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Growth, chlorophyll index and production of common and cowpea beans using different fertilizations

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Beans are a the major component in the Brazilian diet population, mainly in the northeast of Brazil, though yield is considered low due to the low technological content that is conducted in most producing regions, making it necessary for fertilizations to increase this feature. Considering the above, this study aimed to evaluate growth, chlorophyll index and the production of cowpea bean and common bean under different fertilizations. The experiment had been conducted in the Centre of Human, Social and Agricultural Sciences at The Federal University of Paraíba. The experimental design was a randomized block in factorial arrangement 2 × 4 with seven repetitions. The treatments consisted of two-bean varieties (*Phaseolus vulgaris* L. and *Vigna unguiculata* L.) and four fertilization (Leaf biofertilizer, organic compost made with goat manure, mineral fertilization and a without fertilizer treatment). The variables analyzed was growth, chlorophyll index and bean production. The bean cultivar Sempre Verde obtained higher growth and chlorophyll index *a, b* and total in relation Carioca. Fertilization with organic compost provided higher productivity of bean cultivars. The organic compost may be indicated as fertilizer alternative to the bean in the Paraíba swamp region.

Key words: *Phaseolus vulgaris L., Vigna unguiculata* L., Fertilization, chlorophyll, productivity.

INTRODUCTION

Bean is a high quality nutritional food because of its high protein content (20-25%), high lysine content, and low fat and high fiber contents, making it a major component of the Brazilian diet (Costa, 2008). Despite being a culture little competitive and despite a strong competition with products targeted to the foreign market, beans are still in a prominent position in the Brazilian agribusiness, playing an important role in generating employment and income in Brazil (Carvalho, 2009).

The main species of beans cultivated are *Phaseolus vulgaris* L. (common bean, grown throughout the country), and *Vigna unguiculata* L. (cowpea, Macassa or Macassar bean, grown mainly in the Northeast region and in the Amazon region).

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The use of organic compost in the agricultural production is a practice adopted worldwide, and its efficiency depends on the system and the way its preparation process and raw material used is managed. There may be several quality variations. The nutritional and biological richness that organic compost provide to the soil and plants helps in its cultivation, improving the chemical, physical and biological properties of the soil (Melo et al., 2007). It also provides increased growth, dry matter accumulation and chlorophyll index of crops (Cavalcante et al., 2016).

The use of Leaf biofertilizer is a practice increasingly being adopted by producers using alternative materials in their crops (Pereira et al., 2010). Organic solutes from bovine biofertilizers may provide more suitable conditions for plant cell elongation because of a physical improvement of the soil environment and stimulation of the action of organic protein and solutes, resulting in increased microbial activity (Freire et al., 2010).

The use of biofertilizers may be a viable alternative for providing nutrients, especially for short-cycle crops such as beans. Studies conducted by Mendes et al. (2007) indicate that it is possible to produce beans with an organic production system, achieving yields similar to those obtained with a conventional system.

Biofertilizers provide improvements in physical, chemical and biological properties of the soil and, when applied on leaves, contribute to a balanced supply of macronutrients and micronutrients to plants (Alves et al., 2009; Patil, 2010), allowing the plant to develop all its genetic and productive potential. Its use as a liquid provides an increased absorption of nutrients by the plants (Souza and Resende, 2003).

Considering the importance of bean crops to farmers, the low crop productivity in most producing states, the low adoption of efficient technologies adapted to local conditions, and the capitalization of small farmers to purchase inputs derived from petrochemicals, the study of the use of alternative fertilizing by means of biofertilizers and organic compost is needed as a fertilization and soil conditioning technique involving maximizing the use of existing natural resources in the agro-ecosystem and a less dependence on large industrial conglomerates, holders of chemical-mechanical technologies. Considering the above, this study aimed to evaluate growth, chlorophyll index and the production of cowpea bean and common bean under different fertilizations.

MATERIALS AND METHODS

The experiment was conducted from April to July 2014 at the Humanities, Social and Agricultural Center located in Bananeiras, Paraíba state, a municipality belonging to the Agreste mesoregion and Brejo Paraibano microregion, Brazil (IBGE, 2013).

The soil of the area was classified according to the criteria of the Brazilian System of Soil Classification (SiBCS) (EMBRAPA, 2013) as a Dystrophic Yellow Latosol. The rainfall and the maximum and minimum temperature of the city of Bananeiras-PB recorded during the experiment are shown in Figure 1.

