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Agronomic performance of hybrids and varieties of maize in function of nitrogen in coverage

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This study aims to compare the agronomic performance and the productivity of the corn hybrid AG 1051 and the Incaper Capixaba 203 variety in function of different nitrogen (N) doses in coverage. The experiment was held at the Federal Institute of Espírito Santo - Campus Santa Teresa. The design was of randomized blocks and the treatments were arranged in a split plot scheme, with four repetitions. The plots were represented by two corn genotypes and the subplots consisted of five N doses coverage: 0, 60, 120, 180 and 240 kg ha^{-1} N. After flowering, the plant height, stem diameter, the height of ear insert and the number of leaves per plant were evaluated. After harvest, the number of grains per spike, the 1000 grain and grain productivity were evaluated. All N dosages influenced all the features evaluated for both genotypes, which showed an increase with the increasing dose of the nutrient. The differences between the genetic materials to all the analyzed variables, except in grain productivity were found. The N dose estimated provides greater productivity for average grain (8785.98 kg ha^{-1}) for both genotypes 207.17 kg ha^{-1} of N.

Key words: Genetic material, levels of nitrogen, productivity, urea, *Zea mays*.

INTRODUCTION

Corn is a major cereal because of its various forms of use, ranging from animal feed till the industry. According to Conab (2016), 9th survey of crop, the Brazilian area designated for cultivation of the corn in the 2015 to 2016

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harvest was of 10.28 million hectares and the grain production was of 79,955,200,000 tons. The culture has a high production potential, however, the Brazilian average productivity is low (5,107 kg ha^{-1}) when compared with China and the United States (Conab, 2016).

Even though the productivity is dependent on the balance between the essential soil nutrients, nitrogen (N) is the most responsive nutrient in production of corn. According to Lourente et al. (2007), N is one of the minerals required in larger amounts in the cultivation of corn. This nutrient plays an important role in achieving high productivity, verifying wide range of recommendations, which vary from 50 to 150 kg ha^{-1} (Mendes et al., 2011).

Most studies involving nitrogen fertilization in corn is directed almost exclusively to evaluations with hybrid materials, neglecting the responsive capacity of varietal cultivars, which are still used by most farmers in the country. In addition, few studies relate the genetic potential to the nitrogen amount.

Fertilizer recommendations in Espírito Santo are based on Prezotti et al. (2007), which state that the level of N varies according to the corn productivity, indicating that corn crops with productivity between 3500 and 5500 kg ha^{-1} should receive 10 kg ha^{-1} of N at seeding and 60 kg ha^{-1} N in coverage. Crops with higher productivity than 5,500 kg ha^{-1} should receive 10 to 15 kg ha^{-1} N at seeding and 100 to 120 kg ha^{-1} N in coverage.

Another important fact noted in the recommendations of Prezotti et al. (2007) is that these authors do not consider the genetic potential as characteristics in their fertilizer recommendations for corn, being that the morphological and physiological changes in modern maize hybrids suggest changes in the dynamics of absorption of N by increasing the ability of the plant to absorb it during the grain filling (Silva et al., 2005).

According to Carvalho et al. (2011), the information about the absorption efficiency, associated with the genetic potential of cultivars and the optimal dose of N for each genetic material, can assist in the making of producers' decisions about the management and the choice of the crop cultivar to be used, in increasing the productivity and profitability of the same crop.

With this, the objective of this study was to evaluate the agronomic performance and productivity of the corn hybrid and a variety in function of different doses of N in coverage.

MATERIALS AND METHODS

The experiment was carried out in the field, from November 2014 to April 2015, in a soil classified as eutrophic ultisol (Embrapa, 2013) with sandy clay loam texture, located at the Federal Institute of Espírito Santo - Campus Santa Teresa, at 138 m of altitude and coordinates 19° 48'9 "S and 40° 40'32"O. The climate is Cwa type (subtropical dry winter) with an annual average temperature and precipitation of 18°C and 845.2 mm, respectively (Nascimento, 2013).

