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EVALUATION OF DIFFERENT POPULATION ARRANGMENTS TO BE USED IN SOYBEAN CULTURE IN ORDER TO IMPROVE YOUR PRODUCTIVE SYSTEM

[1]Carlos A. Mariotti, [1]Leonardo Franzim, [*,1]Kleber L. Longhini, [2]Raíssa F. Matias, [2]Daniele F. Felipe, [2]Graciene S. Bido and [2]Anny R. Mannigel

[*,1]Agrarian Science Departament, Maringá University Center – Unicesumar, Maringá-PR, Brazi. 87050-900
[2]Master Program in Science, Technology and Food Safety at the Maringá University Center – Unicesumar, Research at ICETI – Cesumar Institute of Science, Technology and Innovation. Maringá-PR, Brazil. 87050-900

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***Corresponding author:** Ugariogu, S.N.,

ABSTRACT

Given the relevance of soybean culture in Brazilian agriculture, new sowing systems have been researched in order to improve its production system. Among these, the double row sowing technique is standing out as an alternative in which the spatial arrangement of plants can be reflected in significant increases in grain productivity. However, in relation to the effect of row spacing, there are conflicting results in the literature. Therefore, the main objective of the research was to evaluate the different population arrangements, in order to recommend the appropriate spacing for the productive system of this culture. The following population arrangements were evaluated in relation to the biometric parameters of soy: T1 = 50 cm between rows; T2 = 35 cm between the lines; T3 = 25 cm between lines T4 = 25 cm and 50 cm between parallel lines; T5 = 35 cm and 70 cm between parallel lines. Through the statistical analyzes performed, the response variables assuming a fixed effect, were not responsive to the adoption of the double row planting system. In order to facilitate the management and sowing of the crop, conventional planting adopting single lines with both 35cm between rows and 25cm stands out above the others.

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INTRODUCTION

Soy is a plant belonging to the legume family, scientifically called *Glycine max*, whose center of origin is China, where it has been used as a food source for nearly five thousand years (TONISSI *et al*., 2013). Among the main benefits of its consumption, both in the animal and human diet, is its high content of total digestible nutrients between 90 to 100% and high content of crude protein around 42% (CÂMARA, 2012).
In economic terms, the crop occupies about 57% of the arable area in Brazil, with the country being the second largest world producer with approximately 120 million tons in the 2018/2019 harvest (CONAB, 2019). In view of the economic, food and social relevance that the crop has for Brazilian agriculture, new soybean sowing systems are being researched, in order to improve its production system and obtain greater grain productivity. Among these studies, the double row sowing technique stands out, in which the spatial arrangement of soybean plants, through the spacing between rows and plant density, can be reflected in significant increases in grain productivity, without changes in sustainability of production systems (ASSIS *et al*., 2014). The positive results obtained with the adjustments in the plant arrangement of the crops are associated, according to Rambo *et al*. (2002) to several factors, such as: greater use of water, due to the faster closing of the canopy and reduction of losses through evaporation; greater ground cover; better horizontal root distribution; reduction of intraspecific competition; increased use of nutrients present in the soil; and greater interception of solar radiation by plants. In addition, according to Bruns (2011), the improvement in the photosynthetic rate and greater longevity of leaves close to the soil maximize the production of grains. However, some researches have been showing a low response of the soybean crop to variations in plant density (HEIFFIG *et al*., 2006; PROCÓPIO *et al*., 2013). Regarding the effect of row spacing, there are conflicting results in the literature (RAMBO *et al*., 2002; HEIFFIG *et al*., 2006), as this response is dependent on the cultivars and the cultivation environment. According to some authors, the change in the spatial arrangement of plants, determined by the spacing between rows and the density of

plants, can affect intraspecific competition and, consequently, the amount of environmental resources (water, light and nutrients) available for each plant, which may influence grain yield (COX *et al*., 2010; WALKER *et al*., 2010). In addition, it can affect the speed of closing the rows (SILVA *et al*., 2013), the production of phytomass (COX & CHERNEY, 2011), the architecture of plants (PROCÓPIO *et al*., 2013), the severity of diseases (LIMA, 2012) and lodging (BALBINOT, 2013). Considering that soy has great economic, social and food importance, this work is necessary in order to provide more technical information to farmers, in order to enable them to improve their production system, aiming to meet the demand of the crop in the global market. Considering the following scientific hypotheses: H0 = The soybean productivity does not differ significantly from the control with double row cultivation, H1 = At least one of the double row treatments differs statistically from the control. The main objective of the research was to evaluate the productivity of the soybean crop through the different population arrangements, in order to recommend the adequate spacing for the productive system of this crop.

