Productivity of Dry Grains of Cowpea [*Vigna unguiculata* (L.)] Creole Cultivar (Canupum), as a Function of Different Planting Densities

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

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Original Research Article

ABSTRACT

Aims: Cowpea *[Vigna unguiculata (L.)]* is a legume of great importance, being a source of food rich in protein, being essential for human nutrition and produced during the rainy season in the semi-arid region of Brazil. In this sense, the objective was to study the efficiency of different planting densities on cowpea productivity in the Brazilian semi-arid region.

Place of Study: The experiment was conducted from September to December 2021 at the Rafael Fernandes experimental farm, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil,

Study Design and Methodology: The experimental design used was randomized complete blocks with five treatments (1.0; 2.0; 3.0, 4.0 and 5.0 plants hole^{-1}) with four replications. Each plot consisted of dimensions of 3.5 m x 4.8 m, with six rows of 4.8 m in length, with a total area of 18.2 m^2, with the useful area being the four central rows, with dimensions of 2.8 x 4.8 m, with an area of 13.44 m^2, for collecting dry grains.

Agronomic Characteristics of Cowpea [*Vigna unguiculata* (L.)]: Number of pods, expressed in units ha^{-1} (NV), length of pods, expressed in cm (CPV), weight of one hundred grains, expressed in grams (P100G), dry grain productivity, expressed in kg ha^{-1} (PG), number of grains pod^{-1}, expressed in units (GV), dry grain index, expressed in percentage (IGS) and pod production, expressed in grams (PV) of cowpea, Creole cultivar (canapum).

Conclusions: The highest grain productivity was influenced by planting densities, with the density of 3.4 plants per pit being the one that resulted in the highest productivity (409.78 kg ha^{-1}). For the characteristic weight of 100 dry grains, the density of one plant per hole was the one that promoted the highest average weight with a maximum value of 28.24 g.

For farmers who cultivate in a family farming system, a planting density of three plants per hole is recommended.

1. INTRODUCTION

Among the crops of economic interest for the northeast region, cowpea *[Vigna unguiculata (L.)]* stands out, originally from Africa, being introduced to Brazil in the 16th century in the state of Bahia [1]. The crop has a wide ability to adapt to soil conditions and has a low production cost, standing out for its high nutritional value, being a source of proteins, mineral salts and carbohydrates. These factors are of great importance as a source of nutrients. Furthermore, culture constitutes the strengthening and consolidation of Brazilian agribusiness [2].

The largest production of cowpeas is concentrated in the north and northeast regions,

the latter being responsible for 64% of production in the 2019 harvest, with emphasis on the state of Ceará, with the largest planted area (359.5 thousand ha), however, presenting the second lowest productivity (305 kg ha^{-1}) [3]. The use of a low level of technology, associated with irregular rainfall and the use of cultivars poorly adapted to growing conditions, are among the main factors that cause the low yield of cowpea in the Northeast [4].

The current trend is the increased use of high technology in culture, which has led to a greater demand for highly productive cultivars that are well adapted to climate and soil conditions, being one of the main objectives of breeding programs [5]. Furthermore, cowpea cultivation is extremely

important as a source of employment and income, especially for family farmers, considering that this segment normally requires manual labor, from planting to the grain threshing process. Now, marketing is done in bulk and open-air markets, and this activity is largely linked to farmers with a low technological level [5,6].

Given the importance of cowpea cultivation in the Northeast region of Brazil by farmers who work in agricultural activities and who use this crop for consumption and retail, it is extremely important to have the ideal planting density that provides the crop its maximum agronomic efficiency.

In view of the above, work was developed to evaluate the efficiency of different planting densities on cowpea productivity in the semi-arid region of Brazil.

2. MATERIALS AND METHODS

2.1 Location of the Experiment Installation

The experiment was conducted from September to December 2021 at the Rafael Fernandes experimental farm, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, with an area of 400 hectares [7]. According to [8] and the Köppen classification, the local climate is BSwh', dry and very hot, with a dry season, often from June to January, and a rainy season from February to May, average annual precipitation of 673.9 mm and average relative humidity of 68.9%.

Before installing the experiment, soil samples were taken at a depth of 0-20 cm, which were air-dried and sieved in a 2 mm mesh, then analyzed at the Laboratory of Soil Chemistry and Fertility at UFERSA, whose results were the following: pH (water 1:2.5) = 7.7; Ca (calcium) = 2.6 cmol dm^{-3} ; Mg (magnesium) = 1.5 cmolc dm^{-3} ; K (potassium)= 56.0 mg dm^{-3} ; Na (sodium) = 10.0 mg dm^{-3} ; P (phosphor) = 4.8 mg dm^{-3}; M.O (organic matter)= 5.8 g kg^{-1} and N (nitrogen)= 0.62 g kg^{-1}.