The soil had the following characteristics in the topsoil from 0 to 20 cm: pH (in H_2O) = 6.0; Al exchangeable ($cmol_c$ dm^{-3}) = 0.0; H+Al = 2.5 ($cmol_c$ dm^{-3}); Ca ($cmol_c$ dm^{-3}) = 2.5; Mg = ($cmol_c$ dm^{-3}) = 0.7; P Mehlich (mg dm^{-3}) = 8.0; P remaining (mg L^{-1}) = 28.0; K (mg dm^{-3}) = 110; S (mg dm^{-3}) = 9.0; organic matter (dag kg^{-1}) = 2.2; Fe (mg dm^{-3}) = 85; Zn (mg dm^{-3}) = 9.9; Cu (mg dm^{-3}) = 3.2; Mn (mg dm^{-3}) = 218; B (mg dm^{-3}) = 0.31; Na (mg dm^{-3}) = 40; V (%) = 58.2; CTC effective ($cmol_c$ dm^{-3}) = 3.5; CTC a pH 7.0 ($cmol_c$ dm^{-3}) = 6.0; sum of bases ($cmol_c$ dm^{-3}) = 3.5; saturation of Ca in CTC (%) = 41.8; saturation of Mg in CTC (%) = 11.7; saturation of K in CTC (%) = 4.7; clay (g kg^{-1}) = 300; silt (g kg^{-1}) = 118; sand (g kg^{-1}) = 582.

The design was in randomized blocks with treatments arranged in split plots, with four repetitions. The plots were represented by two genetic material, being one commercial hybrid (AG-1051), considered with high productivity, and one varietal (Capixaba 203), material developed by the Capixaba Institute of Research, Technical Assistance and Rural Extension (INCAP). Each subplot consisted of five N doses on coverage: 0, 60, 120, 180 and 240 kg ha^{-1} N. Each subplot composed of four rows of corn, 7 m long. The two central lines were considered useful, despising 1 m at each end.

The soil preparation was done by one plowing and two disking and the correction of the soil for sowing followed the recommendations of Prezotti et al. (2007), in function of the results of the chemical analysis from the soil, being employed 786 kg ha^{-1} dolomitic limestone (PRNT 90), 10 kg ha^{-1} N; 50 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} K_2O.

Sowing was done manually in the groove line. Spacing of 0.9 m was used between rows and 10 seeds were distributed in each linear meter. It was made rough three days after emergence (DAE), remaining five plants per linear meter, in order to secure a final stand of 55,000 plants ha^{-1}, according to plant density recommendation suggested by seed suppliers.

Nitrogen fertilization of coverage in each treatment was parceled into four times, following the recommendation suggested by Prezotti et al. (2007), being that 30% of the total dose was applied to 15 (DAE), 30% at 30 DAE, 20% at 45 DAE and 20% at 60 DAE, using urea as a source of N. Applications of fertilizers were done manually after irrigations with homogeneous distribution in continuous bead to 10 cm from the plant. Irrigation was carried out in the morning by means of spraying and performed according to the crop needs in relation to the reference evapotranspiration, whilst maintaining the water content in soil at field capacity.

After flowering, 75 DAE, following the characteristics were evaluated in 15 plants within each useful subplot: (a) plant height (pH), measured from the ground level to the insertion of the last fully expanded leaf; (b) stem diameter (SD), measured with the aid of a digital caliper in the second internode stem from the ground; (c) spike insertion height (SIH), measured from the ground level to the insertion of the first tenon; (d) number of leaves per plant (NLP), obtained by counting the fully expanded leaves.

The harvest was done manually within the area of each subplot, picking up all the grain with straw. The threshing of the corn was performed with the manual thresher aid. Subsequently, evaluated: (e) number of grains per spike (NGS), multiplying the number of kernel rows by the number of kernels per row of each tenon; (f) mass of 1,000 grains (MMG), obtained by manual count of 400 grains, weighing and moisture correction to 13%, extrapolating the results for 1000 grains by simple rule of three; g) grain productivity (GP), determined by harvesting the corn, threshing and weighing of grain with higher moisture correction to 13% and extrapolating the results to kg ha^{-1}.

The data was subjected to analysis of variance. For the purposes of the amounts of N, variables were studied by polynomial regression analysis and for the differentiation of genotypes, the treatment averages were compared applying the Tukey test at 5% probability level. For the variables that regression showed quadratic effect, the first order derivative of the function to estimate its maximum point was used.

Table 1. Average values of plant height (AP), height of insertion of the first tenon (IEA), stem diameter (DC), number of leaves per plant (NFP), number of grains per tenon (NG), mass of 1000 grains (MMG) and grain productivity (GP) for hybrid and varietal corn.

