Cowpea {*Vigna unguiculata* (L.)} productivity in the semi-arid region of Brazil.

Aims: Cowpea cultivation is of great importance for farmers who work in this agricultural activity, in this sense, we evaluated the agronomic characteristics of cowpea {*Vigna unguiculata* (L.)} Creole cultivar (Semper verde), in the semi-arid region of Brazil.
Place of Study: The experiment was carried out from November 2021 to February 2022 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.
Study Design and Methodology: A randomized complete block design was used with five treatments, which will consist of planting densities (35,714; 71,428; 107,142; 142,856 and 17,8570 plants ha^{-1}) with four replications.
Agronomic characteristics of cowpea {*Vigna unguiculata* (L.)}: pod length, expressed in cm (PL), number of grains, expressed in pod^{-1} units (NG), Pod weight, expressed in grams (PW), number of grains, expressed in pod^{-1} units (NG), Weight of 100 grains, expressed in grams (P100G) and grain production, expressed in kg ha^{-1} (PG) of cowpea, Creole cultivar (Sempre verde).
Conclusions: Planting densities contributed greatly to cowpea productivity, with productivity of 184.82 kg ha^{-1}.The cowpea cultivar (Semper Verde) is agronomically viable for planting in the semi-arid region.

Keywords: Family farming; agroecological production and grain production**.**

1. INTRODUCTION

Cowpea [*Vigna unguiculata* (L) Walp.] is a legume of great importance for family farmers, considering that it contributes to the social, nutritional and economic aspects of thousands of people [1]. In the northeast region of Brazil, this crop is planted mainly during the rainy season, when farmers cultivate large areas to produce grains for food and commercialization, bringing income to those who work in this activity.

It is worth noting that this crop has genetic variety, and can be used for different purposes, being sold in different ways, mainly as dry grain, green grain, green pod and seeds, greatly contributing to increasing the producer's income [2]. The low technological level, associated with irregular rainfall, predisposes bean cultivation to low productivity in the northeast region of Brazil, making it especially important for producers to cultivate crops during the rainy season in the region.

In this sense, it is extremely important to use technologies that will contribute to an increase in cowpea productivity in the northeast region of Brazil, which will bring economic returns to farmers in the region [3].

The use of cowpea in the northeast region of Brazil constitutes an extremely important alternative for those who work in this activity, requiring the development of the crop in edaphic-climatic conditions to understand the behavior of the crop and its maximum agronomic efficiency.

It is worth noting that this culture is extremely important for the semi-arid region, however, the lack of knowledge regarding technology transfer is present in many areas [4].

In view of the above, we evaluated the agronomic characteristics of cowpea {*Vigna unguiculata* (L.)} Creole cultivar (Semper verde), in the semi-arid region of Brazil.

2. MATERIAL 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, in the period November 2021 to February 2022. According to [5] 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%.

The region's climate, according to the Köppen Geiger classification, is dry and very hot with two seasons: a dry season starting in June and ending in January and a rainy season starting in February and ending in May [5]. The soil in the experimental area was classified as a typical dystrophic red yellow argisol, with a sandy loam texture [6].

Before setting up the experiment, soil samples were collected from the 0-20 cm arable layer, homogenized, and sent to the soil chemistry and fertility laboratory for the following analyses: pH (water) = 6.6; EC = 0.44 dS m^{-1}; O.M. = 9,8 g kg^{-1}; N = 0.52 g kg^{-1}; P = 44.30 mg dm^{-3}; K = 60.28 mg dm^{-3}; Ca=18.50 cmolc dm^{-3}; Mg = 6.80 cmolc dm^{-3}; Na = 2.33 mg dm^{-3}; Cu = 0.60 mg dm^{-3}; Fe = 4.30 mg dm^{-3}; Mn = 10.45 mg dm^{-3}; and Zn = 4.56 mg dm^{-3}.