2.2 Experimental Design

The experimental design used was randomized complete blocks with five treatments (1.0; 2.0; 3.0, 4.0 and 5.0 plants hole^{-1}) with four replications. Each plot consisted of dimensions of 3.5 m x 4.8 m, with six rows of 4.8 m in length, with a total area of 18.2 m², with the useful area

being the four central rows, with dimensions of 2.8 x 4.8 m, with an area of 13.44 m², for collecting dry grains. The spacing used between rows was 0.70 m. Within the row, the spacing used was 0.40 m between pits, which resulted in 12 pits per row, corresponding to 35714; 71428; 107142; 142856 and 178570 plants ha^{-1}, at densities of 1.0; 2.0; 3.0; 4.0 and 5.0 plants hole^{-1}, respectively.

The preparation of the area consisted of weeding the bush, using a hoe, followed by marking the area, laying the hoses and digging the pits.

Planting was carried out on September 29, 2021, sowing corresponding to different planting densities. Thinning took place fifteen days after planting, and was carried out on October 14, 2021 (Fig. 1).

Fig. 1. Representation of the cowpea *[Vigna unguiculata (L.)]* plant area in the experimental area of the Universidade Federal Rural do Semiárido, Brazil. Photograph: Agricultural Engineer, Researcher and member of the hairy woodrose research group, Natalia Fernandes de Oliveira Alves

Weeding was carried out regularly, as needed, to avoid competition for water and nutrients with weeds, especially in the initial phase of crop development. Irrigation was carried out via drip, with a daily irrigation shift divided into two applications (morning and afternoon).

2.3 Measurement of the Agronomic Characteristics of cowpea [*Vigna unguiculata* (L.)]

Dry beans were harvested, the first being carried out on November 25, 2021, for a total of three harvests (Fig. 2).

Fig. 2. Representation of the cowpea harvest on the experimental farm at the Universidade Federal Rural do Semi-arid, Brazil. Photograph: Photograph: Agricultural Engineer, Researcher and member of the hairy woodrose research group, Natalia Fernandes de Oliveira Alves

After harvesting dry pods, they were stored in bags, identified and taken to the DCAF/UFERSA Post-Harvest laboratory, where the following characteristics were measured: Number of pods, expressed in units ha^{-1} (NV), length of pods, expressed in cm (CPV), weight of one hundred grains, expressed in grams (P100G), dry grain productivity, expressed in kg ha^{-1} (PG), number of grains pod^{-1}, expressed in units (GV), dry grain index, expressed in percentage (IGS) and pod production, expressed in grams (PV) of cowpea, Creole cultivar (canapum).

2.4 Statistical Analysis

Statistical analysis was performed according to conventional methods of analysis of variance [9], using ESTAT statistical software [10]. The response curve fitting procedure was performed using the ESTAT Software [10].

3. RESULTS AND DISCUSSION

There was a significant effect for all characteristics evaluated at $p < 0.01$ probability for all characteristics evaluated in cowpea (Table 1). Interspecific competition was probably a preponderant factor in the characteristics evaluated, having a direct influence on the development of the culture.

There was a linear adjustment for the pod length characteristic, with the density of one plant per pit, which promoted the greatest length at 17.3 cm (Fig. 3). This decrease with the increase in planting densities is probably related to the plants' nutrient requirements. [11], studying the evaluation of pod bean lines for the North and Northwest regions of Rio de Janeiro, found an average value of 13.86 cm, which is lower than this characteristic. Freitas [12], studying the morphological and agronomic characterization of cowpea accessions collected in municipalities in RN, found a general average of 20.84 cm, a value higher than that of the aforementioned research. [13] observed that the length of pods was not significantly affected by plant populations, with an average plant length of 14.99 cm for the BRS Novaera cultivar, being lower than the aforementioned research.