Trat.	PH (cm)	SIH (cm)	SD (mm)	NLP	NGS	MMG (g)	GP (kg ha^{-1})
Hybrid	200.15^{b}	128.36^{b}	22.83^{a}	11.17^{b}	572.06^{a}	258.37^{b}	7,419.79^{a}
Varietal	236.61^{a}	138.26^{a}	21.99^{b}	12.16^{a}	485.66^{b}	342.75^{a}	7,345.99^{a}
CV (%)	1.14	4.14	1.94	7.03	7.34	6.64	6.92

The averages followed by the same letter in each column do not differ statistically from each other. Tukey's test was applied at the level of 5% probability.

RESULTS AND DISCUSSION

Differences were found (P<0.05) between genetic materials for all variables, except for grain productivity. Because of their higher rusticity, varietal material showed plants with larger insertion of the first tenon, higher number of leaves, heavier grains, smaller stem diameter, and fewer grains per tenon than the hybrid material as shown in Table 1.

According to Costa et al. (2012), higher plants often have more leaves and accumulate more nutrients, which are translocated to the grain in the grain filling period. Moreover, the higher plants are more prone to lodging occurrence. Fields et al. (2010) state that the greater the height of insertion of the spikes, the greater the chance of bedding plants, resulting in losses in productivity. Furthermore, smaller plants are more efficient in mechanical harvesting (Vilela et al., 2012).

In contrast, plants with thick stems are more resistant to overturning by wind, rain and soil compaction caused by the machine traffic and implementations during the management operations of culture and harvest of crops (Cruz et al., 2008).

The N doses influenced all the characteristics evaluated in both genetic materials. As regression analysis was being analyzed, linear effect increasing due to the increase of N doses in both corn genotypes studied was observed, for the variables: pH (Figure 1A), SIH (Figure 1B), and SD (Figure 1D), which showed similar behavior. When it comes to the number of leaves per plant, the hybrid showed linear increase with increasing doses of N. As for the varietal, quadratic behavior in function of N levels was observed (Figure 1C).

The increase in N rate increase brought the pH and SIH parameters, showing the direct effect of nitrogen on the vegetative functions of the plants. Similar results were obtained by Lange et al. (2014) who observed a significant linear increase in pH with increase in urea dosing in coverage. The SD followed the same principle, but the hybrids showed greater slope inclination when compared with the variety, indicating that this genetic material has greater capacity to synthesize nitrogen and deposit it in reserve tissues. The results obtained are in accordance with the Goes et al. (2013), which showed that higher doses of nitrogen in coverage generates an increase in the SD of the plants.

Regarding the NLP, nitrogen had greater influence on the corn variety, which expressed maximum yield at a dose of 222.14 kg ha^{-1} of N, producing an average of 13.45 leaves per plant. Plants with larger leaves tend to have higher photosynthetic rate and consequently greater production reserves, influencing directly on the crop yield. However, this result shows the lower N assimilation capacity of the corn variety, because when subjected to high doses of N shows an adverse effect on sheet formation, possibly as early shading, since the height of plants showed increase under the same conditions of N.

According to Figure 2A, there was a quadratic effect in function of the regression of N rates for the number of grains per spike in both materials. Figure 2B shows the weight of 1,000 grains, wherein the regression analysis showed linear effect for the hybrid and quadratic in the varietal, which showed maximum mass (373.59 g) obtained at a dose of 157.69 kg ha^{-1} of N.

The hybrid had higher average grain yield per spike (639.72) at a dose of 213.18 kg ha^{-1} N, however, the varietal showed the maximum production (520.36) when subjected to the dosage 161.03 kg ha^{-1} N.

These results show the morphological characteristics of genetic material, where the varietal corn, probably due to its greater hardiness, uses its reserves to produce larger size and mass grains, unlike hybrid corn, which has increased production of grains per spike but with smaller size and mass grains.

Sichocki et al. (2014) observed the same behavior mass of 1,000 grains of corn hybrids, which showed a steady increase in its mass with increasing nitrogen content coverage. However, the corn variety, despite its greater mass, found restrictions of absorption and utilization of nutrients, showing that doses above the maximum agronomic point become harmful, and can cause low economic return.

Figure 3 show that the average grain productivity showed a quadratic effect due to the N dose in coverage, with no difference between genotypes statistics.