MATERIALS AND METHODS

The work was carried out in the municipality of Marialva-PR, Brazil. Marialva has a climate called subtropical, with an annual average of 22ºC; and semi-humid, with an average of 1,590 mm of annual rain. The lowest temperatures are between May and July, while the highest temperatures are between November and March (DEFFUNE *et al*., 1994). Regarding the predominant soil in the region, it has the following classification: Dystrophic Red Latosol, with 200, 200 and 600 g kg-1 of sand, silt and clay, respectively (SANTOS *et al*. 2018). The cultivar used for the experiment was Garra 6364, from Brasmax, planted on September 13, 2019 and harvested on January 26, 2020, totaling 136 days in the field. The experimental unit consists of an area of 25 m2, with a complete randomized block design. To carry out the research, five different spacings were evaluated, with each treatment containing 8 repetitions. It is important to highlight that during the conduct of the experiment the plant population in the area remained constant at 400.000 plants per hectare, with only the different population arrangements being tested.

The treatments were as follows:

T1 = 50 cm between the rows
T2 = 35 cm between the rows
T3 = 25 cm between the rows
T4 = 25 cm within the double rows and 50 cm between the rows
T5 = 35 cm within the double rows and 70 cm between the rows

Based on the methodology established by BENINCASA (1988), the following biometric parameters were analyzed:

Height: The height of the plant was determined by measuring in meters, the distance from the plant's neck to the stem apex.

Dry matter: Determined as the weight of the root, stem and leaves after being in the oven for 48 hours, at a temperature of 85-95 degrees Celsius.

Yield: Determined as the weight of the grains harvested from each treatment, after threshing the plants.

Number of pods per plant: The number of productive pods each treatment had was counted and the average per plant was found.

Number of stems and branches: In relation to these response variables, the number of productive stems and branches that each plant had was quantified and subsequently averaged for each treatment.

After data collection, the assumptions were verified and after they were met, the analysis of variance (assuming fixed effect) and the Scott Knott test were performed, with a 5% probability for evaluating the treatments and the respective variables analyzed responses (BANZATTO and KRONKA, 2008). The analyzes were carried out using the Genes statistical program (CRUZ, 2006). In order to give greater reliability to the results obtained, the variables that present a significant difference in the treatments analyzed in relation to the control will still be subjected to a second statistical analysis by the test of contrasts by orthogonal polynomials, with the objective of verifying whether the significance of the same through the studied variable occurred due to the effect of one treatment alone or two treatments together, considering that this test is a cluster test. The analyzes were carried out using the Genes statistical program (CRUZ, 2006).

RESULTS AND DISCUSSION

The results of the response variables analyzed during the experiment are shown in Table 1. As can be seen in Table 1, in relation to the variables responses of: productivity; dry matter production and number of pods per plant, there was no significant difference between the different spacing evaluated at work. According to Pires *et al*., (2000), this can be explained by the soybean's ability to present characteristics of high plasticity, that is, its ability to adapt to environmental and management conditions, through changes in the plant's morphology and income components. In relation to the variable response of the number of nodes per branch, its increase did not result in a significant difference in the number of pods and the final production of the plant, possibly some environmental factor during the experiment hindered the flowering of the plants and their analysis variable responses. However, the results are close to those observed by Freitas *et al*. (2010), who worked with six strains of the Soy Improvement Program of the Federal University of Uberlândia (UFU) and four commercial cultivars (Chapadões, Luziânia, Msoy 8411 and Msoy 8914), found that population density did not influence grain productivity of the evaluated genotypes. Purcell *et al*. (2002) demonstrated that the soybean crop yield does not increase at high population densities, due to the decrease in the efficiency of radiation use by plants.

