Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online
DOI: https://doi.org/10.18188/sap.v19i4.24572

GROWTH OF COWPEA SUBMITTED TO MINERAL FERTILIZATION AND DIFFERENT DOSES OF BIOFERTILIZER

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SAP 24572 Received: 16/04/2020 Accepted: 21/08/2020
Sci. Agrar. Parana, Marechal Cândido Rondon, v. 19, n. 4, oct./dec., p. 321-328, 2020

ABSTRACT - In the Northern region, the cultivation of cowpea is mainly carried out by small producers, who have little financial and technological resources to optimize and increase production. Therefore, the objective of this work was to evaluate the growth of cowpea subjected to mineral fertilization and doses of biofertilizer produced in domestic compost. The experiment was carried out in a protected environment, covered with a 50% shade screen, at the Federal University of Western Pará (UFOPA), Santarém PA, in 2017. Seeds were arranged in 5 L pots, containing 3.5 Kg of Yellow Latosol. For sowing, 3 seeds per pot were used and thinning occurred 7 days after seedling emergence, leaving only the most vigorous. The experimental design used was randomized blocks, with subdivided plots, where the plots were the doses of biofertilizer (50, 100, 150 and 200 mL plant^{-1} + mineral fertilizer) and the subplots, the time periods: T1 (0 to 20 days), T2 (24 to 33 days), T3 (37 to 47 days) and T4 (51 to 61 days), containing five repetitions. Plant height, stem diameter, absolute stem growth rate and absolute growth rate in stem thickness were evaluated. The greatest growth of cowpea was obtained in treatments with mineral fertilization. The dose of 200 mL plant^{-1} of the biofertilizer showed results close to mineral fertilization, in different vegetative stages. Cowpea plants, starting at 45 DAE, tend to stabilize their growth in diameter.
Keywords: *Vigna unguiculata* (L.) Walp, organic fertilizer, domestic compost.

CRESCIMENTO DE FEIJÃO-CAUPI SUBMETIDO À ADUBAÇÃO MINERAL E DIFERENTES DOSES DE BIOFERTILIZANTE

RESUMO - Na região Norte, o cultivo de feijão-caupi é principalmente realizado por pequenos produtores, os quais dispõem de pouco recurso financeiro e tecnológico para otimizar e aumentar a produção. Diante disso, o objetivo deste trabalho foi avaliar o crescimento do feijoeiro-caupi submetido à adubação mineral e doses de biofertilizante produzido em composteira doméstica. O experimento foi realizado em ambiente protegido, coberto com tela de 50% de sombreamento, na Universidade Federal do Oeste do Pará (UFOPA), Santarém/PA, em 2017. Sementes foram dispostas em vasos de 5 L, contendo 3,5 Kg de Latossolo Amarelo. Para a semeadura utilizaram-se 3 sementes por vaso e o desbaste ocorreu 7 dias após emergência das plântulas deixando apenas a mais vigorosa. O delineamento experimental utilizado foi blocos casualizados, com parcelas subdivididas, onde as parcelas foram as doses de biofertilizante (50, 100, 150 e 200 mL planta^{-1} + adubação mineral) e as subparcelas, os períodos de tempo: T1 (0 a 20 dias), T2 (24 a 33 dias), T3 (37 a 47 dias) e T4 (51 a 61 dias), contendo cinco repetições. Foram avaliadas a altura das plantas, diâmetro do caule, taxa de crescimento absoluto caulinar e taxa de crescimento absoluto em espessura caulinar. O maior crescimento do feijoeiro-caupi foi obtido nos tratamentos com adubação mineral. A dose de 200 mL planta^{-1} do biofertilizante apresentou resultados próximos a adubação mineral, em diferentes estádios vegetativos. Plantas de feijão-caupi, a partir de 45 DAE, tendem a estabilizar seu crescimento em diâmetro.
Palavras-chave: *Vigna unguiculata* (L.) Walp, adubação orgânica, composteira doméstica.