2.2 Experimental Design

A randomized complete block design was used with five treatments, which will consist of planting densities (35,714; 71,428; 107,142; 142,856 and 17,8570 plants ha^{-1}) with four replications. He used the Creole cultivar Semper Verde. Each plot consisted of dimensions of 5.0 m x 4.0 m, with six rows of 5.0 m in length, with a total area of 20.0 m^2. The spacing used between lines was 0.70 m. Within the line, the spacing used was 0.40 m between pits.

During the period in which the cowpea crop was in the field, weeding was carried out to remove invasive plants that compete for water and nutrients during the crop cycle. Irrigation was carried out by drip, with a daily irrigation shift divided into two applications (morning and afternoon).

When harvesting took place, the cowpea pods were taken to the Phytotechnics Laboratory of the Department of Agricultural and Forestry Sciences belonging to UFERS to evaluate the following characteristics: pod length, expressed in cm (PL), number of grains, expressed in pod^{-1} units (NG), Pod weight, expressed in grams (PW), number of grains, expressed in pod^{-1} units (NG), Weight of 100 grains, expressed in grams (P100G) and grain production, expressed in kg ha^{-1} (PG) of cowpea, Creole cultivar (Sempre verde).

Statistical analysis

Statistical analysis was performed according to conventional methods of analysis of variance [7], using ESTAT statistical software [8]. The response curve fitting procedure was performed using the ESTAT Software [8], applying regression analysis and conducting hypothesis testing that helps the researcher accept or reject a statistical hypothesis based on experimental results [9], [10].

3. RESULTS AND DISCUSSION

It was observed that there was a statistical difference for all cowpea characteristics evaluated at the level of $p< 0.01$ probability (Table 1). For the characteristics of pod length, numbers of pod grains, pod weight and weight of 100 grains, the data were adjusted to the linear equation (Figure 1 to 4), in relation to grain production the data were adjusted to a quadratic equation (Figure 5). The use of landraces of cowpea is extremely important as an alternative for farmers working in family farming, reducing production costs and increasing profitability [11].

Table 1. F values for pod length, expressed in cm (PL), number of grains, expressed in pod^{-1} units (NG), Pod weight, expressed in grams (PW), number of grains, expressed in pod^{-1} units (NG), Weight of 100 grains, expressed in grams (P100G) and grain production, expressed in kg ha^{-1} (PG) of cowpea, Creole cultivar (Sempre verde).

Causes of Variation	GL	PL	NG	PW	NG	P100G	PG
Blocks	3	11.08**	9,30**	7.65**	10.78**	8,45**	6,49**
Treatments	4	16.47**	8.16**	17.02**	14.18**	10.27**	7.46**
Residue	12	---	---	---	---	-----	------
CV (%)	----	13.42	10.12	14.75	23.1	6.17	5.49

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

These variables are extremely important, as they demonstrate the productive aspect of cowpea, being used by farmers as an agronomic parameter.

Pod length showed the greatest growth in density of 35,714 plants ha^{-1}, with a value of 19.46 cm, 3.85 cm higher than the highest planting density (178,570 plants ha^{-1}) (Figure 1). Pod length is an extremely important characteristic, as it is related to the number of pod^{-1} seeds. [12], evaluating cowpea productivity under doses and sources of organic fertilizer in the municipality of Chapadinha-MA, found a pod length of 20.5 cm with the application of 20 t ha^{-1}, higher than the aforementioned research.

According to [13], the number of grains per pod is directly related to the length of the pods, thus explaining the results found in this research, as there was little variation in the size of the pods and also no statistical difference.

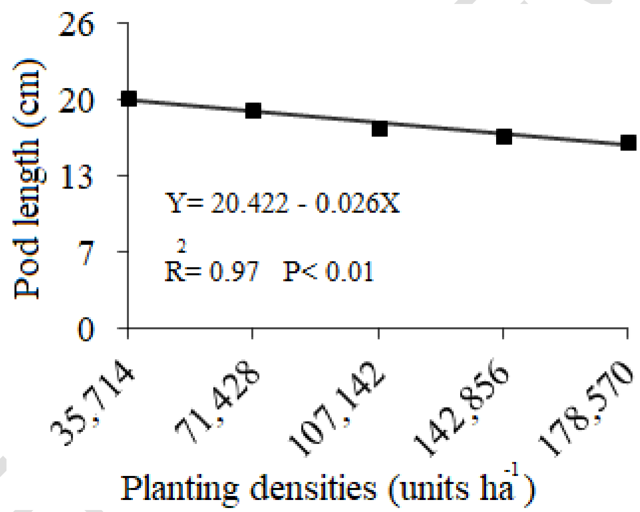

Figure 1. Pod length as a function of different planting densities in the semi-arid region of Brazil.

