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Planting Density and Soybean (*Glycine max* L.) Cultivars Effects on Yield Components in the Amazon

Priscila Pereira Sacramento

Institute of Agrarian Sciences, Federal Rural University of Amazon, Paragominas, Pará, Brazil. E-mail: priscila.sacrame@gmail.com

Letícia Cunha da Hungria (Corresponding Author)

Soil department, Institute of Agrarian Sciences, Federal Rural University of Amazon, Belém, Pará, Brazil. E-mail: leth_hungria@hotmail.com

Jamil Chaar El-Husny

Empresa Brasileira de Pesquisa Agropecuária, Belém, Pará, Brazil.

E-mail: jamil.husny@embrapa.br

Luis de Souza Freitas

Institute of Agrarian Sciences, Federal Rural University of Amazon, Paragominas, Pará, Brazil. E-mail: luisfreitas@ufra.edu

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Abstract

The aim of this study was to evaluate the influence of planting density and cultivar of soybean on yield components in the southeast Amazon. The experiment was carried out in an Oxisol, with a randomized block design in a 2 x 4 factorial scheme. The treatments were two soybean cultivars (BRS 9090 RR and BRS 8990 RR) and four planting densities (13, 15, 18 and 20 plants m^{-1}), with three replications. First pod insertion height (IFP), plant height (H), number of pods per plant (NPP), grain yield (Y) and weight of 100 grains (W100) were evaluated. The insertion height of the first pod showed a tendency of increase with the increment of plants per linear meter for cultivar BRS 8990 RR, different of the behavior observed for the cultivar BRS 9090 RR, which only showed difference when the density of

300.000 plants ha^{-1} was tested. For plant height, among soybean cultivars, there was only difference in D400, with BRS 8990 RR showing a maximum height of 83.3 cm, 21% higher than BRS 9090 RR. When evaluated under D350, BRS 8990 RR showed an increase of 13% in the number of pods compared to BRS 9090 RR. Both cultivars showed linear behavior for the grain yield, increasing according the plant population, with the highest grain yield obtained under the density of 400.000 plants ha^{-1} (4527.3 kg ha^{-1}). The weight of 100 grains was not influenced by any variation factor.

Keywords: Glycine max, cultivars, yield

1. Introduction

Soybean (*Glycine max* L.) is one of the main oilseed commodities grown in the world and has great socioeconomic importance for Brazil, which is one of the main producers. Alongside beans and peanuts, soybeans are considered the main crop among leguminosae (Henriques Neto *et al*., 1998). The chemical composition of soybeans, with high protein content, is one of the reasons for its utilization for human food and agroindustrial application, including agricultural input industries (Mauad *et al.*, 2010).

The highlight of soybeans in brazilian agribusiness is mainly associated with its high productive potential in different regions of the country. Achieving maximum productivity is the main objective in crop planning and it depends, besides the edaphoclimatic conditions, on the various management techniques employed (Cruz *et al*., 2016).

For Assis *et al*. (2014), among the practices adopted to obtain higher productivity, the choice of planting density and the best arrangement between plants are highlighted as potential tools. Tourino *et al*. (2002), also highlight the plant population per linear meter as one of the factors that most influence productivity, because competition of plants for water, nutrients and light may occur in function of the chosen density.

Thus, studies have shown the importance of knowing the ideal planting density (Peixoto *et al*., 2002 Mauad *et al*., 2010; Assis *et al*., 2014; Cruz *et al*., 2016) and cultivar (Perini *et al*., 2012) for a given region whose characteristics have an effect on crop performance. The aim was to evaluate the influence of soybean planting density and cultivar on yield components in the Amazon southeast.

2. Materials and Methods

2.1 Description of the Study Location

The study was conducted from February to August of 2015 in the experimental area of Embrapa Eastern Amazon, Paragominas city (02º 59 ’45” S and 47º 21’ 10” W). The climate region is tropical rainy (Aw, according to the Köppen classification), with a rainy season beginning in December, extending until May, and lower water availability between June and November. The average annual precipitation is 1.800 mm, the annual relative humidity is 82% and the average temperature is 26.3 ºC (Rodrigues *et al*., 2003). The soil in the experimental area was classified as Oxisol (Embrapa, 2011), whose physical and chemical properties are presented in Table 1.

