spikelets have larger diameters, often because they are past the point of harvest and are fertilized. Visually, the harvest point is confusing, requiring practice and knowledge of the person performing it. After fertilization of the grains, the demand for photoassimilated by the drain rises, which culminates in the rapid development and growth of spikelets, which is confirmed by the requirement and balance of nutrients by the plant (Von Pinho, *et al*. 2009; Bastiani, *et al*. 2012).

The soluble solids content of baby corn spikelet increased ($p < 0.05$) as a function of nitrogen fertilization, with maximum values of 10.05 ° Brix when applied 222 kg ha^{-1} of N (Figure 6). Von Pinho, *et al.* (2003) evaluating physical and chemical characteristics of cultivars for baby corn production, reported soluble solids values of 10.5º Brix in triple hybrid destined for green maize, with fertilization of 152 kg ha^{-1} of N.

This result is different from what was reported in the present study and may be associated with the different cultivation sites, the genotype used and the phytotechnical management, since these can influence the quality characteristics of corn (Perfeito, *et al*. 2017).

The post-harvest quality variables: hydrogen potential, soluble solids/acidity ratio, total titratable acidity and firmness were not influenced ($p > 0.05$) by the N rates applied in the culture, presenting means of 5.8; 5.85; 1.66 meq kg^{-1} (citric acid) and 8.5 N respectively.

The pH is an important attribute in determining the state of conservation of a product, widely used in products that are intended for industrial processing, and aims to indicate the degree of hydrogen to dissociate in the food solution, measuring its acidity (Nielsen, 2008). According to Pereira Filho *et al.* (2009) the baby corn is a vegetable included among high pH products, above 4.3, as observed in this study, because it requires attention during the canning industrialization process.

Total titratable acidity is related to acid formation mainly from carbohydrate hydrolysis, and the faster this hydrolysis, the higher the acidity value. Reis *et al.* (2004) in their studies, observed acidity around 2.0 meq kg^{-1}, values higher than that observed in this study. As total titratable acidity was not influenced by the different N rates applied, there was a reflection on the soluble solids and acidity ratio, which remained stable. This relation expresses "flavor", and the higher the value, the more pleasant the product will manifest (Baldwin, 2002).

The firmness of plant products is related to the consistency of the cell wall, its carbohydrate content. In vegetable crops, the firmness is an important feature because a lower stiffness results in fragile bodies, subject to deformation and disruption of cellular structures, causing fermentation and deterioration of the product, and the value found in this study is appropriate (Chitarra and Chitarra, 2005).

CONCLUSION

The nitrogen fertilization increases the agronomic yield of baby corn, and the fertilization between 150 and 165 kg ha^{-1} provides the best results in the evaluated agronomic characteristics.

The characteristics of quality in the post-harvest are not affected by nitrogen fertilization, except for the soluble solids content, which presents a maximum response of 10.05 ° Brix with the application of 122 kg ha^{-1} of N.

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