Regarding the analysis of contrast by orthogonal polynomials for the response variables that showed a significant difference, the results are shown in Table 2. As can be seen in Table 2, the contrast test by orthogonal polynomials showed significance only for the variable height of the plant, significance with a p value of 0.0028, giving greater data reliability. Through this technique we can observe that the difference expressed in the plant heights, with a reduction in size in treatment T4 and T5 in relation to treatment T2 and T3 happened due to the use of a

Table 1. Evaluation of biometric parameters through different spacing in soybean in T1 treatments = 50 cm between the rows; T2 = 35 cm between the rows; T3 = 25 cm between the rows T4 = 25 cm within the double rows and 50 cm between the parallel rows; T5 = 35 cm within the double rows and 70 cm between the parallel rows

FV	GL	QM (Height)	QM (Num. of branches)	QM (Num. of knots per branches)	QM (Number of pods)	QM (Productivity)	QM (DryMatter)
Tratments	4	0.007220**	0.570*	3.375*	20.75^{ns}	0.007195^{ns}	0.0275^{ns}
Error	15	0.001385	0.16667	0.8333	16.45	0.007985	0.0130
Total	19						
Media		1.02	2.4	11	85.25	1.435	1.701
CV (%)		3.64	17.01	8.30	4.76	6.23	6.71
Pr>Fc		0.0078	0.0345	0.0201	0.3282	0.4878	0.1296

** significant at the 1% probability level; * significant at the 5% probability level, ns: not significant at the 5% probability level by the F. FV test: Source of Variation; GL: degree of freedom; QM: medium square; CV: coefficient of variation; Pr> Fc: P-value.

Table 2.Comparison of biometric parameters assuming fixed effect by the Scot-Knott test

Treatments	height (m)	Number of branches	Num. Of knots per branches	Number of pods	Productivity (kg.ha^{-1})	Drymatter (kg/plant)
1	1.08a	2.5 a	10.8 b	85.5 a	1.3937 a	1.662 a
2	1.05a	2.0 b	12.5 a	88.3 a	1.4760 a	1.702 a
3	1.08a	2.8 a	10.0 b	82.0 a	1.4835 a	1.825 a
4	0.99b	2.0 b	10.8 b	84.5 a	1.3982 a	1.719 a
5	1.00b	2.8 a	11.0 b	86.0 a	1.4245 a	1.599 a
CV (%)	3.59	19.02	9.13	4.72	6.64	7.33

* Means followed by distinct letters in the column, differ from each other at the level of 5% by the Scott-Knott test.

Table 3. Treatment cluster analysis using the orthogonal polynomial contrast technique

Contrast	Response Variable	Fcal	Pr>Fc
(T2 + T3) vs (T4 + T5)	Height	14.005**	0.0028
(T2 + T3) vs (T4 + T5)	Numberofbranches	0	1
(T2 + T3) vs (T4 + T5)	Numberofknots per branch	1.776	0.4695

greater spacing between parallel rows, and not due to the effect of spacing within the rows. Probably the alteration of the spatial arrangement provided by the application of treatment 4 and 5 altered the culture's capacity to absorb solar radiation and consequently its photosynthetic use, thus contributing to the reduction of plant height. The use of reduced spacing between rows, keeping the same plant population per area, resulted in equidistant plant distributions. This more equidistant condition provided less competition for light at the beginning of the plant's life cycle, reducing the shade between soybean plants and contributing to a better vegetative development of the plants (PROCÓPIO *et al*., 2013), providing higher treatment heights 2 and 3 in relation to treatments 4 and 5. Regarding the variables number of branches and number of nodes per branch, although it gave a significant difference by the Scott Knott average test at 5% probability, these variables when submitted to the cluster test did not show the same response, indicating that for these variables there was no difference between conventional cultivation (T2 and T3) and double rows (T4 and T5). According to Caliskan *et al*. (2007), there is no ideal spacing and density of soybean plants for all environments and cultivars, being relevant the observation of the interaction between plant spacing and density for each cultivation condition. Norsworthy and Shipe (2005) ratify this information, emphasizing the need to group genotypes that respond or not to the spacing reduction, optimizing the potential of the cultivar. According to Edwards *et al*. (2005), cultivars that have compact plants and that reach full grain filling before 80 days after emergence require greater plant densities in relation to later cultivars that have high branching.

Conclusion

It is concluded through this research that maintaining the same population of plants per hectare, the different population arrangements analyzed did not contribute significantly to the optimization of the productive system of the culture using these technologies. The only variable that showed a significant difference when analyzed was the height of plants that showed higher values in treatments with double rows than conventional treatments, however this difference did not contribute to a direct increase in plant production. Therefore, in view of the facts and taking into account the two statistical analyzes carried out, for the variable responses analyzed assuming a fixed effect, the soybean culture was not responsive to the technology analyzed. In order to facilitate the management and the planting system, conventional planting adopting single rows with both 35 cm between rows and 25 cm stands out above the others.

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