Table 1. F values for number of pods, expressed in units ha^{-1} (NV), pod length, expressed in cm (CPV), weight of one hundred grains, expressed in grams (P100G), dry grain productivity, expressed kg ha^{-1} (PG), number of grains pod^{-1}, expressed in units (GV), dry grain index, expressed as a percentage (IGS) and pod production, expressed in grams (PV) of cowpea, Creole cultivar (canapum)

Causes of Variation	GL	NV	CPV	P100G	PG	GV	IGS	PV
Blocks	3	23.18**	0.4ns	3.4ns	13,2**	2.9ns	2.9ns	6.9**
Treatments	4	7.63**	15.6**	11.2**	14.8**	16.5**	0.9ns	6.17**
Residue	12	---	---	---	---	-----	------	-----
Overall Average	----	105600	16.8	27.3	343.8	14.1	80.8	489.5
CV (%)	----	23.09	3.6	6,5	23.1	4.0	2.80	8.24

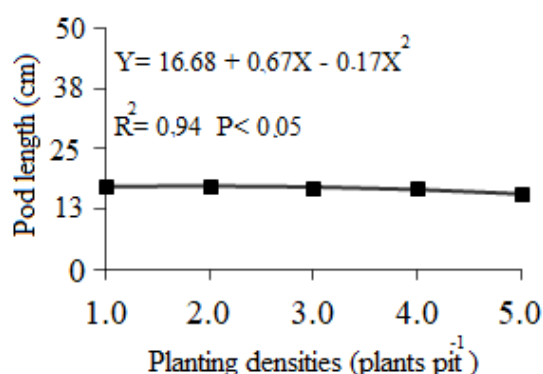*** = P<0,01; * = P<0,05; ns = not significant*

Fig. 3. Cowpea pod length [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

For the characteristic number of pods ha^{-1} there was a statistical difference at the level of 1% probability, with the density of 3.6 plants per pit providing the highest number of pods per hectare with a maximum value of 131.96 ha^{-1} (Fig. 4). This characteristic is important because it highlights the greater grain production after threshing the pods. [14], the number of pods plant^{-1} is the basic component that most relates to the grain productivity, being greatly influenced by the environment. [15], higher densities of cowpea plants result in an excessive number of plants in the line, with less availability of photoassimilates for their development.
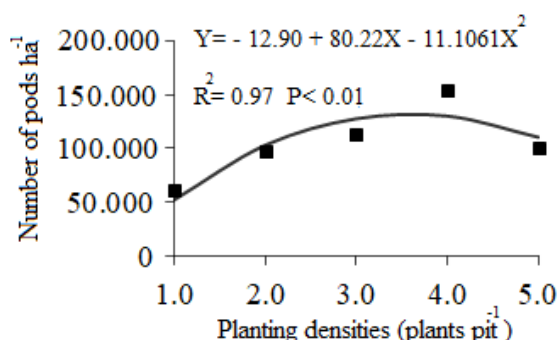

Fig. 4. Number of cowpea pods [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

For the number of grains per pod, the density of one plant per pit presented the highest number, with an average value of 14.6 pods, with a statistical difference in relation to the other densities (Fig. 5). Freitas (2020), studying the morphological and agronomic characterization of cowpea accessions collected in municipalities in Rio Grande Norte, Brazil, found an average of 74.61 in five pods, equivalent to 14.8 grains dry

pods^{-1}. For [16]. (2003), the component number of grains per pod is of little importance for increasing productivity, as it presents a low correlation for this characteristic. [17] states that this characteristic has high genetic heritability, being little influenced by the environment [18], studying productive aspects and biomass of cowpea (*Vigna unguiculata* L.) under doses of bovine biofertilizers in agroecological cultivation, found a number of grains per pod of 13.4 units, a value lower than that of the present research.
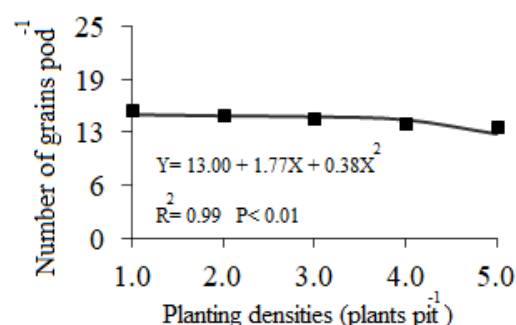

Fig. 5. Number of grains per cowpea pod [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

Planting density influenced the characteristic weight of 100 dry grains, where it was observed that the density of one plant per hole, presented the highest average weight of dry grains, with a maximum value of 28.24g, with a decrease due to the increase in densities of planting (Fig. 6). [19], studying the yield of dry grains and production components of cowpea cultivars (*Vigna unguiculata* L.) in cultivars irrigated in the dry season in Pedro Afonso – Tocantins, found a maximum weight of 19.05g, being less than said research. This component constitutes a productivity factor, being greatly influenced by the environment [19]. Freitas (2020) found an average weight of 100 grains of 19.91g, a value below that of the aforementioned research. The decrease in the weight of 100 grains depending on planting densities is probably due to intraspecific competition. Saraiva et al. (2020), studying productive aspects and biomass of cowpea (*Vigna unguiculata* L.) under doses of bovine biofertilizers in agroecological cultivation, found a weight of 100 grains of 25.6g, a value lower than the present research.