A randomized block design was adopted in a 2 × 4 factorial design with seven replications. The factors under study consisted of two bean cultivars (*Phaseolus vulgaris* L. and *Vigna unguiculata* L.) and four types of fertilization (Leaf biofertilizer, organic compost made with goat manure, mineral fertilization and a without fertilizer treatment) with seven replications. The biofertilizer was prepared according to Penteado (2007) and weekly applied 15 days after emergence. In the first two sprays, the concentration was 5 and 10%. The organic fertilization consisted of organic compounds prepared with goat manure, being applying two liters per hole. For the mineral fertilization, 5.62 g/hole of P_2O_5 were used according to soil analysis (Table 1).

The experimental unit consisted of 16 plants in a 0.50 × 0.25 m spacing, with a total area of 2 m^2, considering four plants as a use area. At forty days, bean plants were in full bloom, and stem diameter, plant height, chlorophyll index *a*, *b* and total were evaluated. The production was harvested at ninety days, and the number pods per plant, number of seeds per pod, weight of 100 seeds, pod length and productivity were evaluated.

To measure plant height, a centimeter-graduated ruler was used from the base of the plant until the end of the main stem. The stem diameter was measured with a precision digital caliper at the base of the plant two centimeters from the soil. Chlorophyll *a*, *b* and total index were measured with a portable chlorophyll meter, ClorofiLOG CFL1030, with readings performed in the flowering period on fourth leaf of the main stem, evaluating the three leaflets exposed to solar radiation.

The number of pods per plant was determined in four plants per sample plot. The number of seeds per pod was determined by counting the grains of 20 random pods per plot. For weight of 100 seeds, after harvesting and threshing the beans, the grains were weighed with 11% humidity. The pod length was measured using a ruler graduated in centimeters.

Data were submitted to analysis of variance and the comparison of means was performed by Tukey test at 5% probability using the statistical software ASSISTAT version 7.7 beta (Silva and Azevedo, 2002).

RESULTS AND DISCUSSION

The greatest plant height was observed for the Sempre Verde bean cultivar, and the fertilization with organic compost provided an increase of this variable (Table 2). The organic inputs contribute to the improvement of the growth of agricultural crops by providing improvements in chemical and physical characteristics of the soil (Barros et al., 2013; Adejobi et al., 2014), making it economically viable and ensuring the productivity of cultures without causing a long-term potential threat to the environment (Nur et al., 2013).

The cultivar Sempre Verde stood out in relation to the Carioca cultivar with a greater stem diameter. This response may be a result of genetic differences existing between species (Table 3). The use of organic fertilizers with organic compost and biofertilizer provided an increase in stem diameter of Sempre Verde bean plants. The organic inputs from plants and animals may have beneficial effects on physical characteristics. They were expressed by the increase in the stability of aggregates and soil total porosity (Mellek et al., 2010). They also act in the chemical improvement, providing nutrients and

