Corn Agronomic Performance According to Crop Year, Spacing and Plant Population Densities in Vale of São Patrício Region.

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ABSTRACT: The present study aimed to evaluate the influence of row spacing, plant density, crop year and yield in crop agronomic parameters in a 'Cerrado' area in Brazil. The experiments were conducted during the 2010/2011 and 2011/2012 crop years, at an experimental Farm of the IF Goiás Campus Ceres, located in the city of Ceres, Goiás, Brazil. The experiment was conducted in a complete randomized block design in a 2x3x2 factorial (two crop years: 2010/2011 and 2011/2012, three population densities: 60,000, 70,000 and 80,000 plants ha^{-1} and two spacing: 0.50 and 0.80 m) with four repetitions, totaling 48 plots. For the first crop year, the highest yield were obtained for populations of 70,000 and 80,000 plants ha^{-1}, with values of 10,922 and 11,796 kg ha^{-1} of grain, respectively, differing from the productivity of 9,118 kg ha^{-1} of grain obtained by the population 60,000 plants ha^{-1}. The corn production is significantly influenced by plant density, where the number of cob per area is the main factor for this increase. For the second crop year, the population of 70,000 plants ha^{-1} resulted in a yield of 6,253 kg grains ha^{-1}, differing from populations of 60 and 80 thousand plants ha^{-1} that produced 5,045 and 5,606 kg ha^{-1} of grains, respectively. The density of 70 thousand plants ha^{-1} lead to a yield increase.

Indexing terms: Cerrado, Stress hídrico, *Zea mays*.

INTRODUCTION

To achieve high grain yield is necessary to adequate the management practices to the environment available resources, allowing better conditions for the plant development. Between the management strategies that can be used, the plant density plays an important role (Serpa et al., 2012).

The appearance of new corn genotypes increased the demand for studies determining the better plant spatial arrangement because of the morphologic and genetic variations, since this crop is very sensitive to these variations due to its lower capacity to emit fertile tillers, limited prolificacy, low leaf plasticity and its monoic flower structure, where the male and female inflorescences competes for photoassimilates under stress conditions (Sangoi et al., 2011).

The modern hybrids have lower size, better leaf architecture and lower plant mass. Thus, these hybrids exert lower shading indexes and are able to capture better the sunlight (Cruz et al., 2006).

Thus, it is necessary to evaluate the management practices and recommendations for the crop, such as the plant arrangement.

The present study aim to evaluate the corn agronomic characteristics under different spacing between lines, plant densities and crop year in a 'cerrado' region.

MATERIAL AND METHOD

The experiments were conducted in an experimental farm of the Federal Institute of Goias, Ceres campus, on the municipality of Ceres, Go, with S 15º 21' 03'' of latitude and longitude of W 49º 35' 37'' and 564 m of altitude. The variation on rainfall and average temperature were registered during the two studied crop years (**Figure 1**).

The soil of the experimental area is classified as a red dystrophic oxysol (Embrapa, 2006), and the chemical analysis of the 0-0.2m layer indicated the following values: Ca= 2.4; Mg= 1.3; Al= 0.0; H= 3.5 ($cmol_c$ dm^{-3}); P= 5.6; K= 101.0 (mg dm^{-3}); pH= 5.0

($CaCl_2$); bases saturation (V%)= 51.8% and organic matter= 1.5 g kg^{-1}. A management dissection was realized seven days before sowing, with 3 L ha^{-1} of glyphosate for both crop years.

The experiment was installed in a no-tillage system area during the both crop years, on November 18, 2010 and November 18, 2011. The cultivar used was P30F35H whose seeds were industrially treated with Thiamethoxam + fipronil. Sowing was done manually by distributing eight seeds per meter, and 12 days after germination the thinning was carried out, leaving the pre-established population of plants for each treatment.

