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Agronomic Efficiency of Rizóbios in Cowpea in the Central South of Ceará Region

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Abstract: The symbiosis of cowpea with atmospheric nitrogen-fixing bacteria can increase productivity and decrease production costs. Thus, the objective of the present work was to evaluate the agronomic efficiency of selected rhizobia strain for cowpea in Iguatu-CE soil and climatic conditions. The experimental design was a randomized complete block design, with four replications. The treatments were as follows: T1-planting with seeds inoculated and without nitrogen fertilization; T2-planting with nitrogen fertilization and without inoculated seeds; T3-Planting with nitrogen fertilization and inoculated seeds and T4-control, with only one variety of beans. The agronomic efficiency of the strain was analyzed by plant height, fresh mass of nodules, dry mass of nodules, fresh mass aboveground part, dry mass aboveground part, number of nodules per plant and productivity. There was a significant difference for all analyzed characters except plant height. The highest fresh mass of the aerial part and the greatest mass aboveground part were obtained from beans that were just inoculated. The highest productivity was obtained in treatment 2 (beans fertilized without inoculation), not differing statistically from treatments 1 (inoculated without fertilizer) and 3 (inoculated and fertilized). The worst productivity was control, 41% less than the maximum value obtained and 30% less than just inoculated beans.

Key words: Vigna unguiculata, nitrogen, symbiosis

1. Introduction

Cowpea (Vigna unguiculata L. Walp), also known as macassar beans or string beans, is a crop of African origin, which was introduced in Brazil in the second half of the 16th century by Portuguese colonizers in the State of Bahia [1].

Has a relevant importance for the low-income population of the region Northeast of the Brasil, having a great acceptance representing an important source of protein, energy, fiber and minerals, in addition to generating employment and income for the population [2].

Brazilian cowpea production in the 2018/2019 crop was 636,000 tons (equivalent to 21% of total bean production which was 3,021,800 tons), in an area of 1,275,300 hectares, with 498 kg ha^{-1}. The Northeast region stands out as the largest producer and consumer of cowpea in Brazil. Since much of the production is linked to small and medium-sized properties that generally use low level technological [3]. In total, 217,000 t were produced in the Northeast with 410 kg ha^{-1} and 109,900 tons were produced in Ceará state with 310 kg ha^{-1} (CONAB, 2020). These productivities are well below countries like United States (1392.6 kg ha^{-1}) and Peru (1300.7 kg ha^{-1}) [4]. Maintaining or elevating the crop productivity depends on biotic and abiotic factors that can controlled to a certain extent. Several factors contribute to low productivity, such irrigation [5, 6] and mineral and organic fertilization managements [7]. Therefore, fertilization management strategies are necessary to maintain the productivity of agricultural areas [8]. The fixation biological nitrogen has been to shown indispensable for the sustainability of Brazilian agriculture, given the supply of nitrogen to

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crops with low economic cost and impact reduced environmental impact [9].

The biological fixation of atmospheric nitrogen (BFN) is a process that makes available large amount of nitrogen for agroecosystems, mainly through the association of symbiotic legumes and diazotrophic bacteria, collectively called rhizobia. The technique used to increase the efficiency of nitrogen biological fiction (BFN) in legumes is the inoculation of seeds with bacteria efficient in fixing nitrogen in order to provide a sustainable source of this nutrient, which is one of the main production limiters [10].

However, there are few studies with cowpea, mainly in the state of Ceará, and the challenge that arises is to achieve an adequate management of this symbiosis, aiming at increase your efficiency. The present work aims to evaluate the behavior of Bradyrhizobium spp. in the edaphoclimatic conditions of the south-central region of the state of Ceará.

2. Material and Methods

The study was conducted at the experimental area of the Federal Institute of Education, Ceará Science and Technology, Campus Iguatu. A scaled classification of the region, according to Köppen, is of the BSw'h' type (hot and semiarid), with an average temperature always above 18°C in the coldest months, and maximum autumn rainfall. The historical average of the annual average for the Iguatu between 1974 and 2008 is 970 mm ± 316 mm [11]. Prior to the experiment, soil samples were collected from a depth of 0-20 cm. The following results were obtained: M.O. 19.48 g kg-1; pH = 6.6; P = 93 mg dm-3; K = 4.7 mmolc dm-3; Ca = 41.7 mmolc dm-3; Mg = 16.8 mmolc dm-3; Na = 2.61 mmolc dm-3; H + Al = 10.7 mmolc dm-3; SB = 65.68 mmolc dm-3; CTC = 76.5 mmolc dm-3; V = 86%; PST = 3%; EC = 0.54 dS m-1. The soil preparation involved plowing of the area, followed by harrowing. The cowpea crop was irrigated with a microsprinkler system was used, with two shifts of daily watering, one in the morning and the other in the afternoon.

