

## Short Research Articles

# Influence of different population densities in the production performance of azuki beans lineages

### ABSTRACT

The demand for azuki beans has increased because it is indicated to combat diabetes, it presents high levels of phytochemicals, bioactive compounds and phenolics, but Brazil still has enough product to meet its demand. The objective of this research was to evaluate the influence of different population densities in the production performance of azuki beans lineages. The experimental design used was in randomized blocks, in the factorial scheme (2 x 3) with four replications. They were evaluated six treatments, constituted by the combination between two Azuki bean lines, the L1 lineage (obtained commercially) and lineage L2 (obtained from farmer) and three population densities, 500 thousand plants.ha<sup>-1</sup> (through the spacing 0.3m x 0.2m), 375,000 plants.ha<sup>-1</sup> (through the spacing 0, 4m x 0.2m) and 300,000 plants.ha<sup>-1</sup> through the spacing 0.5m x 0.2m). The population density of 500 thousand plants.ha<sup>-1</sup> provided a higher yield of grains in relation to the other population densities, reaching grain yield of 2222.22 kg.ha<sup>-1</sup>, however a tendency was observed that above population densities of 500,000 plants.ha<sup>-1</sup> could have even greater yields.

**Keywords:** *Vigna angularis*, line spacing, genotypes, population of plants, sowing densit.

### 1. INTRODUCTION

In Brazil the beans is among the main grain crops produced, with an estimated production of 3 million tons for the 2016/2017 harvest. For being a crop low cost of production, the beans is the main source of protein in the poorest populations. Due to all its relevance, the beans are cultivated in all brazilian states [1].

The bean is a cultivated crop in almost all countries of tropical and subtropical climate, being the constituent of great importance in human food, which is related to its low cost of production and its nutritional characteristics [2].

Among the genus of beans, the genus vigna contains about 160 species, where only seven are cultivated, among them the azuki bean [*vigna angularis* (willd.) Ohwi & Ohashi], which has its origin in the asian continent being widely consumed in china, japan and korea, being introduced in brazil by the japanese [3].

Several researchers report the functionalities of the azuki bean, being indicated to combat diabetes, due to its hypoglycemic effect, they also present high levels of phytochemicals,

bioactive compounds and phenolics, which help to promote health and prevent various diseases, besides presenting price higher than the common bean, thus increasing the economic return of the crop [4, 5 and 6]. Even though a food with many functionalities, Brazil still has a low consumption in relation to other countries, however the demand for this product is increasing, reaching the demand to surpass the supply at some times of the year [7].

In order to meet the growing demand, it is necessary to increase the production of azuki bean, which involves the introduction of genotypes adapted to the growing region and for a more efficient management of the crop, such as the adequate population density, because despite its big importance, the culture still presents a shortage of this information [8].

With the introduction of new cultivars the probability of identifying superior genotypes is increased, adapted to the edaphoclimatic conditions of the region and exhibiting good agronomic characteristics. In this way, it is possible to obtain better options for the cultivation, which will result in greater productivity [9].

Adequate population density is fundamental for the efficiency of the factors of production and the maximization of the productive potential of the cultivar, where the scarcity or excess of plants per area is a determining factor for low productivity. Therefore, the knowledge of the optimum combination between the population density and the cultivar to be used in each production system is essential for the culture to express its full potential, being that this knowledge becomes more relevant in more technified systems [10].

The scarcity of information in the literature regarding lineages and population density causes a gap for the proper management of the azuki bean, thus, the present work had the objective of evaluating the influence of different population densities on the productive performance of azuki bean lineages.

## 2. MATERIAL AND METHODS

### 2.1 local

The experiment was conducted in the experimental field of the agricultural sciences center of the federal university of Alagoas (CECA/UFAL), located in the municipality of Rio Largo-al (09 ° 28'02 "s, 35 ° 49'43" w), where according to [11], the soil is classified as argisolic cohesive yellow latosol of medium-clayey texture. According to the classification of Köppen, the climate of the municipality is type as, rainy tropical climate with dry summer, with annual average temperature and rainfall between 24 to 26 °C and 1300 to 1600 mm, respectively [12].