The highest quantity of grains per pod was observed at a density of 35,714 plants ha^{-1}, with a maximum value of 14.65 pod units^{-1} (Figure 2). The number of pod^{-1} grains is of great importance, as it is related to productivity. [14], evaluating cowpea production depending on the use of inoculant and organic and mineral fertilizers, found a number of pod^{-1} grains of 14.3 units with biofertilizer application, which is lower than the aforementioned research. [15] evaluating yield of Pingo de Ouro cowpea bean under different sowing densities and goat manure doses in the region of Mossoró, Brazil, with a number of seeds worth 12.0 pod units^{-1}, being lower than the aforementioned research.

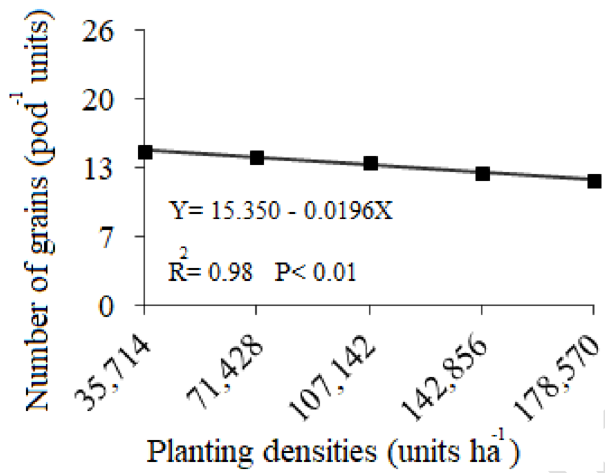

Figure 2. Number of grains as a function of different planting densities in the semi-arid region of Brazil.

For pod weight, there was a decrease depending on planting densities, with a maximum value of 5.9 g at a density of 35,714 plants ha^{-1} (Figure 3). Pod weight is an important characteristic, as it is related to the productive aspect of the crop. [16], evaluating the characteristics and pod yield of snap beans depending on sources and doses of organic matter, found a pod weight of 12 g at a dose of 10 t/ha, a value higher than that of the aforementioned research. [17], studying the characterization of yield in green cowpea grains, found a pod weight of 11.08 g, higher than the aforementioned research.

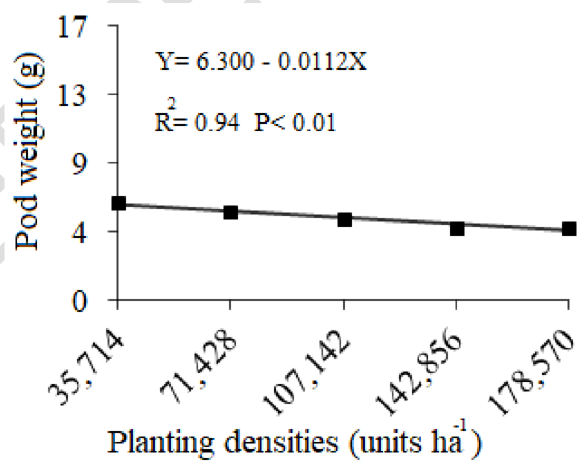

Figure 3. Pod weight as a function of different planting densities in the semi-arid region of Brazil.

In relation to the number of grains per pod, the density of 35,714 plants ha^{-1} was the one that promoted the greatest increase in the characteristic, with a maximum value of 14.7 units per pod. In subsequent densities, there was a decrease to a density of 178,570 plants with a value of 11.9 grain units per pod (Figure 4). [18], studying the productivity and water use efficiency of cowpea cultivars under drip irrigation, found a number of grains per pod of 11.1 units, a value lower than that of the aforementioned research. [19], studying the potential of cowpea for the green pods and grains market, found an average number of green grains under cultivation conditions (rainfed) of 15.1 units per pod, which is lower than the aforementioned research, a value close to that of the aforementioned research.