Planting was carried out on May 14, 2018. The evaluation of the nodules and the aboveground part was held on July 5, 2018, when more than 50% of the plants were flowering. The harvest was carried out on July 25, to determine productivity. The experimental design was a randomized blocks completely, with four treatments and five repetitions. The treatments were as follows: T1-planting with seeds inoculated and without nitrogen fertilization; T2-planting with nitrogen fertilization and without inoculated seeds; T3-Planting with nitrogen fertilization and inoculated seeds and T4-control (planting without nitrogen fertilization and without inoculation), with only one variety of beans.

Sowing was conducted an approximate depth of 5 cm, by placing thee seeds per hole. The thinning was carried out between 8-10 days after planting, leaving two plant per hole. The spacing used was 1 m × 0.4 m, in each plot it contained four lines of 5 meters. The two central lines were considered as useful area. Seed inoculation cowpea creoles, were made with peat inoculant (concentration of 109 cells g-1), of the strain of Bradyrhizobium spp. obtained on Instituto Agronômico de Pernambuco (IPA). The dosage used was 200 g of inoculant for 8 kg of seeds, inoculation was carried out by pre-moistening the seeds with a sugary solution of 6 mL kg-1. The evaluated characteristics were: plant height (HEIGHT), fresh mass of nodules (FMN), dry mass of nodules (DMN), fresh mass aboveground part (FMAP), dry mass aboveground part (DMAP), number of nodules per plant (NNP) and productivity (PROD) determined by harvesting all plants in the plot's useful area and expressed in kg ha^{-1}.The nodules were detached, counted and put to dry in an oven at 65°C for 72 hours, then its mass is determined.

The evaluated characteristics were subjected to analysis of variance applying the F test at the 5% probability level. Having verified the significant effect, the averages of treatments we compared by the Tukey test at 5% probability. The analysis Statistics we performed using the SISVAR 3.01 software application [12].

3. Results and Discussion

There was a significant difference for fresh mass of nodules, dry mass of nodules, fresh shoot weight, dry shoot weight, number of nodules per plant and productivity. The plant height showed no significant difference for the F test at the 5% level of significance (Table 1).

Table 1 Analysis of variance, with F test values for plant height, fresh mass of nodules (FMN), dry mass of nodules (DMN), fresh mass aboveground part (FMAP), dry mass aboveground part (DMAP) and number of nodules per plant (NNP) and productivity (PROD) of cowpea. IFCE, Campus Iguatu, 2018.

		Height	FMN	DMN	FMAP	DMAP	NNP	PROD
Source of variation	DF	F	F	F	F	F	F	F
Treatment	3	1.13^{ns}	5.22*	10.20*	4.51*	5.80*	14.79*	5.35^{*}
Block	3	0.34	0.59	0.38	2.39	1.24	0.83	0.57
Resideo	9							
CV%		6.38	40.74	27.50	18.01	17.93	14.68	17.82
Mean		56.03	0.487	0.0837	75.63	10.70	20.06	787.17

DF = degrees of freedom; **, *, and ns = significant at 1%, at 5%, and not significant by the F test, respectively. CV = coefficient of variatio

The largest fresh mass of nodules was obtained in the T3 treatment (fertilized and inoculated), not differing statistically from the T4 treatments (control), and T2 treatments (fertilized and without inoculate). The lowest fresh mass of nodules was obtained in the T1 treatment (inoculated and without fertilization), not differing statistically from treatments T2 (fertilized and without inoculate) and T4 (control).

The highest dry mass of nodules was obtained in the T4 treatment (control), with no difference statistically from treatments T3 (fertilized and inoculated) and T2 (fertilized and without inoculate). Zilli et al. (2006) [13] observed that there was no reduction nodulation used the same treatment. The lowest mass of nodules was obtained T1 treatment planting with seeds inoculated and without nitrogen fertilization. The largest fresh mass of the aerial part was obtained in the T1 treatment, planting with seeds inoculated and without nitrogen fertilization not differing statistically from treatments T3 and T2. The lowest fresh mass of the aerial part was obtained treatment T4, not differing statistically from treatments T2 and T3.