### 2.2 Experimental Design and Treatments

The experimental design used was in randomized blocks, in the factorial scheme (2 x 3) with four replications. They were evaluated six treatments, constituted by the combination between two azuki bean lines, the I1 lineage (obtained commercially) and lineage I2 (obtained from farmer) and three population densities, 500 thousand plants.ha<sup>-1</sup> (through the spacing 0.3m x 0.2m), 375,000 plants.ha<sup>-1</sup> (through the spacing 0, 4m x 0.2m) and 300,000 plants.ha<sup>-1</sup> through the spacing 0.5m x 0.2m). The area was divided in four blocks with a total of 24 experimental plots, each plot was constituted by 4 lines of 5m in length, with 75 plants per line, totaling an area of 6m<sup>2</sup> for the density of 500,000 plants.ha<sup>-1</sup>, of 8 m<sup>2</sup> for the density of 375 thousand plants.ha<sup>-1</sup> and 10 m<sup>2</sup> for the density of 300 thousand plants.ha<sup>-1</sup>, being

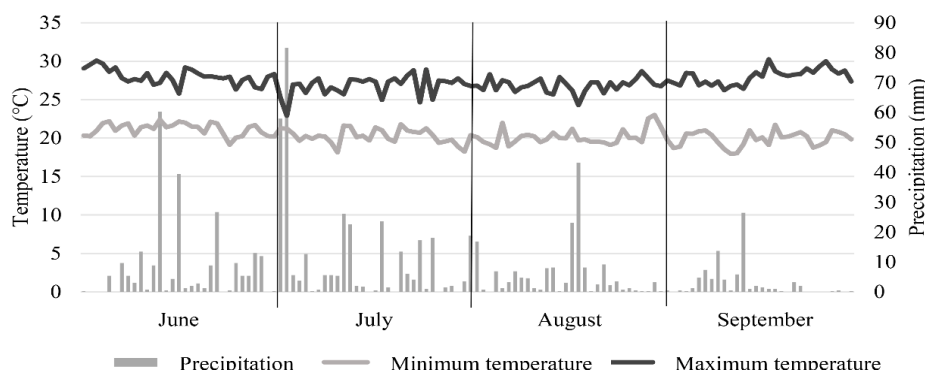
74 considered as the useful area for data collection the two central rows, discarding the first six  
75 and the last six plants of each end.

## 76 2.3 Soil and Date

77 Initially, prior to the preparation of the experimental area, sampling was carried out  
78 composed of soil, 0-20 cm deep, to characterize the chemical properties of the soil, which  
79 were  $\text{ph} = 5,7$ ,  $\text{m.o.} = 1,67\%$ ,  $\text{na} = 38\text{ ppm}$ ,  $\text{p} = 13\text{ ppm}$ ,  $\text{k} = 83\text{ ppm}$ ,  $\text{ca} = 2,6\text{ meq/100 ml}$ ,  
80  $\text{mg} = 1,8\text{ meq/100 ml}$ ,  $\text{al} = 0,04\text{ meq/100 ml}$ ,  $\text{h+al} = 4,0\text{ meq/100 ml}$ ,  $\text{base sum (sb)} = 4,8$   
81  $\text{meq/100 ml}$ ,  $\text{ctc} = 8,8\text{ meq/100 ml}$ ,  $\text{base saturation (v)} = 54,4\%$ ,  $\text{fe} = 236\text{ ppm}$ ,  $\text{cu} = 0,37$ ,  $\text{zn}$   
82  $= 1,79\text{ ppm}$  e  $\text{mn} = 11,40\text{ ppm}$ .

83 Soil preparation was carried out with a harrowing, no soil correction is required. At the time  
84 of sowing was performed a chemical fertilization on foundation with  $30\text{ kg.ha}^{-1}$  of n and  $30$   
85  $\text{kg.ha}^{-1}$  of p2o5.

86 The sowing was carried out on 02/06/2013, in a manual way, where 300 seeds were  
87 distributed per plots, the where each 0.20 m 3 (three) seeds were distributed evenly and the  
88 thinning was not done, remaining 15 plants per linear meter. The control of weeds was done  
89 through manual weeding (hoeing), with a total of two operations during the crop cycle. It was  
90 recorded during the experiment the maximum and minimum temperatures, as well as  
91 precipitation (figure 1).



92  
93 **Figure 01. Daily records of maximum temperature, minimum temperature and**  
94 **precipitation during the experiment, from June to September 2013, in the municipality**  
95 **of Rio Largo-AL.**  
96

97 During the crop cycle irrigation was performed whenever the crop presented water stress,  
98 even if the experiment was implemented in the rainy season, irrigation was necessary due to  
99 the summers periods. The azuki bean harvest started to 78 days and was carried out in  
100 three stages in view of the unevenness of the maturing of the pods. The first harvest was  
101 carried out on August 20, 2013 and the rest followed an interval of 7 days and the last  
102 harvest was 92 days after sowing. The harvest was done collecting 126 plants, useful area  
103 of each plot.