Table 1. Physical and chemical properties in the 0.2 m deth of the soil at the study área

pH	Total P	K	Ca	Ca+Mg	Al	H+Al	CEC	V	Sand	Silt	Clay
H_2O	mg dm^{-3}		$cmol_c$ dm^{-3}					%	g kg^{-1}		
5.5	2	31	3.6	5.2	0.1	4.8	4.8	47	34	286	680

2.2 Treatments and Experimental Design

The study design was a 2x4 factorial in randomized blocks. The treatments consisted of two soybean cultivars (BRS 9090 RR and BRS 8990 RR) and four planting densities, with three replications. The corresponding plant populations were 250.000, 300.000, 350.000 and 400.000 plants ha^{-1} for the densities of 13, 15, 18 and 20 plants m^{-1}.

The area had been made up of four lines of 5.0 m in length, spaced 0.5 m between the lines. Two useful plant lines were used to evaluate grain yield at harvest, discounting 0.5 m from each extremity, and the others were used for other evaluations or constituting the borders.

2.3 Field Planting and Maintenance

All plots received liming (300 kg ha^{-1} dolomitic limestone under haul), 100 kg ha^{-1} of P_2O_5 and 50 kg ha^{-1} of K_2O at sowing, mixed and distributed in the furrow. The sources used were monoammonium phosphate (MAP) and potassium chloride, respectively. In addition, maintenance fertilization with 172 kg ha^{-1} of MAP and 150 kg ha^{-1} of potassium chloride (KCl) was performed in the planting line. At the time of planting, seeds were inoculated with *Bradyrhizobium japonicum* strains, in order to obtain a good nodulation of the plant roots, ensuring nitrogen supply to the crop.

The seeds were treated with 200 mL Standak Top fungicide (Piraclostrobin + methyl thiophanate + Fipronil) for 100 kg of seeds.

2.4 Data Collection

Five plants were selected by accessing the two central collection lines for data collection on first strip insertion height (cm), plant height (cm), number of pots per plant, grain yield (kg ha^{-1}) and weight of 100 grains (g). A grain mass was corrected to 13% humidity.

2.5 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) to determine the effects of distinct planting densities of soybean cultivars, as well as the interaction of factors on the measurements. Significant treatment means were compared by Tukey test at 5% of probability.

3. Results and Discussion

The effects of planting density on the yield components of soybean cultivars are presented in Table 2. There was no interaction between cultivars and planting densities on the studied variables, except for the number of pods per plant. Evaluating the cultivars in isolation, it was observed that there was significant effect for plant height and number of pods per plant, while the adoption of different densities did not influence the weight of 100 grains.

Table 2. Means of first pod insertion height (IH), plant height (H), number of pods per plant (NPP), grain yield (Y) and weight of 100 grains (W100) in two soybean cultivars at four planting densities

Variation factor	IH (cm)	H (cm)	NPP	Y kg ha^{-1}	W100 g kg^{-1}
Cultivars (C)	0.71^{ns}	4.89^{*}	14.98^{*}	0.11^{ns}	0.23^{ns}
Density (D)	16.33^{*}	10.04^{*}	9.87^{*}	29.89^{*}	1.03^{ns}
C x D	1.09^{ns}	3.00^{ns}	4.04^{*}	1.52^{ns}	1.67^{ns}
CV (%)	9.38	9.14	15.20	6.79	9.17

ns = not significant; * = significant at 5% probability to F test.

The height of insertion of the first pod showed a tendency of increase with the increment of plants per linear meter for cultivar BRS 8990 RR, not the same behavior for cultivar BRS 9090 RR, which only showed difference when the density of 300.000 plants ha^{-1} was used of the other treatments (Table 3). For BRS 8990 RR, there was an increase of up to 36% in height when compared to lower (D250) and higher densities (D350 and D400). The study of this variable is fundamental for the definition of plant suitability for mechanized grain harvesting (Medina, 1994). For Sediyama *et al*. (1999), the ideal range of height is between 10 and 12 cm. Queiroz *et al.* (1981) considers that this height must be at least 13 cm in order to reduce losses during harvest.

For plant height, among soybean cultivars, there was only difference in D400, with BRS 8990 RR showing a maximum height of 83.3 cm, 21% higher than BRS 9090 RR (68.7 cm) (Table 3). BRS 9090 RR showed no difference in relation to the planting density. On the other hand, cultivar BRS 8990 RR showed linear growth as planting density increased, reaching a higher height when the plant population per hectare was 400.000. The higher growth of plants subjected to higher planting density may be associated with the increased intraspecific competition that this environment provides, mainly by light, resulting in blunt plants (Mauad *et al*., 2010; Cruz *et al*., 2016).

