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MAIZE YIELD CULTIVATED UNDER DIFFERENT ROW SPACING

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ABSTRACT

In corn crop, the correct determination of row spacing, and plant population can produce improvements in the yield. However, it is necessary to manipulate the spatial arrangements to aim for a better distribution of the plants, thus improving the use of cultivation resources. The work aimed to evaluate the corn yield under different row spacing. The experiment was carried out in the municipality of Angatuba, State of São Paulo, Brazil (23.4° S, 48.26° W and altitude of 535 m). The sowing was realized in December 16th, 2019. The hybrid P4285VYHR was sown, adopting a plant population of 65,000 plants ha^{-1}. The treatments evaluated were: T1 - twin-row configuration, using the distance of 0.2 and 0.7 m; T2 – row spacing of 0.6 m; and T3 - 0.7-m line spacing. The experimental design was blocks, arranged in bands, with five (5) repetitions. The variables evaluated were as follows: the average number of grains per ear (NGE); the mass of one hundred grains (MHG); and the final yield (PROD). The data was subjected to the variance analysis (ANOVA), and subsequently to the Tukey test. Analyzing the variable NGE, it was found that T1 presented a lower value compared to the other treatments, which presented values of 622.6 and 642.6 grains per ear, in treatments T2 and T3, respectively. Regarding the PROD variable, it was found that in T1, using the twin-row configuration, the result was 6586.0 kg ha^{-1}, providing an increase of 12.15% and 19.16% compared to yield obtained in T2 and T3, respectively. For the MHG, there was no statistically significant variation among the treatments used. Thus, growing corn in twin-row of 0.2 and 0.7 m results in higher grain yield.

Keywords: *Zea mays*, twin-row, narrow row spacing, production

PRODUTIVIDADE DO MILHO EM DIFERENTES ESPAÇAMENTOS ENTRELINHAS

RESUMO

A manipulação dos arranjos espaciais visa a correta distribuição das plantas a fim de melhorar o aproveitamento dos recursos necessários para o seu cultivo. O presente trabalho objetivou avaliar a produtividade da cultura do milho semeado em diferentes espaçamentos entrelinhas. O experimento foi realizado em Angatuba, SP, com semeadura no dia 16 de dezembro 2019. Utilizou-se o híbrido P4285VYHR, adotando uma população de 65.000 plantas ha^{-1}. Os tratamentos avaliados constituíram-se de distintos espaçamentos entre linhas de cultivo, sendo: T1 - 0,2 x 0,7 m; T2 – 0,6 m; e T3 – 0,7 m. O delineamento experimental foi o de blocos, dispostos em faixas, com cinco repetições de 5 linhas com 5 m lineares cada. As variáveis avaliadas foram: o número médio de grãos por espiga (NGE); a massa de cem grãos (MHG); e a produtividade final (PROD). O T1 apresentou valor de NGE inferior aos demais tratamentos, 582,9 grãos, os quais apresentaram valores de 622,6 e 642,6 grãos por espigas nos tratamentos T2 e T3, respectivamente. Para a variável PROD, verificou-se que em T1 o resultado foi de 6586,0 kg ha^{-1}, proporcionando um aumento de 12,15% e 19,16% comparado a T2 e T3, respectivamente. Para MHG não houve variação significativa entre os tratamentos utilizados. Assim, o cultivo de milho em espaçamento duplo de 0,2 e 0,7 m resulta em maior produtividade de grãos.

Palavras-chave: *Zea mays*, linhas gêmeas, espaçamento reduzido, produção

INTRODUCTION

Due to the increase in world population and the higher demand for food, it becomes necessary to develop cultivation techniques aimed at greater productivity and improvement of the quality of the food produced (SAATH; FACHINELLO, 2018). Among the possible cultivation techniques that can raise the productivity of agricultural systems, the management practices linked to the manipulation of the spatial arrangements of plants stand out, mainly by alternating inter-row spacing, plant density, and distribution of plants in the row of cultivation (BALEM et al., 2014).

In the culture of corn (*Zea mays* L.), proper selection of spacing and densities interfere in the use of abiotic factors such as water, light and nutrients, allowing the crop a better use of these

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resources, maximizing its productive potential (BALEM et al., 2014). Furthermore, the spatial arrangement of crop plants can promote weed control, due to the accelerated closing of the crop canopy, reducing the incidence of solar radiation in between rows, which would be used for weed growth (ALVES, et al., 2019).

Another interference of modifications in the population density and row spacing of corn crops are related to the morphological characteristics of the plant. According to Ferreira et al. (2015), there may be an increase or decrease in diameter and height of the stalk, size and weight of the ear, height of the first ear and grain length, directly affecting the productivity of the crop.