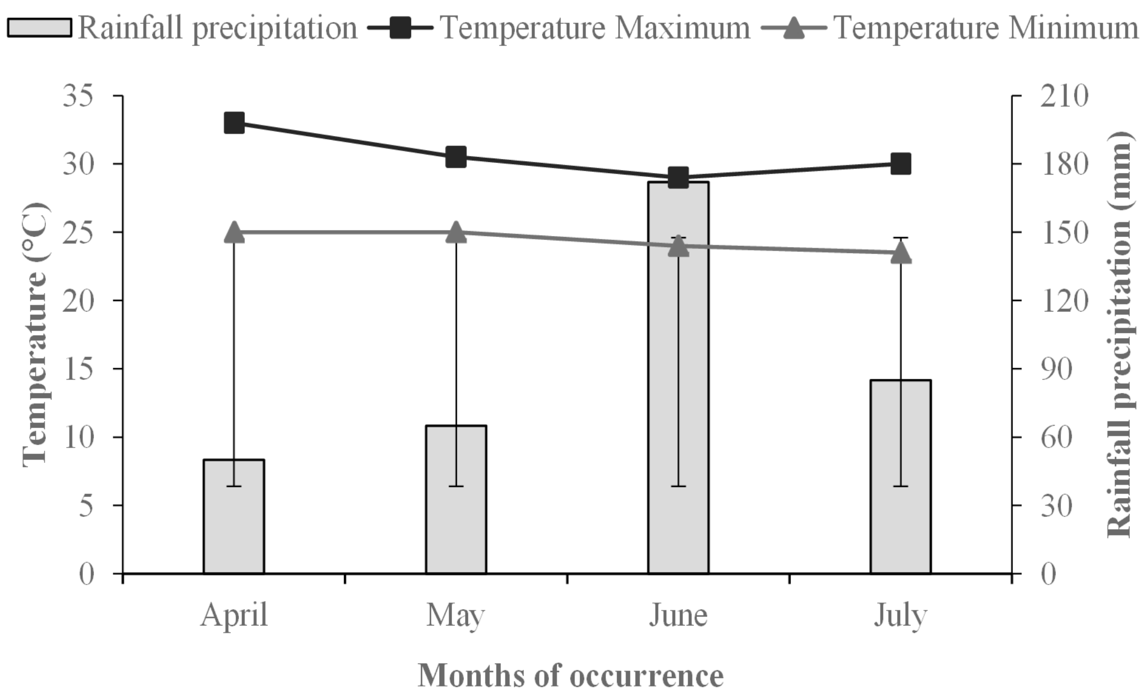

Figure 1. Rainfall precipitation and temperature of the city of Bananeiras-PB between April and July 2014.

Table 1. Characterization of chemical and soil fertility, organic compost and biofertilizer.

Sources	**pH H_2O	P	K^+	Na^+	H^+Al^{3+}	Al^{3+}	Ca^+	Mg^{2+}	BS	CEC	V	m	OM
		Mg dm^{-1}	cmol$_c$ dm^{-3}								---%---		g kg^{-1}
*S	6.51	6.94	0.29	0.03	1.32	0.00	4.45	1.65	6.42	7.75	82.96	0.00	19.38
OC	6.83	136.8	9.53	1.22	4.62	0.00	8.50	5.45	24.68	29.30	84.23	0.0	141.1
	***pH	N	P		K^+	B			S		ORG. C.		OM
B.		g/kg										%	
	3.27	15.93	0.40		0.52	153.58			10.47		47.25		81.46

*S = soil; OC = organic compost; B. = biofertilizer. **pH = active acidity, P = phosphorus available, K^+ = available potassium, Na^+= exchangeable sodium, H^+Al^{3+} = potential acidity, Al^{3+}= exchangeable acidity, Ca^+ = exchangeable calcium, Mg^{2+} = exchangeable magnesium, BS = base sum, CEC = effective cation exchange capacity, V = base saturation, m = Al^{3+} saturation, OM = organic matter. B. = biofertilizer, ***pH = active acidity, N = available nitrogen, P = available phosphorus, K^+ = available potassium, B = available boron, S = available sulfur, ORG. C. = organic carbon, OM = organic matter.

Table 2. Plant height of cowpea *[V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars height (cm)		
	Sempre Verde	Carioca	Mean
Leaf biofertilizer	37.21	33.14	35.17^b
Organic compost	40.54	35.37	37.95^a
Mineral fertilizer	35.98	34.47	35.22^b
Without fertilizer	37.05	37.05	34.59^b
Mean	37.70^A	33.77^B	-
CV (%)			6.86

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 3. Diameter stem plants of cowpea *[V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	**Cultivars stem diameter (mm)**		
	Sempre verde	**Carioca**	**Mean**
Leaf biofertilizer	10.38^{bA}	9.14^{aA}	9.76
Organic compost	14.08^{aA}	9.10^{aB}	11.59
Mineral fertilizer	9.61^{bA}	8.37^{aA}	8.99
Without fertilizer	10.97^{bA}	7.07^{aB}	9.02
Mean	11.26	8.42	--
CV (%)			18.62

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 4. Chlorophyll *a* index of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	**Cultivars**		
	Sempre Verde	**Carioca**	**Mean**
Leaf biofertilizer	37.21	33.14	35.17^{b}
Organic compost	40.54	35.37	37.95^{a}
Mineral fertilizer	35.98	34.47	35.22^{b}
Without fertilizer	37.05	37.05	34.59^{b}
Mean	37.70^{A}	33.77^{B}	-
CV (%)			6.86

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

improving the ability of the soil's cation exchange (Benbouali et al., 2013; Cavalcante et al., 2016), and provide an increase in the diversity of soil fauna (Sall et al., 2015).

