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Original Paper

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Agronomic performance of caupi beans (*Vigna unguiculata* (L.) walp. as influenced by substrates and mulching

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Abstract

Cowpea is a crop grown in several Brazilian regions, rich in protein and is one of the most important legumes and even in less favorable edaphoclimatic conditions, it produces satisfactorily. The cultivated area with cowpea in Brazil for the 2017/2018 harvest was approximately 1,440 thousand ha, where the Northeast region had the largest planting area, 404.20 thousand ha. In view of its great importance for the Northeast region and, considering a culture that presents rapid expansion throughout Brazil, it is also considered as another option for export culture. By the other hand, the creation of confined animals grows every year and this growth favors a considerable volume of waste that, if thrown into the environment, can cause damage to that environment. In this sense, the present study aimed to evaluate the behavior of two Creole varieties of cowpea, LA2017 and CB2017, when submitted to three proportions of soil and swine manure, in two cultivation conditions, with and without mulch. Through the observed results it was concluded that, in general, the presence of swine manure increased the weight of seeds by approximately 27% by the treatment composed of 100% swine manure, when compared to 50% swine manure + 50% Ground; The 50% treatment of swine manure + 50% soil increased the weight of pods per plant by 41%; The cultivation system with mulch influenced up to 37% the weight of pods and the number of pods per plant, in favor of LA2017.

Key-words: *Vigna beans*, Organic Matter, Agronomic Responses, Mulching

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.), despite advances in research, is still considered a subsistence culture for many smaller families purchasing power and residing in areas with less favorable edaphoclimatic characteristics for the cultivation of other more demanding crops. Since its domestication, cowpea has been of fundamental importance, because besides serving as food it is a great generator of employment and income. Rich in protein, minerals and fibers, it is part of the basic diet of rural and urban populations in the North and Northeast regions of Brazil.

Due to its rustic characteristics related to some edaphoclimatic factors such as tolerance to temperatures of up to 38 ºC, water stress and low soil fertility, cowpea production in Brazil also occurs in the second harvest (succession to corn, faseolus and soybean crops)) in the North, Northeast and Midwest regions. The increase in cultivated area has occurred, especially in the cerrado, in the second crop period, due to its characteristic of precocity and tolerance to water deficit in relation to other crops, in addition to its good adaptation to mechanized cultivation, making this legume attractive for its good yields under low production cost (Silva; Rocha; Júnior, 2016).

In this sense, it is important to note that in some semiarid regions of Brazil, crop management is still of low technological level and the search for

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alternatives to improve fertility and soil structure, through organic material from animal manure, gains important function. Thus, Araújo et al. (2011) suggest that manure can be considered as an alternative widely adopted for the supply of nutrients to the soils of the semiarid regions, favoring the production of crops and improving the soils of the region through the addition of organic matter, in addition to promoting the recycling of materials from animal dejections. However, Souto et al. (2005) added that the available nutrient content is influenced by factors such as animal species and food, which will determine the residence time of the residues added to the soil, as well as the rate of nutrient release.

Studying the performance of pigs, Costa (1989) concluded that for every thousand kilos of live weight of pigs, 15 tons of excrement were produced per year. These residues are highly polluting and are often thrown into water courses. Thus, the use of swine manure as organic fertilizer in production would represent a benefit, both for the reduction of pollution from drinking water sources, and for the producer, by improving the conditions of physical-chemical characteristics of the soil. Therefore, the use of swine manure in beans or any other crop must be based on the promotion of increased productivity and reduced costs with mineral fertilizers. After completing its fermentation process, it can be applied to the soil with immediate availability of nutrients to the plants, resulting in a low-cost fertilization option.

Regarding the use of plant residues as soil cover, Andrade et al. (2019) consider an important management strategy that aims to increase efficiency in the use of water by promoting soil moisture and its microbiota, in addition to reducing erosion caused by the impact of rain, it also acts as an insulating agent, preventing sudden variations in soil temperature, minimizing the evaporative process, favoring the use of stored water by plants - factor that contributes to less occurrence of environmental impacts in agricultural areas, providing an increase in production (Teófilo et al., 2012).