INTRODUCTION

The cowpea is also known as macassar bean or string bean, it was introduced in Brazil at the time of the great navigations by the Portuguese, it is a culture originating in Africa (FREIRE FILHO et al., 2011). Cowpea is mainly produced in the North and Northeast, its cultivation in Brazil is around one million hectares (SANTOS et al., 2014; FILHO et al., 2017).

The cowpea's crop has great socioeconomic importance in the Amazon, it is one of the most important components in the human diet, since its production ensure food with a high nutritional content, source of proteins, carbohydrates and fibers, besides being an important supplier of income to small farmers (FERNANDES et al., 2013).

In the North region, a large part of the cowpea's production comes from family farming (CASTELLETTI and COSTA, 2013). However, the high price of fertilizers ends up being a limitation for the small farmers to intensify crop productivity, so it is necessary to develop techniques that benefit these producers and help increase productivity (LINHARES et al., 2016), without raising the cost of production.

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The exacerbated use of chemical fertilizers, especially nitrogen fertilizers, can acidify the soil, change the microbiota and the physical quality of the soil, thus decreasing production (FERREIRA et al., 2018). In this case, organic fertilization can be an alternative to mineral fertilizers, bringing economic benefits to the production (GERLACH et al., 2013).

The use of organic fertilization in the soil improves fertility, physical, chemical and biological characteristics, leveraging agricultural production (MUELLER et al., 2013). Depending on the degree of the compound's particles, the plant will be able to absorb more quickly (RODRIGUES et al., 2014). In addition to solid compounds, there is also biofertilizers, a liquid that can be applied by leaf or by fertigation (JUNIOR et al., 2011).

The liquid biofertilizer is the result from the fermentation of organic matter with water, in an aerobic or anaerobic environment (SANTOS et al., 2014), it is a material that presents a complex and variable composition, its nutritional composition depends on the organic material used (OLIVEIRA et al., 2014). After its production, the biofertilizer is made up of several microorganisms, besides the vitamins, antibiotics, toxins, and organosineral chelates (SANTOS et al., 2017).

The biofertilizer can be obtained from different methods, the most known is from anaerobic digesters that generates the biofertilizer and biogas (BARBOSA and LANGER, 2011), however the costs for implementing the technology vary according to the model, the cost of the Canadian model varies from R$ 2,104.00 to 7,266.00 depending on its capacity (CALZA et al., 2015).

Thus, the use of adapted composters can be an alternative for small farmers to acquire biofertilizer, as composting is a simple and low-cost technique (RODRIGUES et al., 2014b). In this sense, the objective in this work was to evaluate the growth of cowpea submitted to mineral fertilization and different doses of biofertilizers from domestic composter.

MATERIAL AND METHODS

The experiment was carried out in a nursery area covered with canvas (50% shading) at the Federal University of Western Pará/UFOPA - Tapajós Unit, under the geographical coordinates 2° 25' 09.4" S and 54° 44' 31.4" W, in the city of Santarém, state of Pará, Brazil, from 10/13/2017 to 12/4/2017. The city has a hot humid climate, with an average temperature varying from 25 to 28ºC, and an average rainfall of 1,920 mm, during the months from July to November occurs the highest temperatures and the greatest rainfall is from December to May (GONÇALVES et al., 2012).

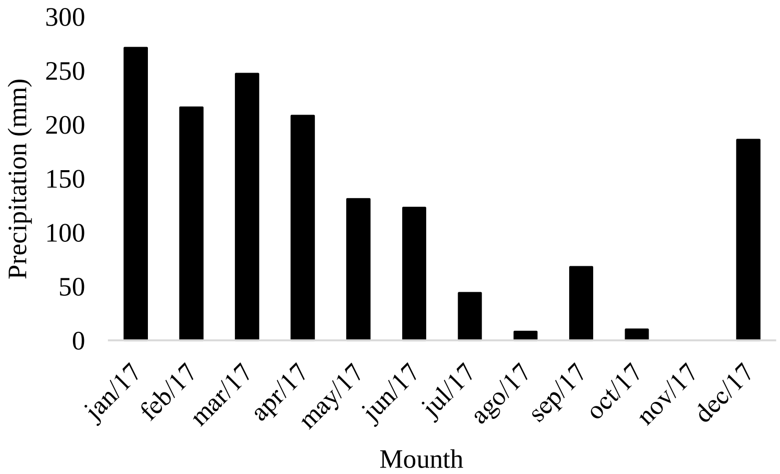

FIGURE 1 - Monthly rainfall in the municipality of Santarém (PA) during 2017. Santarém Automatic Station (INMET, 2018).