Chlorophyll *a* index were higher in fertilization with organic compost. This input may have improved the soil fertility and the availability of nitrogen and magnesium, nutrients that are part of the chlorophyll molecule (Table 4). For Ndubuisi-Nnaji et al. (2011), organic fertilizers provide a greater diversity of nutrients to the soil and can provide a better nutritional balance of the culture. The Sempre Verde bean cultivar had higher chlorophyll *a* index compared to the Carioca cultivar, possibly a genotypic response. For sources of fertilization, the response may have happened because the amount of nitrogen supplied by the organic compost was higher and met the needs of this nutrient by plants, favoring the higher chlorophyll content. For Taiz and Zeiger (2013), plants with a high concentration of chlorophyll are potentially capable of achieving higher photosynthetic rates due to its light energy capture value per time unit.

Fertilization did not significantly affect the chlorophyll *b* index of the cultivar Carioca, a behavior different from what was observed for the cultivar Sempre Verde, where the goat compost performed better when compared to the other fertilizers (Table 5). Among cultivars, Sempre Verde captured the most quantity of quantum lights. According to Scalon et al. (2003), the activity of chlorophyll *b* is an important feature because this chlorophyll pigment captures energy from other wavelengths and transfers them to chlorophyll *a*, which effectively operates the photochemical reactions of plant photosynthesis.

As Table 6 shows, the total chlorophyll index accumulated in bean leaves followed the same tendency of chlorophylls *a* and *b*, in which fertilization with organic compost and the Sempre Verde bean cultivar had the best results (Table 6). The results can be explained by the greater availability of compost nutrients, by the benefits provided by the physical properties of soil, and by the possible increment of humic substances to the substrate, according to the results found by Cavalcante et al. (2013). On the other hand, Silva et al. (2015) found similar results for a lima bean crop when different organic substrates were incorporated into the substrate with the foliar application of cow urine.

There was a significant effect of type of fertilization regarding the variable number of pods per plant. It is observed that the organic compost provided the greatest number of pods per plant, probably due to the beneficial characteristics that the use of the compost provides to

Table 5. Chlorophyll *b* index of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars		
	Sempre Verde	Carioca	Mean
Leaf biofertilizer	10.38^{bA}	9.14^{aA}	9.76
Organic compost	14.08^{aA}	9.10^{aB}	11.59
Mineral fertilizer	9.61^{bA}	8.37^{aA}	8.99
Without fertilizer	10.97^{bA}	7.07^{aB}	9.02
Mean	11.26	8.42	-
CV (%)			18.62

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 6. Chlorophyll total index of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars		
	Sempre verde	Carioca	Mean
Leaf biofertilizer	47.60	42.28	44.94^{b}
Organic compost	54.62	44.47	49.55^{a}
Mineral fertilizer	45.60	42.84	44.22^{b}
Without fertilizer	48.02	39.20	43.61^{b}
Mean	48.96^{A}	42.20^{B}	-
CV (%)			8.35

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 7. Number of pods per cowpea plant [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars		
	Sempre verde	Carioca	Mean
Leaf biofertilizer	13.63^{aB}	28.73^{aA}	21.18
Organic compost	14.11^{aB}	28.72^{aA}	21.42
Mineral fertilizer	14.79^{aB}	21.76^{bA}	8.27
Without fertilizer	13.68^{aB}	22.46^{bA}	18.07
Mean	14.05	25.42	-
CV (%)			11.34

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

the soil (Table 7). Pereira et al. (2013), in a research adding to the soil 2.45 kg of goat manure per hole, observed 29.64 pods per plant in *Vigna* beans. Beltrão Jr. et al. (2012) observed that the addition of organic inputs to the soil provided a decrease in the number of cowpea pods, different from this research.

The Carioca cultivar had the highest increase in the number of pods per plant. Hawerroth et al. (2011) also observed differences in the number of pods per plant upon assessing six common bean cultivars with seed inoculation with Rhizobium, obtaining an amount of 29 pods per plant for the Carioca cultivar.