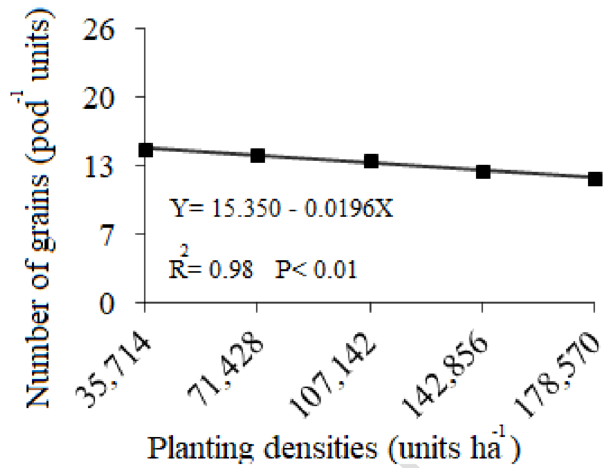

Figure 4. Number of grains as a function of different planting densities in the semi-arid region of Brazil.

The weight of 100 grains is a very important characteristic, as it is related to the productive variable, and in this research, the density of 35,714 plants ha^{-1} obtained the highest average weight, with a value of 24.81 g (Figure 5). In higher densities there was a decrease, with a minimum weight in density of 178,570 plants ha^{-1}, with a value of 21.3 g. [20], studying the productivity and water use efficiency of cowpea cultivars under drip irrigation, found a weight of 100 grains of 20.22 g, a value lower than that of the aforementioned research.

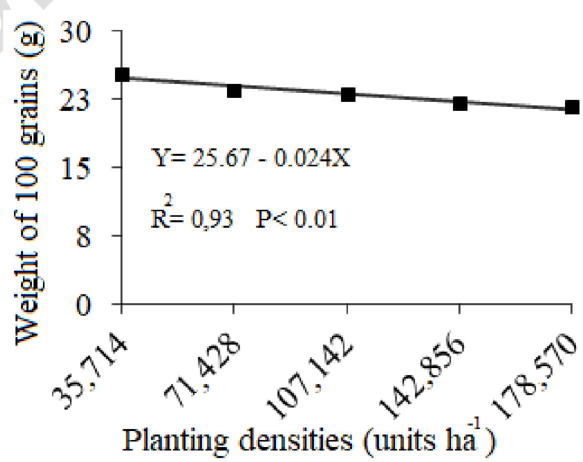

Figure 5. Weight of 100 grains as a function of different planting densities in the semi-arid region of Brazil.

The highest grain production was obtained at a density of 142,856 plants ha-1, with a maximum value of 184.82 kg ha^{-1}, with an increase depending on the other densities, with a value of 164.10 kg ha^{-1} (Figure 6) . The observed productivity is a function of the Creole cultivar used. [21], studying the productivity and water use efficiency of cowpea cultivars under drip irrigation, found a weight of 100 grains of 20.22 g, a value lower than that of the aforementioned research. [22], 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 higher than those in the aforementioned research. [23] studying the production of semi-prostrate cowpea in rainfed and irrigated crops with an average productivity of 851.59 kg ha^{-1}, higher than the aforementioned research.

It is worth mentioning that the size of the grain, as well as the color, constitutes a market preference and is important in determining the price of the product, being characters that should not be markedly altered during the selection process, since there is a preference for grains with a weight of 100 grains around 18 g of kidney-shaped or rounded shapes [24]. Knowledge of the association of grain productivity and its components is important for the selection of parents and in promising segregating populations, making the selection process efficient [25].