Regarding the dry mass of the aerial part, the greatest result was obtained in the T1 treatment (inoculated and without fertilization), not differing statistically from the T3 treatments (fertilized and inoculated) and treatments T2 (fertilization and without inoculating). The lowest dry mass of the aerial part was obtained treatment (T4-control), not differing statistically from treatments T2 (fertilization and without inoculating) and treatments T3 (fertilized and inoculated).

The highest number of nodules per plant was obtained in the T4 treatment (Control), with no difference statistically from T2 treatment (fertilization and without inoculating). The lowest number of nodules per plant was obtained in T1 treatment, (inoculated and without fertilization) planting with seeds inoculated and without nitrogen fertilization not statistically different from T3 treatment (fertilized and inoculated) (Table 2). Nascimento et al. (2010) [14], evaluated the efficiency of inoculation of cowpea with native rhizobia obtained from soil samples collected in the Agreste region of Paraíba state and found that rhizobia or native rhizobia isolates were able to promote the development of cowpea equivalent to the development of plants that received fertilization with nitrogen mineral or inoculation with the recommended strain.

Table 2 Fresh mass of nodules (FMN), dry mass of nodules (DMN), fresh mass of aerial parts (FMAP), dry mass of aerial parts (DMAP) and number of nodules per plant (NNP) of cowpea. IFCE, Iguatu campus, 2018.

Treatment	FMN	DMN	FMAP	DMAP	NNP	PROD
	g pla^{-1}	g pla^{-1}	g pla^{-1}	g pla^{-1}		Kg ha^{-1}
1. Inoculated and without fertilization	0.246 b	0.037b	86.71 a	12.96 a	13.87 c	815.13 a
2. Fertilization and without inoculating	0.346ab	0.071ab	80.17 ab	10.82 ab	22.37 ab	970.25 ab
3. Fertilized and inoculated	0.717ª	0.108 a	81.32 ab	11.53 ab	17.25 bc	787.63 ab
4. Control	0.641ab	0.117 a	54.34 b	7.50 b	26.75 a	575.66 b

*Means followed by the same letter do not differ by the Tukey test (p > 0.05).

The highest productivity of 970.25 kg ha^{-1} was obtained in treatment 2 (beans fertilized without inoculation), not differing statistically from treatments 1 (inoculated without fertilizer) and 3 (inoculated and fertilized). The worst productivity of 575.66 kg ha^{-1} was control, 41% less than the maximum value obtained and 30% less than just inoculated beans. (Table 1).

These results show that what is more important than the number of nodules and their mass, is its quality and the affinity of the rhizobia with the legume. Because despite presenting largest fresh mass of nodules, dry mass of nodules and number of nodules per plant, the control did not reflect this behavior in the fresh mass of the aerial part and dry mass of the aerial part, where the best performance was observed in the inoculated treatment. Productivity was influenced by treatments, showing that cowpea responds both to nitrogen fertilization and inoculation. As inoculation with rhizobia is much cheaper than nitrogen fertilization, in addition to not impacting the environment, this practice should be recommended.

Several studies have been carried out with the aim of increasing the production of cowpea and among the main strategies used is symbiosis with nitrogen fixing bacteria and the increase in its symbiotic efficiency [15, 16]. Chagas Junior et al. (2010) [17], evaluating the Agronomic efficiency of rhizobium strains inoculated in cowpea in the Brazilian Cerrado, they verified yields of cowpea grains of 743 kg ha^{-1} and 826 kg ha^{-1} for the treatments with nitrogen fertilization and the treatment inoculated with the strain BR 3302, respectively. These values are similar to those found in this work.

Gualter et al. (2011) [18], studying the agronomic efficiency of rhizobia strains in cowpea grown in the pre-Amazon region of Maranhão state tested several strains Bradyrhizobium and found positive responses from cowpea to inoculation with strains evaluated with productivity increases of up to 500% compared to the control. Ferreira and Borges (2016) [19] studying the effect of cowpea inoculation associated with different phosphorus doses, observed an increasing linear behavior of dry matter from the aerial part to the inoculated plants and the phosphorus doses.

4. Conclusions

The maximum agronomic efficiency of cowpea was obtained in the T2 treatment (planting with nitrogen fertilization and without inoculated seeds), increasing the production of cowpea by 41 percent in terms of control.

The treatment T1 (Inoculated and without fertilization) was also profitable, as it obtained statistically similarity to the T2 treatment with good production, 30 percent higher than control. As inoculation with rhizobia is much cheaper than nitrogen fertilization, in addition to not impacting the environment, this practice should be recommended.

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