The Sempre Verde bean cultivar obtained the highest number of seeds per pods compared to the Carioca cultivar. This is a genetic trait (Table 8). There were no significant effects of fertilizations on this feature in the

Table 8. Number of seeds per pod of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars		
	Sempreverde	Carioca	Mean
Leaf biofertilizer	18.15[aA]	10.73[aB]	14.44
Organic compost	18.40[aA]	10.91[aB]	14.65
Mineral fertilizer	18.38[aA]	10.75[aB]	14.57
Without fertilizer	15.72[bA]	10.34[aB]	13.03
Mean	17.66	10.68	-
CV (%)			5.84

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 9. Length pods of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars pods length (cm)		
	Sempre Verde	Carioca	Mean
Leaf biofertilizer	18.15[aA]	10.73[aB]	14.44
Organic compost	18.40[aA]	10.91[aB]	14.65
Mineral fertilizer	18.38[aA]	10.75[aB]	14.57
Without fertilizer	15.72[bA]	10.34[aB]	13.03
Mean	17.66	10.68	-
CV (%)			5.84

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Carioca cultivar. For the Sempre Verde cultivar, the highest number of seeds per pod was observed in the treatments with goat compost and mineral fertilization.

Studying *Phaseolus vulgaris* L. beans, some authors also found no significant differences in the number of seeds per pod with the increase in doses of fertilizer, as is the case studied by Andrade et al. (2004) using mineral fertilization, Carvalho et al. (2011) using different doses of organic waste and mineral fertilizer, and Viana et al. (2011) using fertilization with nitrogen and phosphorus.

Table 9 shows that the Sempre Verde cultivar stood out in relation to the Carioca cultivar regarding pod length, probably a genetic trait, little influenced by other production factors. Smaller pods were observed in cultivar without fertilizer treatment. Results similar to those of this study were found by Araújo et al. (2001) with snap beans, in which there was no significant response for pod length with the use of increasing doses of swine manure and NPK. Using phosphorus fertilization, Zucareli et al. (2006) found no significant differences between the doses tested for pod length in common beans.

The lowest weight of 100 seeds was observed for the Sempre Verde bean cultivar. As for fertilization, treatments with foliar biofertilizers and goat compost were those that provided the highest weight of 100 seeds accumulations (Table 10). Silva et al. (2011) also did not observe an influence on weight of 100 grains using different mineral sources and the inoculation of cowpea bean seeds. Alves et al. (2009), in a study with cowpea, observed that there was no significant effect of the increase in biofertilizer doses on the treatments when compared to the without fertilizer treatment.

There was no significant difference between the productivity of bean cultivars (Table 11). However, the fertilized treatments had higher yields, especially the treatment with organic compost, which provided a productivity higher than that obtained by Moreira et al. (2013), who used nitrogen doses up to 120 kg ha^{-1}, and Galvão et al. (2013) upon evaluating cowpea productivity in different managements and residual potassium fertilization systems.

According to Galbiatti et al. (2011), biofertilizer fertilization provides a seeds yield similar to the mineral fertilizer, corroborating the present study. However, the addition of two liters of compost per hole provided an increase in grain yield possibly because it favored nutritional balance, improved the physical characteristics of the soil and increased the diversity of soil fauna, thus

Table 10. Weight of 100 seeds of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars weight (g)		
	Sempre Verde	Carioca	Mean
Leaf biofertilizer	13.63^{aB}	28.73^{aA}	21.18
Organic compost	14.11^{aB}	28.72^{aA}	21.42
Mineral fertilizer	14.79^{aB}	21.76^{bA}	8.27
Without fertilizer	13.68^{aB}	22.46^{bA}	18.07
Mean	14.05	25.42	-
CV (%)			11.34

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

Table 11. Productivity of cowpea [*V. unguiculata* (L.) Walp], cultivar Sempre Verde, and common bean (*P. vulgaris* L.), cultivar Carioca, in function of different fertilizations.

Treatments	Cultivars productivity (kg ha^{-1})		
	Sempre Verde	Carioca	Mean
Leaf biofertilizer	2471.57	2240.00	2355.78^{ab}
Organic compost	2993.28	3126.71	3060.00^{a}
Mineral fertilizer	3304.71	2254.42	2779.57^{ab}
Without fertilizer	2136.28	2154.28	2145.28^{b}
Mean	2726.46^{A}	2443.85^{A}	-
CV (%)			18.82

Means followed by the same letter, lowercase on the columns and uppercase on the row do not differ by Tukey test at 5% probability.

improving the development of the culture (Sall et al., 2015).

Conclusion

The Sempre Verde bean cultivar have a higher growth and a higher accumulation of chlorophyll index *a, b* and total contents than the Carioca cultivar. Fertilization with organic compost provides a better development of these variables in relation to the other fertilizations. Fertilization with organic compost provides a greater productivity of bean cultivars. The organic compost may be indicated as a fertilization alternative for family farmers of the Paraíba state swamp region.

Conflict of Interests

The authors have not declared any conflict of interests.

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