Emphasizing the importance of cowpea in Brazil, the area cultivated in the 2017/2018 crop was approximately 1,440 thousand ha, with the Northeast region having the largest planting area, 404.20 thousand ha. In view of its great importance for this region and, considering a culture that presents rapid expansion throughout Brazil, it is also considered as another option for export culture (Conac, 2019). In this context, when it comes to the cultivation of Caupi beans, it appears that in addition to the North and Northeast regions of Brazil, their cultivation, which was once considered a weed in soybean cultivation areas, has been extended to other regions of the country as the Midwest and the South.

According to the evolution of studies on the production of Caupi beans, Pereira et al. (2013), stressed that the management of nutrient availability in the soil is an important factor to ensure good production and nutritional balance throughout the crop cycle. Andrade et al. (2019) pointed out that animal manure, which is assumed to be used as a natural fertilizer, it is suggested that the efficient use of this source of nutrients for production is essential to achieve an ecological balance and sustainability of the production, also contributing to better physical, chemical and biological soil structure and, consequently, better crop development.

In this context, this study aimed to evaluate the agronomic performance of two creole varieties of cowpea grown in different proportions of substrates: swine manure and soil, in conditions with and without mulch, in the Pernambuco semiarid region.

Material and methods

The experiment was conducted at the Federal Rural University of Pernambuco - UFRPE, Academic Unit of Serra Talhada – UAST, in the municipality of Serra Talhada-PE, located at the following geographical coordinates: latitude -7.95°, longitude -38.29º and altitude 499 m (Figure 1). According to the Köppen classification, the region's climate is semiarid with high evapotranspiration rates, with average temperatures around 26 °C, average annual relative humidity close to 63% (Pereira et al., 2015). It is worth mentioning that the rainfall recorded during the study period (March to June, 2019) was 642 mm.

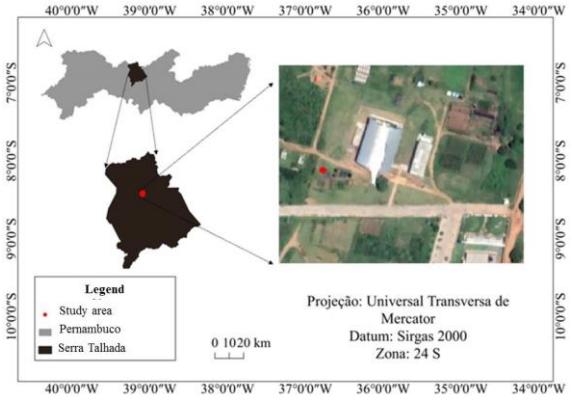

Fig. 1. Geographic location of the experimental area.

The experimental design used was in randomized blocks in a 2x3x2 factorial scheme, with two Creole varieties of cowpea V1 (Creole seed from Sítio Lagoa dos Almeida, 2017 harvest) and V2 (Creole seed from Sítio Caldeirão dos Barros, 2017 harvest); three proportions of soil and swine manure (100% soil; 50% soil + 50% swine manure and 100% swine manure) under two cultivation systems with mulch (WM) and without mulch (NM); in three repetitions.

The experiment was conducted in pots with a capacity of 20 L, which were filled with sieved soil and tanned swine manure. Creole seeds of cowpea were purchased from Seed Banks in two different communities in the municipality of Santa Cruz da Baixa Verde-PE. The seeds were sown for germination in styrofoam trays with capacity for 128 cells (Figure 2).