## 104 2.4 Evaluated Parameters

105 To evaluate the productive performance of the strains, the following characteristics were  
106 evaluated: number of pods per plant (NVP) in unit; length of pods (CV) in cm; number of

seeds per pod (NSV) in unit; weight of one hundred grains (PCG) in g; weight with seed pods (PVCS) in kg.ha<sup>-1</sup>; weight of bark (PC) in kg.ha<sup>-1</sup> and grain yield (RG) in kg.ha<sup>-1</sup>.

## 2.5 Statistical Analysis

The results of the experiment were submitted to analysis of variance and when statistical significance was reached, the means of the treatments were submitted to the Tukey test (P = 0.05) using the AgroEstat computational application [13].

## 3. RESULTS AND DISCUSSION

The variables length of vargem, number of seeds per vargem and weight of one hundred grains presented significant differences between the lineages at the level of (P = 0.01) of probability by the test f and weight of vargem with seed and yield of grains at the level of (P = 0.05) of probability by the test test f. In the same way, population densities had a significant effect on the lineages for the variables vargem weight with seed and grain yield at the (P= 0.05) and (P = 0.01) probability levels by the f test, respectively. It is worth noting that the interaction between lineages x population densities did not present a significant difference by the f test at (P = 0.05) probability for all variables evaluated (table 1).

**Table 1. Summary of analysis of variance and coefficients of variation for the variables evaluated at 92 days after planting on the influence of different population densities on two lineages of azuki bean, Rio Largo-AL, 2014.**

| FV                        | QM      |        |        |        |             |             |
|---------------------------|---------|--------|--------|--------|-------------|-------------|
|                           | NVP     | CV     | NSV    | PCG    | PC          | RG          |
| Lineages (L)              | 0.20ns  | 1.31** | 2.43** | 4.22** | 26811.52ns  | 1120664.34* |
| Population densities (DP) | 14.80ns | 0.02ns | 0.28ns | 0.25ns | 186366.17ns | 1009765.67* |
| Interaction L x DP        | 2.39ns  | 0.03ns | 0.42ns | 0.46ns | 133468.90ns | 111348.27ns |
| Blocks                    | 4.40    | 0.45   | 0.18   | 0.29   | 119868.91   | 305364.25   |
| Residue                   | 4.83    | 0.09   | 0.24   | 0.14   | 91113.39    | 223412.29   |
| CV                        | 23.87   | 2.70   | 5.96   | 4.55   | 33.73       | 25.68       |

ns, \*\* e \* Not significant at (P = 0.05) probability, significant at (P=0.01) probability, significant at (P = 0.05) probability, respectively, by the F test. <sup>1/</sup> number of pods per plant (NVP) in unit; length of pods (CV) in cm; number of seeds per pod (NSV) in unit; weight of one hundred grains (PCG) in g; weight with seed pods (PVCS) in kg.ha<sup>-1</sup>; weight of bark (PC) in kg.ha<sup>-1</sup> and grain yield (RG) in kg.ha<sup>-1</sup>.

For the number of pods per plant, no differences were observed between lineages and the population densities, with an overall mean of 9.2 (Table 2). Noting the agronomic performance of the lineages, seen what [14] obtained na average of 8.09, this difference being related to temperature, where the experiment of the present work was installed in a warmer region in that of [14], being that the azuki bean presents its best development in higher temperatures [8]. In relation to the population densities, something interesting was observed in the present study and going against the results of other studies, where the population density of 500 thousand plants.ha<sup>-1</sup> did not show any difference between the others in relation to the number of vargem per plant, disagreeing with [15, 10 and 16], who observed decrease of the number of vargem as the population density in common bean was increased, indicating that the azuki bean supports higher population densities.

144 **Table 02. Comparison of lineages averages and population densities for the variables**  
 145 **evaluated in azuki bean, Rio Largo-AL, 2014.**

| Lineages                        | NVP <sup>2/</sup> | CV                    | NSV    | PCG    | PC      | RG         |
|---------------------------------|-------------------|-----------------------|--------|--------|---------|------------|
| L1                              | 9.11              | 11.59 a <sup>1/</sup> | 8.70 a | 8.74 a | 928.14  | 2056.38 a  |
| L2                              | 9.29              | 11.13 b               | 8.06 b | 7.91 b | 861.29  | 1624.20 b  |
| Average                         | 9.20              | -                     | -      | -      | 894.71  | -          |
| Population densities            | NVP               | CV                    | NSV    | PCG    | PC      | RG         |
| 500 mil plants.ha <sup>-1</sup> | 7.64              | 11.32                 | 8.57   | 8.17   | 1065.30 | 2222.22 a  |
| 375 mil plants.ha <sup>-1</sup> | 9.83              | 11.33                 | 8.19   | 8.52   | 847.77  | 1779.01 ab |
| 300 mil plants.ha <sup>-1</sup> | 10.13             | 11.42                 | 8.38   | 8.29   | 771.07  | 1519.64 b  |
| Average                         | 9.20              | 11.35                 | 8.38   | 8.32   | 894.71  | -          |