Table 3. Average values of first pod insertion height in plants of two soybean cultivars, at four planting densities

	BRS 9090 RR	BRS 8990 RR	
Density (plants ha^{-1})	First pod insertion height (cm)		Mean
D250	12.0 Aba	11.0 Ba	11.5 B
D300	10.7 Ba	11.0 Ba	10.8 B
D350	14.0 Aa	15.3 Aa	14.7 A
D400	14.0 Aa	15.0 Aa	14.5 A
Mean	12.7 a	13.1 a	12.9
	Plant height (cm)		Mean
D250	62.7 Aa	57.0 Ba	59.8 B
D300	58.3 Aa	64.3 Ba	61.3 B
D350	58.0 Aa	64.3 Ba	61.2 B
D400	68.7 Ab	83.3 Aa	76.0 A
Mean	61.9 b	67.3 a	64.6

Means followed by the same uppercase letter in the column and lowercase in the row do not differ from each other by the Tukey test at 5% probability.

The variations observed in the number of pods per plant showed that, while the cultivar BRS 9090 RR, guaranteed superior number of pods (92.7) under D350, BRS 8990 RR had better performance for this variable under D350 and D400 (Table 4). When evaluated under D350, BRS 8990 RR showed a 13% of increase in the number of pods compared to BRS 9090 RR. Both cultivars showed a tendency to increase the number of pods with increasing density up to 350.000 plants ha^{-1}, with smaller variation of BRS 8990 RR between D350 and D400. The number of pods per plant is one of the main components of soybean production (Vernetti, 1983). However, this component, when evaluated in isolation, is not sufficient to ensure the yield potential of the crop, as it still depends on the ability of the plant to fill the pods with grains (Peixoto *et al*., 2002).

Table 4. Average values of number of pods per plant in two soybean cultivars, cultivated in four planting densities

	Density (plants ha^{-1})				
Cultivars	D250	D300	D350	D400	Mean
BRS 9090 RR	46 Bc	77 Ab	92,7 Aa	64 Bb	69.9B
BRS 8990 RR	77 Ab	72 Ab	104 Aa	103 Aa	89A
Mean	61.5c	74.5bc	98.3a	83.5ab	79.5

Means followed by the same uppercase letter in the column and lowercase in the row do not differ from each other by the Tukey test at 5% probability.

The cultivars studied under the four densities presented satisfactory yields, ranging from 3.262 to 4.726 kg ha^{-1} (Table 5). Both cultivars showed linear behavior as the plant population increased, with the highest grain yield obtained under the density of 400.000 plants ha^{-1} (or 20 plants m^{-1}), with an average of 4527.3 kg ha^{-1}. There was no difference between cultivars, regardless of the density used. Cruz *et al*. (2016), when evaluating soybean yield in density of up to 22 plants m^{-1} also registered linear behavior for this variable.

Table 5. Grain yield (kg ha^{-1}) and weight of 100 grains (g) in two soybean cultivars under four planting density

Density (plants ha^{-1})	Cultivars BRS 9090	BRS 8990	Mean
Grain yield (kg ha^{-1})			
D250	3262.98 Ca	3306.47 Ca	3284.66 C
D300	3518.63 BCa	3323.76 Ca	3421.33 C
D350	4119.88 Aba	4013.79 Ba	4067.00 B
D400	4327.49 Aa	4726.63 Aa	4527.33 A
Mean	3837.33 a	3842.83 a	3894.25
	Weight of 100 grains (g)		Mean
D250	13.93 Aa	12.07 Aa	13.00 A
D300	12.27 Aa	12.20 Aa	12.23 A
D350	12.03 Aa	12.00 Aa	12.02 A
D400	12.33 Aa	13.40 Aa	12.87 A
Mean	12.64 a	12.42 a	12.53

Means followed by the same uppercase letter in the column and lowercase in the row do not differ from each other by the Tukey test at 5% probability.

The weight of 100 grains was not influenced by any variation factor in this study, even if changes are expected mainly due to the cultivars, since this genetic trait has high heritability (Table 5).

4. Conclusion

At higher densities (D350 and D400), soybean plants showed higher yield, except for the 100 grain mass that was not influenced by any of the factors studied. BRS 8990 RR showed better performance under amazon edaphoclimatic conditions.

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