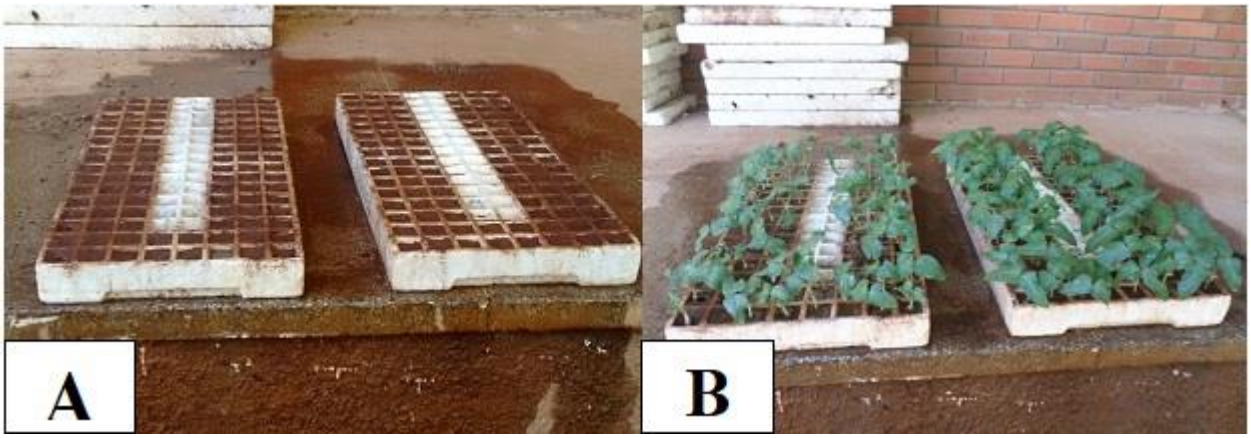

Fig. 2. Production of cowpea seedlings in trays: (A) Sown trays; (B) Sprouted trays.

A fter seven days of germination, seedlings with the same pattern of development and vigor were selected, which were transplanted in 36 pots (Figure 3). At the time of transplanting, the substrates had moisture in the field capacity. Shortly after transplanting, mulch was added. The water supply to the vessels occurred only on days when there was no precipitation, as the experiment took place during the rainy season in the region. During the conduct of the study, the following rainfall volumes were recorded, respectively: March = 214 mm, April = 165 mm, May = 46 mm and June = 48 mm (INMET, 2019).

Fig. 3. Overview of the experimental area.

The evaluated parameters were pod length per plant; number of pods per plant; pod weight per plant; number of seeds per pod; seed weight per pod. The harvest occurred in a staggered manner, starting at 57 days after transplanting and ending at 80 days after transplanting, due to the creole varieties of cowpea having an indeterminate growth habit. The pods were harvested as they reached the phenological stage R9 characterized by the color change of the pods and total filling of the grains. The pods were harvested per plant, weighed, measured and threshed, then the grains were counted per pod and the weight of the grains per pod.

For the evaluations, the following equipment was used: a graduated tape measure to measure the length of the branches, and a scale with a precision of 0.1 g for weighing the pods and grains per pod. The statistical data were evaluated through the program R.

Results and Discussion

To investigate the behavior of the Creole varieties of cowpea according to the treatments, the analysis of variance was initially carried out and through which it was found that there was a significant effect of the substrate for the components weight of pods, at 5% of probability and weight of seeds, to 1% of probability , being necessary the developments to better understand the productive behavior of these plants in their different treatments. A significant effect was also observed in the mulching x variety interaction for the number of pods (Table 1).

Table 1. Summary of the analysis of variance for the variables NP = number of pods per plant; SW = seed weight per plant (g); NS = number of seeds per pod (n); PL = pod length (cm), under two mulching conditions and three types of substrates in two cowpea varieties.

Variation source	DF	Mean square				
		NP (n)	SW (g)	NS (n)	PL (g)	PL (cm)
Substrate	2	41.1944^{ns}	2275.0678^{**}	0.8161^{ns}	1.7261^{*}	1.7593^{ns}
Variety	1	21.7778^{ns}	421.6178^{ns}	0.6972^{ns}	0.0971^{ns}	0.3501^{ns}
Mulching	1	32.1111^{ns}	217.0711^{ns}	2.0497^{ns}	0.0831^{ns}	1.1556^{ns}
Subs x Var	2	6.8611^{ns}	94.3211^{ns}	1.9871^{ns}	0.3874^{ns}	2.022^{ns}
Subs x Mul	2	26.3611^{ns}	434.0411^{ns}	0.0542^{ns}	0.1706^{ns}	0.3149^{ns}
Var x Mul	1	160.4444^{*}	2901.6178^{**}	0.1921^{ns}	0.0182^{ns}	0.065^{ns}
Subs x Var x Mul	2	0.3611^{ns}	455.7078^{ns}	7.2463^{ns}	0.4946^{ns}	5.4251^{ns}
Block	2	46.3611^{ns}	116.8786^{ns}	6.1979^{ns}	1.6857^{ns}	5.7467^{ns}
Residue	22	22.6338	198.60	2.9190	0.3892	2.9419
Total	33	-	-	-	-	-
CV (%)	-	10.85	2.14	23.14	81.48	15.96