146 <sup>1/</sup> Averages with the same letter in the column do not differ from each other by the Tukey test at (P =  
 147 0.05) probability. <sup>2/</sup> number of pods per plant (NVP) in unit; length of pods (CV) in cm; number of seeds  
 148 per pod (NSV) in unit; weight of one hundred grains (PCG) in g; weight with seed pods (PVCS) in  
 149 kg.ha<sup>-1</sup>; weight of bark (PC) in kg.ha<sup>-1</sup> and grain yield (RG) in kg.ha<sup>-1</sup>.

150 It is observed that the variable weight of the bark did not differ between the lineages and nor  
 151 between the population densities, presenting general average of 894.71 kg.ha<sup>-1</sup> (table 2),  
 152 which can be very important for the farmer, being a source of organic matter for the soil and  
 153 feed for ruminant animals. Studies report the relevance of organic matter in soil, which  
 154 improves the physical and chemical characteristics of the soil, reduces water and wind  
 155 erosion (due to the protection caused by mulching), maintenance of soil temperature, in  
 156 addition to preventing infestation of invasive plants [17]. On the other hand, the supply of this  
 157 biomass to animals, in the form of hay, in times of scarcity, is an alternative to guarantee the  
 158 food security of the herds in the regions of tropical climate, being legume fenagem efficient in  
 159 the conservation of the forage, being able be used as a food alternative [18, 19]. Thus,  
 160 farmers could use this biomass to boost their incomes.

161 The population densities did not have a significant effect on pods length, number of seeds  
 162 per pods and weight of hundred grains, which had a mean of 11.35 cm, 8.38 units and 8.32  
 163 g (table 2), respectively, indicating that even with increased competition at higher densities,  
 164 the amount of photoassimilates translocated and stored as carbohydrates in the bark of the  
 165 vargem and in the grains were not altered, making possible the maintenance of the specific  
 166 quantity and weight of the grains, that is, the maintenance of the physiological quality of the  
 167 grains [10].

168 The results of these variables corroborate those found by [15,10], that studying the effects of  
 169 different sowing densities they observed a non-significant effect for number of seeds per  
 170 vargem and weight of one hundred grains, indicating that these characteristics are little  
 171 influenced by the population density, being they more related to the cultivar. Roborating with  
 172 this, the evaluated lineages had a significant effect on the length of vargem, number of  
 173 seeds per vargem and weight of one hundred grains, being the lineage l1 that presented the  
 174 best results for these characters.

175 For the yield of grains variable, the sources of variation lineages and population densities  
 176 presented significant effect, where the l1 lineage obtained the highest grain yield with  
 177 2056.38 kg.ha<sup>-1</sup> (table 2), reflecting the superiority of its genetic makeup, the which provided  
 178 a better agronomic behavior for the region, being she the most suitable for cultivation. With  
 179 regard to population densities, it was verified that the density of 500 thousand plants.ha-1  
 180 presented the highest grain yield with 2222.22 kg.ha<sup>-1</sup>, but not statistically different from the  
 181 density of 375 thousand plants.ha<sup>-1</sup>, however, a grain yield response tendency was observed  
 182 in relation to the population densities, because, in the treatments studied, the increase in  
 183 density also increases yield, being this a consequence of the non-significant effect of density

184 on the number of vargem per plant, number of seeds per vargem and weight of one hundred  
185 grains, which are components of productivity [15, 8], resulting in a higher yield of grains,  
186 making it necessary, for the azuki bean, studies with larger population densities.

#### 187 **4. CONCLUSION**

188  
189 The L1 lineage presented the highest yield of grains, when compared to L2, and considering  
190 that this variable is more important for farmers, the L1 lineage is the most recommended for  
191 cultivation.

192 The population density of 500 thousand plants.ha-1 provided higher productivity in relation to  
193 the other population densities, being this agronomically recommended to the producers.