Grain productivity was influenced by planting densities, with the density of 3.4 plants per hole being the one with the highest productivity, with 409.78 kg ha^{-1}, with a decrease for densities of

four and five plants per hole, with productivity of 396.6 and 325.4 kg ha^{-1} respectively (Fig. 7). This decrease with the increase in plant population is due to interspecific competition, which is more intense in the canopy, enhancing apical dominance to the detriment of the development of lateral branches Bezerra et al. [20].
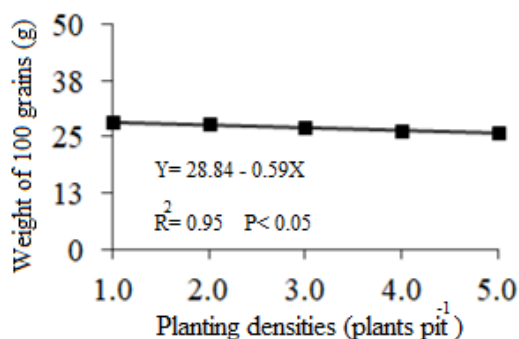

Fig. 6. Weight of 100 grains of cowpea [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

Productivity is the most important component for farmers working in this activity, and it is important to use cowpea cultivars adapted to the region's climate and soil conditions, which can express their agronomic potential. Freitas (2020), studying the morphological and agronomic characterization of cowpea accessions collected in municipalities in Rio Grande Norte, Brazil, found an average productivity of dry pods in the second harvest of accessions A323, AC10 and AC22 of 286.51, 324.41 and 355.90 kg ha^{-1}, values lower than the aforementioned research. According to [21], the formation of pods under organic fertilizer is extremely important, in addition to the use of crop residues to supply nutrients to the soil and subsequently their availability for the crop. [21].
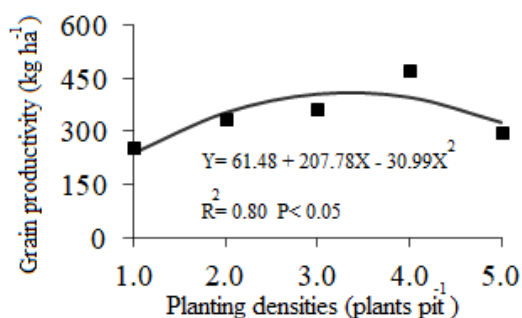

Fig. 7. Grain productivity of cowpea [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

The highest pod productivity was obtained at a density of 3.2 plants per pit, with a maximum value of 645.76 kg ha^{-1}, with a decrease at the highest densities, with values of 593.39 and 389.34 kg ha^{-1} at densities of four and five plants per hole, respectively (Fig. 8). Freitas (2020), studying the morphological and agronomic characterization of cowpea accessions collected in municipalities in Rio Grande do Norte, Brazil, found productivity of dry pods in the first harvest of 514; 520; kg ha^{-1} for accessions AC13 and AC19, values lower than the aforementioned research. This decrease with the increase in the plant population is due to interspecific competition, which is more intense in the canopy, which enhances apical dominance to the detriment of the development of lateral branches Bezerra et al. (2010).
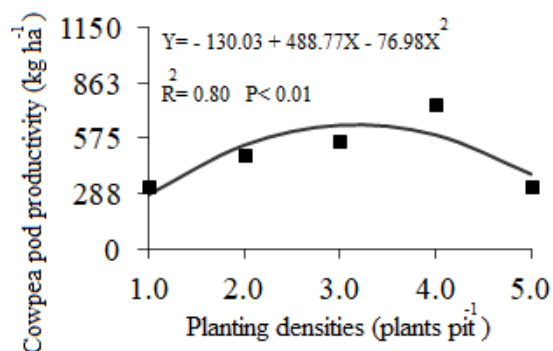

Fig. 8. Cowpea pod productivity [*Vigna unguiculata* (L.)], Creole cultivar (Canapum), in the semi-arid region of Brazil

4. CONCLUSION

The highest grain productivity was influenced by planting densities, with the density of 3.4 plants per pit being the one that resulted in the highest productivity (409.78 kg ha^{-1}).

For the characteristic weight of 100 dry grains, the density of one plant per hole was the one that promoted the highest average weight with a maximum value of 28.24 g.

For farmers who cultivate in a family farming system, a planting density of three plants per hole is recommended.

ACKNOWLEDGEMENTS

use of spontaneous species from the semi-arid region as green manure in the agroecological production of leafy and root vegetables, and the Universidade Federal Rural do Semi-Árido-UFERSA, for the physical structure and granting of scientific initiation scholarships for the development of research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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