**, * - Significant at the level of 5% and 1% probability by the F test, respectively, and ns - not significant.

With regard to the proportions of swine manure and soil (Table 2), the treatment with 100% of manure increased by approximately 27% the weight of seeds per plant when compared to 100% of soil. This information is relevant because it indicates that the plants in this condition of cultivation photosynthesized satisfactorily and the seeds were benefited by the production of photoassimilates guaranteeing greater weight of these seeds. In conclusion, the proportion with 100% of swine manure contributed to the maintenance of moisture in the root environment by better soil structure, with benefits of greater plant productivity.

Evaluating the behavior of the cowpea in function of the consequences in the interaction of the varieties inside the mulching (Table 3), it was verified that the variety LA2017, when submitted to the condition of cultivation with mulching, presented superiority of the order of 35%, with regard to the weight of pods per plant, characterizing a greater performance in this condition, in relation to CB2017 variety. Still in this context, it is important to note that, although there was no significant effect between the varieties in the NM cultivation condition, the weight of the pods of CB2017 variety was 12% higher than that recorded by LA2017 variety.

Tabela 2. N umber of seeds per plant (NS); seed weight per plant (SW); pod length (PL), of two cowpea varieties, on different substrates, with mulching (WM) and without mulching (NM).

Substrate	NS	SW	PL
100% manure	12.45 a	3.60 a	18.02 a
50% manure + 50% soil	12.29 a	3.29 ab	17.86 a
100% soil	11.93 a	2.84 b	17.29 a
Varieties			
LA2017	12.36 a	3.29 a	17.62 a
CB2017	12.05 a	3.19 a	17.85 a
Mulching			
With (WM)	12.46 a	3.29 a	17.90 a
Without (NM)	11.98 a	3.19 a	17.54 a

Means followed by the same lowercase letter in the column, do not differ significantly from each other, at the level of 5% probability by the Tukey test. LA2017 = Creole variety from the Lagoa dos Almeida community. CB2017 = Creole variety from the Caldeirão dos Barros community.

Table 3. Unfolding of the interaction of the varieties within the mulching and of the mulching within the varieties in relation to the weight of pods per plant.

Variety	**Mulching**	
	With (WM)	Without (NM)
LA2017	22.56 a A	20.22 a A
CB2017	16.77 b B	22.89 a A

Means followed by the same lowercase letter in the column, do not differ significantly from each other, at the level of 5% probability by the Tukey test. LA2017 = Creole variety from the Lagoa dos Almeida community. CB2017 = Creole variety from the Caldeirão dos Barros community.

When the behavior of each variety submitted to the two cultivation conditions was analyzed, still in Table 3, it is possible to conclude that LA2017 in the condition of cultivation with mulching (WM) presented a greater weight of pod, of the order of 16%, while CB2017 showed a better performance in the condition without mulching, in the order of 37%.

In view of the results observed regarding the differentiated behavior of the varieties in each cultivation condition, it is possible to affirm that, since they are Creole varieties, the genetic variability between them is real, allowing them to present different behaviors when submitted to the same cultivation conditions, either greater sensitivity or greater tolerance to a particular biotic or abiotic stress.

Therefore, it is possible that the superior behavior of LA2017 variety occurred due to the lower evaporation of water contained in the soil, a better temperature condition in the soil solution, favoring the control of the breathing and transpiration process and, consequently, conditioning better plant development in the condition of cultivation with mulch.

Rocha (2018) evaluating four cowpea cultivars submitted to two cultivation conditions, with cover and without mulch, observed superior behavior of the cultivars when submitted to the cultivation system with mulch, concluding that the mulch on the soil, regardless of the different types, provided better results in all the variables analyzed, despite not having interaction with the cultivars.

On the other hand, although there is no significant difference in cultivation conditions, with and without mulching, the variety CB2017, performed better in the condition without mulch, surpassing LA2017 by approximately 12%, contrary to reports in the literature that highlights better conditions for plants, such as those mentioned in the previous paragraph.