#### 194 **COMPETING INTERESTS**

195 Authors have declared that no competing interests exist.

#### 196 197 **REFERENCES**

- 198  
199 1. CONAB. National Supply Company. Follow-up of the Brazilian grain crop. 8th ed.  
200 Brasília: Conab. 2017. English.
- 201 2. Resende O, Ferreira LU, Almeida DP. Mathematical modeling for drying kinetics of  
202 adzuki bean (*Vigna angularis*). Rev. Bras. Prod. Agroind., Campina Grande. 2010; 12  
203 (2): 171-178. English.
- 204 3. Almeida DP, Resende OMUC, Costa LM, Correa PC, Rocha AC. Influence of drying  
205 on the physiological quality of adzuki beans. Braz. J. Agri. Sci. 2013; 8 (2): 311-315.  
206 English.
- 207 4. Yao Y, Cheng XZ, Wang SH, Wang LX, Ren GX. Influence of altitudi-nal variation on  
208 the antioxidant and antidiabetic potential of azuki bean (*Vigna angularis*). Int. J. Food  
209 Sci. Nutr. 2012;63(1):117–124.
- 210 5. Yao Y, Cheng X, Wang L, Wang S, Ren G. A determination of potential  $\alpha$ -glucosidase  
211 inhibitors from azuki beans (*Vigna angularis*). Int. J. Mol. Sci. 2011;12(10):6445–6451.
- 212 6. Maruyama C, Araki R, Kawamura M, Kondo N, Kigawa M, Kawai Y, et al. Azuki bean  
213 juice lowers sérum triglyceride concentrations in healthy young women, J. Clin.  
214 Biochem. Nutr. 2008;43(1):19-25.
- 215 7. Rodrigues CA, Cardoso AF, Bezerra EFB, Peixoto N, Costa LL. Survey of pests and  
216 natural enemies in adzuki beans in the municipality of Ipameri-GO. Hort. Bras. 2011;  
217 29 (2): 905-909. English.
- 218 8. Carvalho FJ, Carneiro LB, Vaz DC, Peixoto N, Cardoso AF. Behavior of adzuki bean  
219 genotypes in Ipameri-GO. Hort. Bras. 2012; 30 (2): 2387-2390. English.
- 220 9. Allard RW. Principles of genetic improvement of plants. Rio de Janeiro: Editora  
221 Edgard Blucher; 1971. English.

- 222 10. Bezerra AAC, Alcântara Neto F, Neves AC, Maggioni K. Morphoagronomic behavior  
223 of cowpea beans, cv. BRS Guariba, under different plant densities. *Braz. J. Agri. Sci.*  
224 2012; 55 (3): 184-189. English.
- 225 11. Costa CTS, Ferreira VM, Endres L, Ferreira DTRG, Gonçalves ER. Growth and  
226 productivity of four varieties of sugarcane in the fourth crop cycle. *Rev. Caat.* 2011; 24  
227 (3): 56-63. English.
- 228 12. Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G. Köppen's climate  
229 classification map for Brazil. *Meteorol. Z.* 2014;22(6):711–728.
- 230 13. Barbosa JC, Maldonado Júnior W. *Agronomic Experimentation & AgroEstat: System*  
231 *for statistical analysis of agronomic trials.* Jaboticabal: Multipress Graphics; 2015.  
232 English.
- 233 14. Koserá C, Spadotto D, Schulucubier L, Bortolini PC, Marques AC, Oliveira CD.  
234 Production of adzuki beans under different doses of basalt powder. *Rev. Bras Agroec.*  
235 2009; 4 (2): 4227-4231. English.
- 236 15. Santos MGP, Carvalho AJ, David MAS, Amaro HTR, Vieira NMB, Souza VB, et al.  
237 Sowing densities and crop yields on productive performance of common bean  
238 cultivars. *Semina: Ciênc. Agrár.* 2014; 35 (5): 2309-2324. English.
- 239 16. Alves AF, Andrade MJB, Rodrigues JRM, Vieira NMB. Population densities for  
240 alternative bean cultivars in northern Minas Gerais. *Ciênc. Agrotec.* 2009; 33 (6):  
241 1495-1502. English.
- 242 17. Boer CA, Assis RL, Silva GP, Braz AJBP, Barroso ALL, Cargnelutti Filho A, et al.  
243 Biomass, decomposition and soil cover caused by cultural residues in the center-west  
244 of Brazil. *R. Bras. Ci. Sol.* 2008; 32 (2): 843-851. English.
- 245 18. Bayão GFV, Edvan RL, Carneiro MSS, Freitas NE, Pereira ES, Pacheco WF, et al.  
246 Dehydration and chemical composition of Leucena hay (*Leucena leucocephala*) and  
247 *Gliricidia* (*Gliricidia sepium*). *Rev. Bras. Health Prod. Anim.* 2016; 17 (3): 365-373.  
248 English.
- 249 19. Fernandes GM, Possenti RA, Junior EF, Paulino VT. Nutrient value of forage peanut  
250 hay at different cutting ages. *Bull. Anim.* 2011; 68 (2): 133-138. English.