The N rate estimated for the highest average grain yield (8,785.98 kg ha^{-1}) was of 207.17 kg ha^{-1} N. This result contradicts those obtained by Santos et al. (2013), Farinelli and Lemos (2010) and Goes et al. (2013) who obtained maximum grain yield with the culture of doses of

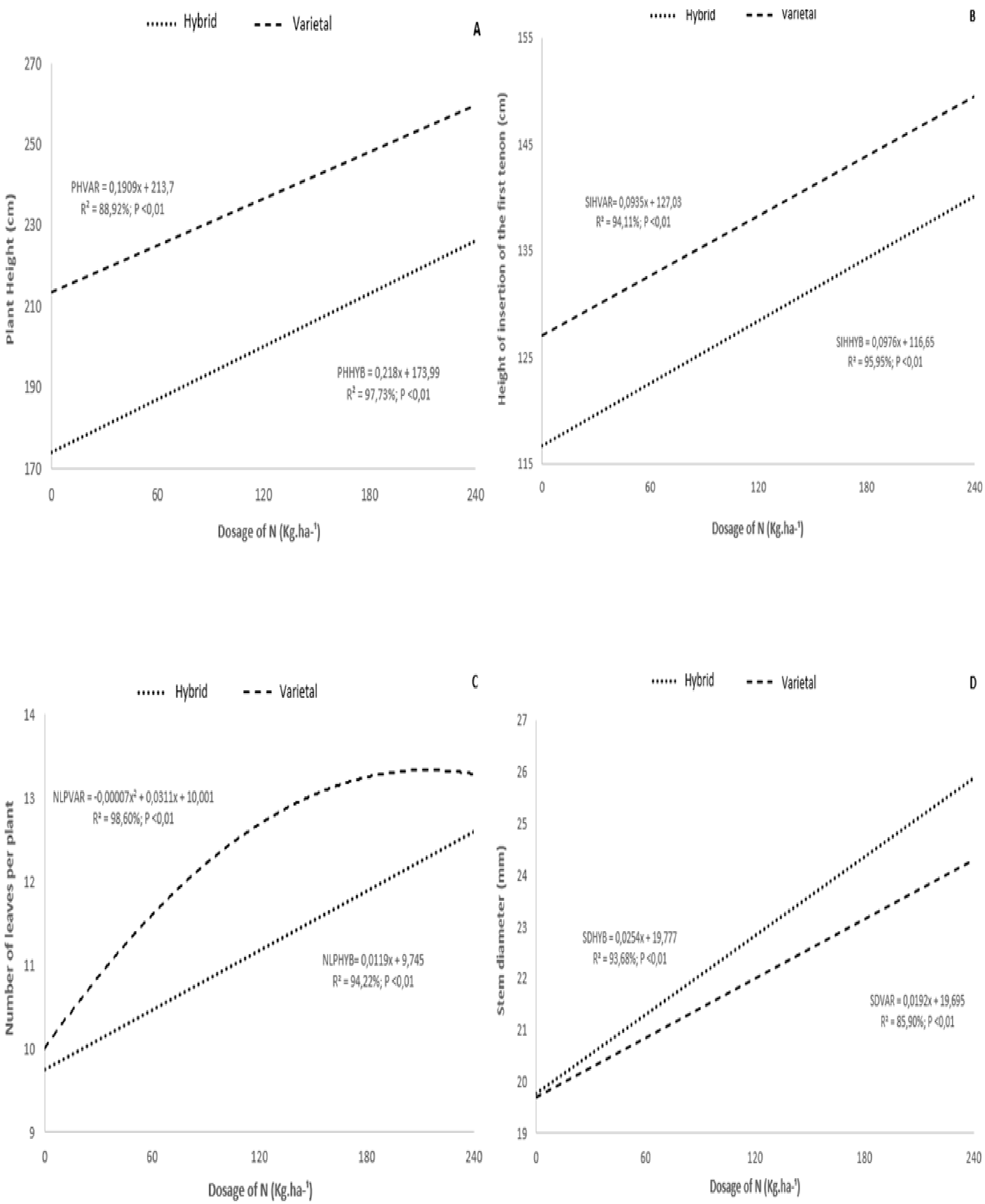
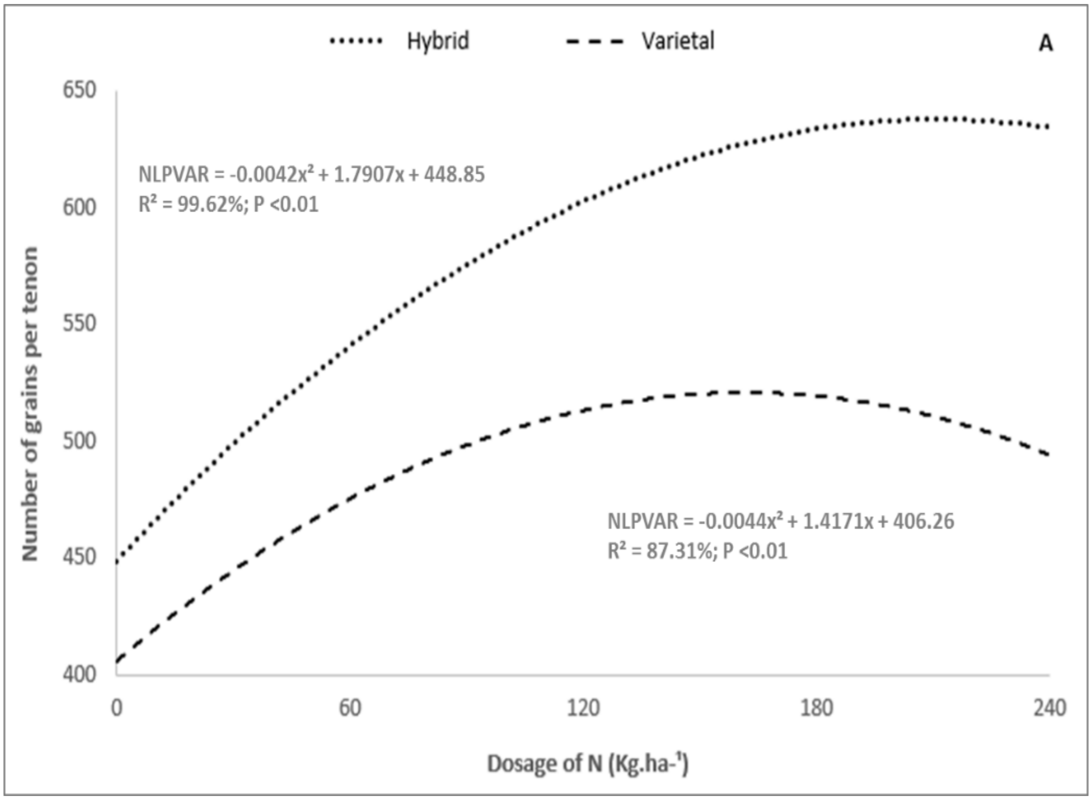