The sowing fertilization consisted of 20 kg ha^{-1} of nitrogen, 150 kg ha^{-1} of phosphorus and 80 kg ha^{-1} of potassium, whose formula was 04-30-16. The topdressing consisted of two applications, the first was performed when the plants have four unfolded leaves, with the application of 40 kg ha^{-1} of N and 40 kg ha^{-1} of potassium (20-00-20). The second application was carried out when the plants presented the sixth leaf, using 70 kg ha^{-1} of N (urea). At this stage, atrazine was also applied in post-emergence at a dose of 3 L ha^{-1}.

The experiment was conducted in a complete randomized block design in a 2x3x2 factorial, two crop years, (2010/2011 and 2011/2012), three plant population densities (60,000, 70,000 and 80,000 plants ha^{-1}) and two spaces between rows (0.50 and 0.80 m) with four repetitions. Each plot consisted of four rows with five meters in length and for the data collection, the two central lines were used, and 0.50 m around the edges was not considered.

The evaluated variables were: height of the first cob; plant height; stem diameter; thousand grain weight and yield (kg ha^{-1}). The harvest of the corn was performed manually for both experiments, at 130 days after emergence and the grain moisture was adjusted to 13%.

Data were submitted to analysis of variance and compared by the Scott Knott´s test at 5% of significance level. Analyses were performed using the R software (R Development Core Team, 2014) and the easyanova package (Arnhold, 2013).

RESULTS AND DISCUSSION

No interaction was observed between the factors for the evaluated characteristics, but for yield an interaction was observed between the plant population x year and spacing x year.

The variables plant height, cob insertion height and stem diameter were not affected by an increase in spacing between lines from 0.50 to 0.80m and by the changes in the plant population (**Table 1**). These values corroborated with the results obtained by other authors, in which the reduction of the spacing between the lines did not influenced plant height and cob insertion (Calonego et al, 2011; Gilo et al, 2011).

The plant height and cob insertion height were different for the evaluated crop years (2010/2011 and 2011/2012), with average values of 2.56 and 2.40 m for plant height and 1.26 and 1.17 m for cob insertion height, respectively.

Stem diameter was not different between the crop years, with values from 20.31 to 20.65 mm (**Table 1**). However, for this variable, an effect of the plant population was observed, in which the population of 60 000 plants ha^{-1} resulted in a higher mean (21.16 mm), differing from the stem diameter of plants from other populations, with 70 and 80 thousand plants ha^{-1}, which presented average values of 20.36 and 19.92 mm, respectively. It is expected that an increase in plant population can lead to a reduction in stem diameter, due to the competition among plants for resources such as water, nutrients and light. Calonego et al. (2011) observed that the plant population of 75,000 plants ha^{-1} promoted a reduction in the stem diameter.

Silva et al. (2008) observed higher plants for larger populations, due to the increased competition between plants for light, water and nutrients. When there was a reduction in spacing, these authors observed a reduction in plant size due to the better plant distribution.

The thousand grain mass was influenced by the change in spacing and agricultural years (**Table 1**). This characteristic is greatly influenced by environmental factors such as water limitation and severe reduction in growth. This component was crucial to the highest yields obtained in the first crop year, regardless the spacing and plant population (**Table 2**).

The variable grain yield was influenced by the interaction between spacing x year and between plant population x year (**Table 2**). For the first crop year, the highest yield were obtained for populations of 70,000 and 80,000 plants ha^{-1}, with values of 10,922 and 11,796 kg ha^{-1} of grain, respectively, differing from the productivity of 9,118 kg ha^{-1} of grain obtained by the population 60,000 plants ha^{-1}. The corn production is significantly influenced by plant density, where the number of cob per area is the main factor for this increase. For the second crop year, the population of 70,000 plants ha^{-1} resulted in a yield of 6,253 kg grains ha^{-1}, differing from populations of 60 and 80 thousand plants ha^{-1} that produced 5,045 and 5,606 kg ha^{-1} of grains, respectively (**Table 2**).