It is important to draw attention to the differentiated behavior of the CB2017 variety, in the condition of cultivation without mulching, suggesting further studies with this variety, even because, in the researches carried out, no work was found to justify this superior behavior of the weight of pods. The fact is that the other variables analyzed did not repeat this behavior.

According to table 4, there is an interaction between variety and mulching for the variable number of pod per plant (NP) where LA2017 showed a significant difference at the level of 1% probability, representing better development within the condition of cultivation with mulching (WM) and differing by approximately 37% from CB2017 variety that presented better results in the condition without mulching, of the order of 14%.

Table 4. Unfolding of the interaction of the varieties within the mulching and of the mulching within the varieties, in relation to the number of varieties per plant.

Variety	**Mulching**	
	With (WM)	Without (NM)
LA2017	91.03 a A	77.98 a B
CB2017	66.23 b A	89.10 a A

Means followed by the same lowercase letter in the column, do not differ significantly from each other, at the level of 5% probability by the Tukey test. LA2017 = Creole variety from the Lagoa dos Almeida community. CB2017 = Creole variety from the Caldeirão dos Barros community.

When we analyzed the behavior of each variety submitted to mulching (Table 4) it was possible to conclude that LA2017 variety in the condition of cultivation with mulching (WM) presented a higher number of pods, in the order of 16%. While CB2017 variety showed a better performance in the condition without mulching, in the order of 37%. Resende et al. (2005), studying the influence of mulch in the control of soil moisture and temperature, in the carrot production in summer cultivation, observed an improvement in the hydrothermal characteristics of the soil promoting the development and productivity of the plants, concluding that this occurs, due to mulch.

Regarding the behavior of cowpea plants in relation to substrate doses (Table 5). For the variable pod weight it was found that the dose 50% manure + 50% soil obtained higher productivity in pod weight. According to Kimoto (1993), the use of falling amounts of good quality manure helps to compose needs in relation to the macronutrients of plants. This is explained by the organic matter together with the nutrients present in the soil to promote the nutritional supply during the growth and development cycle of the plants.

Table 5. Influence of substrates, control (soil) and doses of swine manure in relation to the weight of pods of the cowpea varieties.

Substrate	Average
50% manure + 50% Soil	93.57 a
100% manure	83.38 b
100% Soil	66.32 c

Means followed by the same lowercase letter in the column, do not differ significantly from each other, at the level of 5% probability by the Tukey test.

For the conditions in which the study was developed, the weight of pods of the varieties of Caupi beans (Table 5), it was found that the proportion of 50% of manure + 50% of Soil presented a performance of the order of 41%, when compared to control, that is 100% soil. When comparing the performance of Caupi beans plants with regard to the weight of pods between the proportions of 50% soil + 50% manure compared to 100% manure (Table 5), it was found that the proportion of soil + swine manure had a superiority in order of 12% in relation to the proportion of 100% of swine manure. The greater influence of the proportion 50% soil + 50% manure can be explained when we analyze the components of the treatments, it is understandable that the composition soil + swine manure contains a higher concentration of macro and micronutrients in relation to swine manure, favoring the development of plants of cowpea beans.

Andrade et al. (2019) evaluating the cowpea yield according to different sources of manure - swine, poultry, cattle and sheep, observed significant effects only for the variable grain weight per plant in the condition of cultivation without mulch, concluding that the substrate originated of birds contributed positively to the increase in grain weight, of the order of approximately 70%, when compared to the substrate from swine. The authors justified the superior behavior of the treatment with the poultry litter biofertilizer taking into account two factors: the first is possibly due to the waste produced by the birds to have a higher nitrogen content than the other treatments and the second, this nutrient is made available more quickly and in greater quantity to plants, justifying their differentiated behavior.

Conclusion

Seed weight was increased by approximately 27% by the treatment composed of 100% swine manure, when compared to 50% swine manure + 50% soil.

The 50% treatment of swine manure + 50% soil increased the weight of pods per plant by 41%.

The cultivation system with mulching influenced the weight of pods and the number of pods per plant by up to 37%, in favor of LA2017.

Conflict of interest: All authors declare no conflict of interest.

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