Seeds of cowpea variety Manteiguinha de Santarém were obtained in the municipal market and were sown in pots with a capacity of 5 L, using 3.5 kg of soil, with the pots allocated on benches. For sowing, 3 seeds per pot were used and thinning occurred 7 days after seedling emergence, leaving only the most vigorous. The soil used as a substrate is classified according to Gama et al. (2020), as a Yellow Latosol and was collected in the 0-0.20 m layer at the UFOPA Experimental Farm, located at Km 37 of the Santarém-Curua Una Highway (PA-370). The soil was sieved with a 2 mm mesh and analyzed physically-chemically (Table 1).

The liquid biofertilizer was obtained from a domestic composter built with two buckets with a capacity of 20 L, in the upper bucket several holes were drilled in its bottom and in its upper side to allow oxygen to enter, in the lower bucket was made a circular cut in its lid, so that it could fit between the buckets and the passage of the slurry that was stored in it. After assembling the structure, the upper bucket was filled in layers with the following compounds: watermelon peel, orange pomace and peel, melon, cattle manure, papaya, banana, tomato, pumpkin and dried tree leaves (Table 2). The end of the biofertilizer production process was marked by its maturation, occurring from 30 days after filling the composter, only after this period was made the chemical characterization of the compound (Table 3).

The experimental design used was in random blocks in a split plot scheme (5 doses x 4 times) with five replications, in which the plots were represented by the doses of biofertilizers (50, 100, 150, 200 mL/plant^{-1}) and mineral fertilization (control) with dose applied as a function of soil analysis, the sub-plots were represented by different times [T1 = 0-20 days after emergence – (DAE); T2 = 24-33 DAE; T3 = 37-47 and T4 = 51-61]. The doses of biofertilizer were diluted in 1000 mL of water, applying 200 mL/plant^{-1}, the applications were made every 5 days, starting from sowing and ending at the 55 DAE. For the control of insect pests in particular the aphids were sprayed with Neem extract (*Azadirachta indica*), produced according to the methodology of Carmo and Viera (2016).

TABLE 1 - Physical-chemical characteristics of the soil collected in the 0-0.20 m layer, collected at the UFOPA Experimental Farm, Santarém-PA. Source: Laboratory of Agro Analysis, Cuiabá-MT.

pH ($CaCl_2$)	O.M.	Ca+Mg	Ca	Mg	Al	H	S	T	P	K
	(g dm^{-3})	.... cmol c dm^{-3}							.... mg dm^{-3}	
4.7	33.9	2.8	2.0	0.7	0.3	5.0	2.8	8.1	3.3	28.8
Zn	Cu	Fe	Mn	B	S	Sand	Silt	Clay	V	m
.... mg dm^{-3}						.... g kg^{-1}			.... %	
1.5	0.4	259.9	19.8	0.5	8.7	156	175	669	34.9	9.0

OM = organic matter, S = sum of bases, T = cation exchange capacity, P = available phosphorus Mehlich^{-1}, V = base saturation, m = aluminum saturation.

TABLE 2 - Ratio of the percentage of compounds used in the production of biofertilizer.

Compounds	Percentage (%)
Dry leaves	50
Watermelon peel	15
Cattle manure	8
Papaya	5
Banana	5
Pumpkin	5
Tomato	5
Melon	5
Orange	2
Total	100

TABLE 3 - Chemical characteristics of the biofertilizer formulated after maturation. Source: Soil Quality Laboratory/UFOPA, Santarém-PA.

pH H_2O	pH KCl	Ca+Mg	Ca	Mg	Al	Na
		.... cmolc dm^{-3}				
9.33	8.96	3.30	2.40	0.90	0.00	3.00
P	N	K	TOC			O.M.
.... mg dm^{-3}			.... g kg^{-1}			
387.67	70	1289.00	16.82			28.99

TOC = total organic carbon, OM = organic matter.