The definition of ideal plant arrangements is very variable and constantly changing. In the 1990s, it was common for corn crops to be conducted in using a row spacing of 1.0 to 1.2 m due to the frequent use of animal traction in the implementation and management of crops (PEIXOTO et al., 2019). Over time, and especially with the advancement of agricultural mechanization and improvements imposed on the morphological characteristics of corn plants by genetic improvement processes, crops began to be deployed with spacing between rows between 0.4 and 0.9 m (ROSSI et al., 2017).

In the last few years reduced spacing has been adopted, ranging from 0.4 to 0.6 m. With these reductions, it was possible to make changes in the corn cultivation system by adopting practices aimed at high yields, such as the use of higher population densities, new fertilization technologies, phytosanitary management and the use of hybrids with high productive potential (BALEM et al., 2014).

However, so that the practice of reducing the spacing between planting rows and greater plant densification can lead to increased productivity, it is necessary to evaluate several factors such as water availability, soil fertility level, type of hybrid used, sowing season and investment capacity in management (SANGOI et al., 2019). For example, in the municipality of Alta Floresta, State of Mato Grosso, using a row spacing of 0.45 and 0.9 m was obtained a productivity of 8.5 and 7.2 t ha^{-1} respectively, having an increase of 17.2% of production with the reduction of row spacing (SILVA et al., 2014).

Besides the densification itself, the use of unconventional spacing has also been adopted in corn culture, among which stands out the sowing in twin rows. This practice consists of sowing in staggered rows with different spacing between each row. In this practice, two rows have been used, staggered at 0.2 m apart (MODOLO, 2015), and interspersed with 0.7 m between the twin rows

(BRIAN, 2010). According to Balem et al. (2014), this practice promotes an improvement in plant distribution compared to the conventional planting system and, consequently, attenuates the competition between plants, enabling an increase in productivity.

The objective of this work was to evaluate corn crop productivity using different rows spacings in the municipality of Angatuba, State of São Paulo.

MATERIAL AND METHODS

The experiment was conducted in a commercial cultivation area in the municipality of Angatuba, São Paulo State, located at the geographical coordinates 23.49° S and 48.26° W and 535 m altitude. The soil is classified as Red Latosol and the previous crop to the present experiment was sugarcane. The local climate is classified as Cwa according to the Köppen classification (ALVARES et al., 2013).

Prior to the installation of the experiment, soil was sampled at a depth of 0.2 m, the samples were sent to the *IBRA Ensaios Agronômicos* laboratory for soil chemical analysis, and it was verified that no soil correction was needed (Table 1).

Soil preparation was made with the aid of an intermediate harrow, the process was done twice two days before sowing. Land leveling was made with the aid of a light harrow, on the day of corn sowing, which occurred in December 16th, 2019, in a manual manner. The hybrid used was Pionner P4285VYHR, the seeds were distributed in order to standardize the population density of 65,000 plants ha^{-1}, regardless of the inter row spacings adopted. The fertilizer requirement was determined by soil analysis (Table 1) and was based on Bulletin 100 (RAIJ et al., 1997). Therefore, 250 kg ha^{-1} of chemical fertilizer (N-P-K at formula 8-28-16) was applied during the sowing. Besides, at 30 days after plant emergence, 260 kg ha^{-1} of urea with 45% N content was applied.

Table 1. Chemical characteristics of the soil in the experimental area (0-20 cm).

Chemical Analysis								
pH	P	K^+	Al^{3+}	Ca^{2+}	Mg^{2+}	CTC total	V	MO
$CaCl_2$	mg dm^{-3}			mmol$_c$ dm^{-3}			%	g dm^{-3}
6,1	8	6,0	0	83	29	156	76	15

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Three treatments with five (5) replications were used in the experiment. Treatment 1 (T1) consisted of corn cultivation using double spacing or twin rows, combining 0.2 and 0.7 m spacing between rows, treatment 2 (T2) had row spacing of 0.6 m and treatment 3 (T3) contained rows spaced at 0.7 m. The experimental design used was block layout, distributed in strips.

The experimental units consisted of five rows, with 5 linear meters each. As mentioned, seed distribution in each plot varied so that the final plant population was the same regardless of the spacing used, thus in T1, T2 and T3 29, 39 and 45 seeds were sown for every ten linear meters, respectively. To avoid interference between treatments a 2 m border was maintained between the blocks and plots.

Throughout the experiment there was no need to control pests and diseases. The necessary management was weed control, which occurred in January 16th, 2020, with the application of 4 L ha^{-1} of Roundup® Original DL, using a manual backpack pump.

On May 16th, 2020, the plants reached physiological maturity and the experiment was harvested manually. The harvesting procedure occurred in the three central rows of each replication. The average number of grains per ear (NGE) was evaluated, determined by simple counting of five ears randomly sampled in each plot; the mass of one hundred grains (MHG), determined by weighing 100 grains from each plot on precision scales; and the final productivity (PROD) of each plot, performed by weighing the total volume of grains harvested in the useful area, the value was converted to kg ha^{-1} and standardized at 13% of moisture in the grains, for better representativeness.