The yield from the first crop year was higher than for all plant populations with values ranging from 9,118 to 11,796 kg of grains ha^{-1}, while in the second crop year the yield ranged from 5045 to 6253 kg of grains ha^{-1} (**Table 2**). The lower yield during the 2011/2012 harvest may have occurred due to hybrid stability, that reduced productivity for this season, as the rainfall and temperature were satisfactory for the crop development (**Figure 1**).
The increase in plant population and the reduction in the spacing resulted in an increased grain yield due to the better spatial distribution of plants in the area, mainly in the 2010/2011 crop year (**Table 1**).

The highest yield related to an increase in the plant population is due to an increase of harvested cobs ha^{-1}. Silva et al. (2008) reported an increase in yield with an increase in plant population of the hybrid 30K75 from 40 to 80,000 plants ha^{-1}, whose yield reached 6,239 and 8,703 kg ha^{-1}, respectively. With the spacing of 0.60 m between lines, Silva et al. (2012) achieved an increase of 11% in yield with an increase of plant density from 78 to 100 thousand plants ha^{-1}.

CONCLUSION

The density of 70 thousand plants ha^{-1} lead to a yield increase. The increase in plant population decreases the stem diameter. The reduction on the space between rows increased the thousand grain mass.

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REFERENCES

ARNHOLD, E. Package in the R environment for analysis of variance and complementary analyses. **Brazilian Journal Veterinary Reseach Animal Science**, São Paulo, v.50, n.6, p.488-492, 2013.

CALONEGO, J.C., POLETO, L.C., DOMINGUES, F.M., TIRITAN, C.S. Produtividade e crescimento de milho em diferentes arranjos de plantas. **Agrarian**, Dourados, v.4, n.12, p.84-90, 2012.

CRUZ, J.C., PEREIRA, F.T.F., PEREIRA FILHO, I.A., OLIVEIRA, A.C., MAGALHÃES, P.C. Resposta de cultivares de milho à variação em espaçamento e densidade. **Revista Brasileira de Milho e Sorgo**, Sete Lagoas, v.6, n.1, p.60-73, 2006.

GILO, E.G., SILVA JUNIOR, C.A., TORRES, F.E., NASCIMENTO, E.S., LOURENÇÃO, A.S. Comportamento de híbridos de milho no cerrado Sul-Mato-Grossense, sob diferentes espaçamentos entre linhas. **Bioscience Journal**, Uberlândia, v.27, n.6, p.908-914, 2011.

R DEVELOPMENT CORE TEAM. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/. 2014.

SANGOI, L., SCHWEITZER, C., SILVA, P.R.F., SCHMITT, A., VARGAS, V.P., CASA, R.T., SOUZA, C.A. Perfilhamento, área foliar e produtividade do milho sob diferentes arranjos espaciais. **Pesquisa Agropecuária Brasileira,** Brasília, v.46, n.6, p.609-616, 2011.

SERPA, M.S., SILVA, P.R.F., SANGOI, L., VIEIRA, V.M., MARCHESI, D.R. Densidade de plantas em híbridos de milho semeados no final do inverno em ambientes irrigados e de sequeiro. **Pesquisa Agropecuária Brasileira,** Brasília, v.47, n.4, p.541-549, 2012.

SILVA, R.R., THEODORO, G.F., LIBÓRIO, C.B., PESSOA, L.G.A. Influência da densidade de cultivo de dois genótipos de milho na severidade de mancha de cercospora e no rendimento de grãos na "safrinha". **Semina: Ciencias Agrárias**, Maringá, v.33, n.4, p.1449-1454, 2012.

SILVA, A.G., CUNHA JUNIOR, C.R., ASSIS, R.L., IMOLESI, A.S. Influência da população de plantas e do espaçamento entre linhas nos caracteres agronômicos do híbrido de milho P30K75 em Rio Verde, GO. **Bioscience Journal,** Uberlândia, v.24, n.2, p.89-96, 2008.