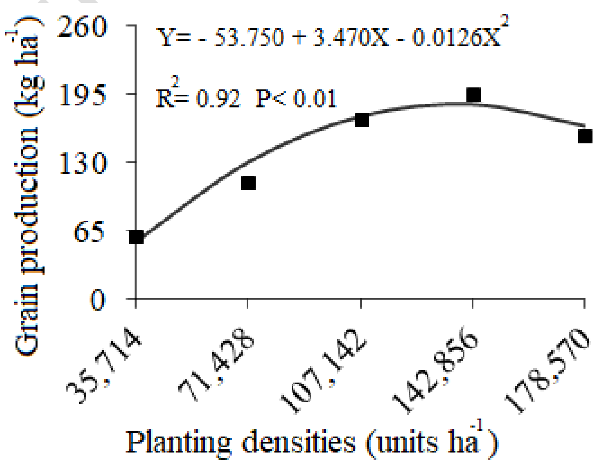

Figure 6. Grain production as a function of different planting densities in the semi-arid region of Brazil.

CONCLUSION

Planting densities contributed greatly to cowpea productivity, with productivity of 184.82 kg ha^{-1}.

The cowpea cultivar (Semper Verde) is agronomically viable for planting in the semi-arid region.

REFERENCES

1. Oliveira IJde, Fontes JRA, Dias MC, Barreto JF (2019). Technical recommendations for the cultivation of cowpea in the State of Amazonas. (Technical Circular, 71). Manaus: Embrapa Amazônia Oeste.

2. Ramos HMM, Bastos EA, Andrade Júnior AS, Cardoso MJ (2013). Water use efficiency and cowpea grain productivity under different water regimes. In: NATIONAL COWBEAN CONGRESS, 3., Recife-PE. Annals… CONAC, Recife/PE.

3. Alves NFdeO, Linhares PCF, Sousa VEde, Carlos KGdaS, Santos MdeFAdos, Peixôto, LSdeL, Lobato LVC, Leite IdeO, Paiva MRdaS, Assis JPde, Rodrigues WM, & Lima IRPde (2023). Productivity of Dry Grains of Cowpea [*Vigna unguiculata* (L.)] Creole Cultivar (Canupum), as a Function of Different Planting Densities. Asian Journal of Research in Crop Science, *8*(4), 421–428. https://doi.org/10.9734/ajrcs/2023/v8i4222

4. Vale JCdo, Bertini CBA. Cowpea: from planting to harvest. Viçosa, vol. 3 n. 1, June, 2017. https://doi.org/10.33447/paubrasilia.v3i1

5. Beck HE, Zimmermann NE, Mcvicar TR, Vergopolan N, Berg A, Wood EF (2018) Present and future Köppen-Geiger climate classification maps at 1-km resolution. Scientific Data 5:180214.

6. Santos JAS, Soares CMG, Corrêa AM, Teodoro PE, Ribeiro LPE, Abreu HKA (2014). Agronomic performance and genetic dissimilarity among cowpea (*Vigna unguiculata* (L.) Walp.) genotypes. Global Advanced Research Journal of Agricultural Science, 3(1):271-277.

7. Banzatto DA, Kronka SN. Agricultural experimentation. 3rd ed. Jaboticabal: FUNEP, 1995:245p.

8. Barbosa JC, Malheiros EB, Banzatto D. A. ESTAT: A system for statistical analysis of agronomic trials. Jaboticabal: Unesp, Version 2.0. 1992.

9. Assis JP, Sousa RP, & Linhares PCF (2020). Statistical hypothesis testing. EdUFERSA. https://livraria.ufersa.edu.br/wp-content/uploads/sites/165/2020/08/testes-de-hipoteses-estatisticas-edufersa.pdf

10. Assis JP (2013). Simple linear regression, simple linear correlation, multiple linear regression and multiple linear correlation. EdUFERSA, 310p. https://livraria.ufersa.edu.br/regressao-e-correlacao-linear-simples-e-multipla/

11. Abreu L, Cansi E, Juriatti C (2007) Assessment of the socioeconomic performance of landraces and commercial corn hybrids in the Chapecó microregion. Brazilian Journal of Agroecology, 2(1): 1230-1233.