Figure 1. Plant height (A), height of insertion of the first tenon (B), number of leaves per plant (C), stem diameter (D) of each genetic material in function of the N dosage in coverage.



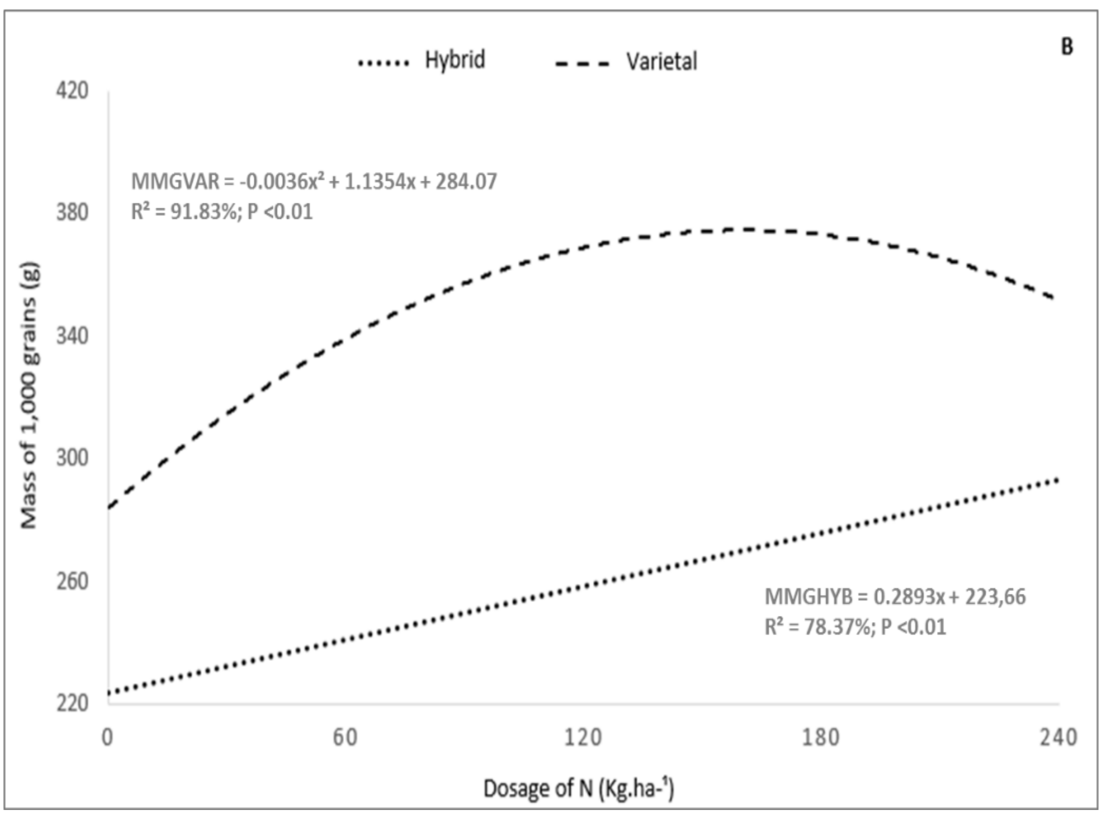


Figure 2. Number of grains per tenon (A) and mass of 1,000 grains (B) from each genetic material in function of the N dosage in coverage.

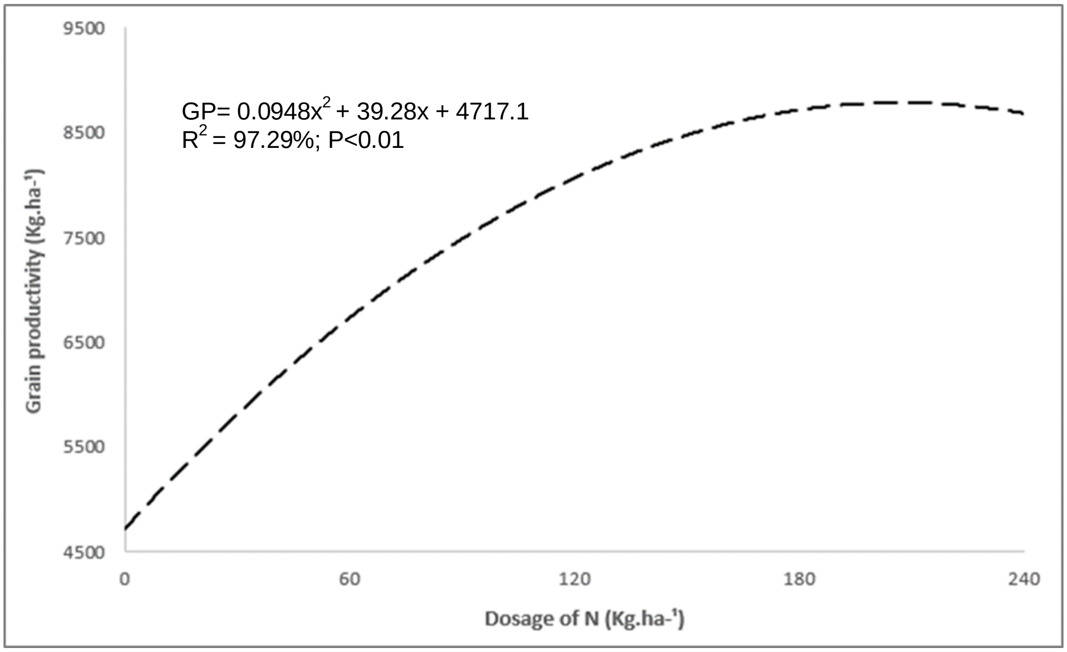


Figure 3. Grain productivity in function of the N doses in coverage.

340.92 and 103.8 lg ha^{-1} of N, respectively.

Pavinato et al. (2008) state that the maximum corn grain productivity under sprinkler irrigation is achieved by applying 283 to 289 kg ha^{-1} N, however, the maximum economic efficiency occurs with 156 to 158 kg ha^{-1} N, and emphasize that producers are using nitrogen fertilizer above the amount needed.

Conclusion

1. The genotype variety Incaper Capixaba 203 presents higher plants, with increased height of the first insertion spike, higher number of leaves and higher grain mass of the hybrid AG 1051, which on the other hand has larger diameter stems and more grains per spike.
2. With respect to productivity, there is no difference between the two genetic materials evaluated when subjected to N doses considered in this study and the estimated nitrogen dose that provides maximum grain yield is the 207.17 kg ha^{-1} N.

Conflict of interests

The authors have not declared any conflict of interests.

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