In possession of the data, for statistical analysis of all variables, after verifying the normality of the data using the Shapiro-Wilk test, analysis of variance (ANOVA) was performed for statistical analysis of all variables, with subsequent use of the Tukey test for comparison of means. Statistical analyses were performed using the R-Studio 4.0.5 software, ExpDes.pt package.

RESULTS AND DISCUSSION

The NGE showed that the highest values were obtained in the treatments with spacing of 0.6 and 0.7 m between the sowing row, with values of 622.6 and 642.6 grains per spike, respectively. Treatment 1 was inferior, with 582.9 grains per ear. According to Pieroson et al. (2016), the use of greater distances between plants reduces the interference of the leaves in the transfer of pollen grain to the ear, increasing the pollination rate, which may have occurred in this study.

Sangoi (2019), in an experiment conducted in the municipality of Lajes, Santa Catarina State, with the 2014/15 and 2015/16 crops, using a population of 50,000 plants and spacing of 0.8 m and 0.4 m between rows, obtained an average number of grains per corn ear of 640 and 600, respectively, agreeing with the results found in the present experiment. Similar results were found in the municipality of Aquidauana, Mato Grosso do Sul State, where the spacing of 0.9 m proved superior regarding the number of grains per ear, compared to the spacing of 0.45 m (TORRES et al., 2013). The authors attributed this fact to the greater length of the cob provided using wider inter-row spacing, consequently increasing the number of grains in the cobs.

Table 2. Corn yield variables as a function of sowing at different inter-row spacings. Angatuba, São Paulo State, 2019/2020 crop.

Treatment	Variables Evaluated					
	Number of grains per ear		Productivity (kg ha^{-1})		Mass of hundred grains (g)	
T1 (0.2 x 0.7 m)	582.9	b	6586.0	a	43.4	a
T2 (0.6 m)	622.6	a	5872.0	b	43.8	a
T3 (0.7 m)	642.6	a	5526.8	b	44.4	a
C.V. (%)	2.31		6.03		3.73	

Means followed by the same letter in the column do not differ by Tukey Test (P≥0.05).

Analyzing the corn crop productivity, it was verified that the use of double rows stood out from the other spacings, producing 6,586.0 kg ha^{-1}, which means an increase of 12.15 and 19.16% compared to T2 and T3, respectively (Table 2). This increase in productivity can be attributed to greater efficiency in capturing radiation and decreased competition for light, water and nutrients of the plants in the row, due to an equidistant distribution provided by the reduction of inter-row spacing, which increases the distance between plants in the row (BALEM et al., 2014).

The productivity values obtained in this study are within the values expected by the Institute of Agricultural Economics (IEA) for the 2019/20 crop in the state of SP, which was 5,218 kg ha^{-1} (IEA, 2020). However, these values are below those obtained in other studies and states, which is

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possibly related to population density. According to Balem et al. (2014), increases in corn crop productivity can be obtained when employing population densities higher than 85,000 plants ha^{-1}, with a limit of 95,000 plants ha^{-1}, and in this work 65,000 plants ha^{-1} was used.

In an experiment conducted in the municipality of Pato Branco, Paraná State, a higher productivity (12.6% more) was also obtained when the double spacing of 0.2 and 0.7 m was adopted, compared to the inter-row spacing of 0.7 m (BALEM et al., 2014).

According to Bettio et al. (2017), in an experiment carried out in the city of Cascavel,Paraná State, using the hybrid FAO200NK with double spacing of 0.2 and 0.4 m; 0.2 and 0.5; 0.2 and 0.7 and single spacing of 0.45 m, it was observed that the results of the double inter row of 0.2 and 0.7 m were higher than the others, reaching a production of 12,740 kg ha^{-1}, approximately 70% more compared to the average productions of the other spacings.

For the MHG variable there was no significant variation among the spacings, which showed values of 43.4; 43.8 and 44.4 g, for T1, T2 and T3, respectively (Table 2). In an experiment carried out in the municipality of Selvíria, Mato Grosso do Sul State, using spacing of 0.9 and 0.45 meters between rows, there was also no significant variation for the results of MHG (FERREIRA et al., 2015).

A similar result was found in an experiment conducted in the municipality of Cascavel, Paraná State, using the FAO200NK hybrid. No significant variation in the MHG variable was found (BETTIO et al., 2017). Torres et al. (2013) cites the same results in his experiment attributing what occurred to factors such as the type of hybrid, plant population, climatic characteristics of the region and the level of soil fertility, among others. According to Demétrio et al. (2008), the mass of one hundred (100) grains does not change as a function of inter-row changes, but changes in plant population can influence the results.

CONCLUSION

The twin-row spacing (0.2 x 0.7 m) resulted in higher grain yield of corn grown in the municipality of Angatuba-SP. Further studies increasing the population density in this spacing must be made aiming for higher grain yield values.

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