12. Oliveira CAB, Mello Pelá G, & Pelá A (2017). Inoculation with Rhizobium tropici and foliar fertilization with molybdenum in common bean crops. Journal of Neotropical Agriculture, 4(5), 43-50.

13. Cavalcante EdaS, Freire Filho FR, Rocha MdeM, Goes ACP, Ribeiro VQ, Silva KJD (2014). BRS Tumucumaque: Cowpea Cultivar for Amapá and Other States of Brazil. Macapá: EMBRAPA Amapá. 5 p. (Technical Announcement 124).

14. Silva CF, Moura MFde, Vilela Ávilo RR, Araújo MBde, & Marques JDS (2019). Production of cowpea depending on the use of inoculant and organic and mineral fertilizers. Diversitas Journal, 4(3), 1130–1145. https://doi.org/10.17648/diversitas-journal-v4i3.832

15. Silva RASda, Linhares PCF, Souza ASdos, Pereira MFS, Assis JPde, Sousa RPde, Neves AM, Alves LSde, Silva RIGda. Yield of pingo de ouro cowpea bean under different sowing densities and goat manure doses in the region of Mossoró, Brazil. Journal of Agricultural Science, 10(12): 329-335. https://ccsenet.org/journal/index.php/jas/article/view/0/37346

16. Santos GM, Oliveira AP, Silva JAL, Alves EU, Costa CC (2001). Characteristics and pod yield of snap beans depending on sources and doses of organic matter. Brazilian Horticulture, Brasília, 19(1): 30 - 35.

17. Coelho TJSda, Coelho RRP, SANTOS V. S. Characterization of yield in green cowpea grains. IV National Agroindustry Meeting. November 27th to 30th, 2018.

18. Pimenta LJL, dos Santos SR, Bernardino DLMP, Barbosa JAE, Alves AGT, & de Carvalho AJ (2023). Productivity and water use efficiency of cowpea cultivars under drip irrigation. CONTRIBUTIONS TO SOCIAL SCIENCES, 16(11), 26504–26522. https://doi.org/10.55905/revconv.16n.11-104

19. Carvalho CDM, Francelino FMA, Manhães CMC, Silva MPS, Ribeiro EC, Bueno JAR (2020). Rendimento de grãos secos e componentes de produção de cultivares de feijão-caupi (*Vigna unguiculata* L.) Em cultivo irrigado na estação da seca em Pedro Afonso – To. Jornada de Iniciação Cientifica e Extensão. Instituto Federal do Tocantins. p. 1-8.

20. Pimenta LJL, dos Santos SR, Bernardino DLMP, Barbosa JAE, Alves AGT, & de Carvalho AJ (2023). Productivity and water use efficiency of cowpea cultivars under drip irrigation. CONTRIBUTIONS TO SOCIAL SCIENCES, 16(11), 26504–26522. https://doi.org/10.55905/revconv.16n.11-104

21. Pimenta LJL, dos Santos SR, Bernardino DLMP, Barbosa JAE, Alves AGT, & de Carvalho AJ (2023). Productivity and water use efficiency of cowpea cultivars under drip irrigation. CONTRIBUTIONS TO SOCIAL SCIENCES, 16(11), 26504–26522. https://doi.org/10.55905/revconv.16n.11-104

22. Freitas SQ. (Agronomic characterization of cowpea accessions collected in municipalities in the state of Rio Grande do Norte. 2010. 39f. Monograph (graduation) – Universidade Federal Rural do Semi-Árido (UFERSA), Mossoró, 2010.

23. Silva Alda, Neves JA. Production of semi-prostrate cowpea in rainfed and irrigated crops. Brazilian Journal of Agricultural Sciences, 6(1): 29-36.

24. Silva Alda, Neves JA. Production of semi-prostrate cowpea in rainfed and irrigated crops. Brazilian Journal of Agricultural Sciences, 6(1): 29-36.

25. Benvindo RN, Silva JALda, Freire Filho FR, Almeida ALGde, Oliveira JTS, Bezerra AAC (2010). Evaluation of semi-prostrate cowpea genotypes in rainfed and irrigated cultivation. Comunicata Scientiae, 1(1): 23-28.