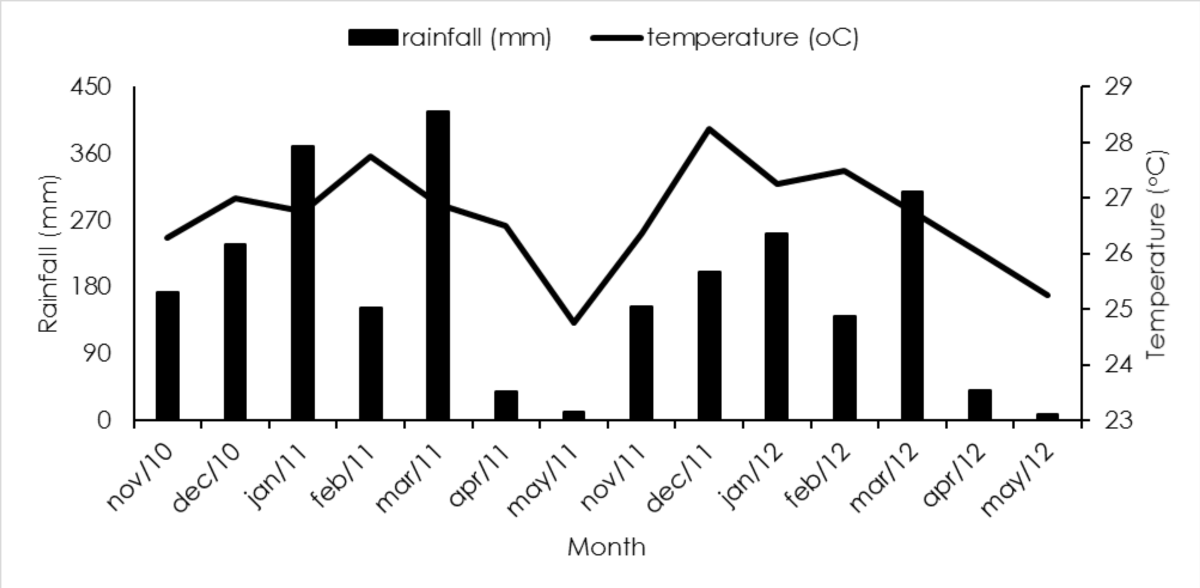

Figure 1. Montly values for rainfall and temperature during the experimental period, in Ceres, GO. Source: Meteorological Station of IF Goiano, Ceres Campus.

Table 1. Mean values for the biometric parameters: plant height, cob height, stem diameter and cob diameter in Ceres, Go, Brazil.

Spacing (m)	Plant height (m)	Cob height (m)	Stem diameter (mm)	Thousand grain mass (g)
0.50	2.46 a	1.20 a	20.34 a	263.65 a
0.80	2.51 a	1.23 a	20.62 a	248.54 b
Population (thousand plants ha^{-1})				
60	2.44 a	1.18 a	21.16 a	259.06 a
70	2.50 a	1.23 a	20.36 b	258.63 a
80	2.51 a	1.23 a	19.92 b	250.75 a
Year				
2010/2011	2.56 a	1.26 a	20.65 a	310.83 a
2011/2012	2.40 b	1.17 b	20.31 a	201.46 b
CV (%)	5.70	6.90	4.31	9.31

Means followed by the same letter in the column are different according to Scott Knott´s test at 5% of probability.

Table 2. Corn yield (kg ha^{-1}) according to plant population and spacing between rows for the 2010/2011 and 2011/2012 crop years. Ceres, Go, Brazil.

Crop year	Plant population (thousand ha^{-1})			Spacings (m)	
	60	70	80	0.50	0.80
2010/2011	9,118 aB	10,922 aA	11,796 aA	10,923 aA	10,301 Aa
2011/2012	5,45 bB	6,253 bA	5,606 bB	6,437 bA	4,831 bB

Means followed by the same lowercase in the columns and uppercase in lines are not different according to Scott Knott´s test at 5% of probability.