The variables analyzed were: plant height (PH); plant diameter (PD); stem absolute growth rate (SAGR) and in stem thickness absolute growth rate (STAGR). The SAGR and ASTGR formulas, presented by Silva et al. (2000), were adapted to present the data in percentage, described by Equation 1 and 2:

$$TCAC = \left(\frac{L2-L1}{T2-T1}\right) * 100 \qquad \text{(Equation 1)}$$

$$TCEC = \left(\frac{C2-C1}{T2-T1}\right) * 100 \qquad \text{(Equation 2)}$$

Where:
SAGR = Stem absolute growth rate (%),
STAGR = Stem thickness absolute growth rate (%),
L = height of the plant (cm),
C = the thickness of the plant (mm) and
T = DAE (days after emergence).

Biometric data were submitted to analysis of variance and regression by the Agroestat software (BARBOSA and MALDONADO, 2014). For the performance of statistical analyzes, the SAGR and STAGR data were presented in percentage and to achieve the normality an arc-sine transformation (root (x/100) was performed, the observed differences were submitted to comparison of averages by the Tukey test, at 5% probability of error.

RESULTS AND DISCUSSION

The use of biofertilizer and mineral fertilizer, as well as the different periods of time significantly affected the growth of cowpea, in height and diameter (Table 4). However, for SAGR and STAGR, divergent responses occurred, in the first variable the test was not significant for the interaction, in the second variable the parameters of the interaction between doses and time presented significance ($p < 0.05$).

TABLE 4 - F test for height, diameter, absolute stem growth rate (SAGR) and absolute growth rate in stem thickness (STAGR).

Treatments	Plant height	Plant diameter	SAGR (%)	STAGR (%)
Doses (A)	48.59**	24.53**	6.98**	1.53^{ns}
Times (B)	634.79**	1302.94**	3.56*	49.39**
A x B	5.04**	3.96**	1.50^{ns}	2.01*

*, **, ns = significant at 5%, significant at 1% and not significant at 5% probability, by the F test, respectively .

The mineral fertilization proved to be statistically superior in vertical and radial growth of cowpea, the dose of biofertilizer that came closest to mineral fertilization, in vertical and radial growth was that of 200 mL/plant^{-1}, where it showed growth statistically equal to mineral fertilization in the periods of T1 and T2, from the periods of T3 and T4 the mineral fertilization presents average results superior in height, for the diameter the period T4 the average growth of the mineral fertilization is statistically equal to the averages of the doses of 200 mL and 50 mL/plant^{-1} of biofertilizer. For height and diameter, the T4 time presented the highest average growth for all treatments (Table 5).

TABLE 5 - Average height and diameter, in their respective times.

	Plant height (cm)			
Treatments	T1	T2	T3	T4
Mineral fertilizer	12.86 Ad*	17.91 Ac	24.74 Ab	31.97Aa
50 mL	8.39 Bd	12.97 Cc	18.11 Bb	25.42 Ba
100 mL	10.45 ABd	15.07 BCc	19.39 Bb	24.1 Ba
150 mL	10.24 ABd	15.22 ABCc	20.16 Bb	24 Ba
200 mL	11.84 Ad	16.47 Abc	20.44 Bb	24.45 Ba
CV (%) dose		15.31		
CV (%) time		14.26		
	Plant diameter (cm)			
	T1	T2	T3	T4
Mineral fertilizer	3.65 Ad	5.45 Ac	6.48 Ab	6.89 Aa
50 mL	2.84 Cd	4.58 BCc	5.66 Bb	6.38 Aab
100 mL	2.75 Cd	4.12 Cc	5.21 BCb	5.81 Bca
150 mL	2.86 BCd	4.09 Cc	4.91 Cb	5.56 Ca
200 mL	3.46 ABd	5.02 Abc	5.79 Bb	6.46 Aa
CV (%) dose		19.10		
CV (%) time		7.64		

*Averages followed by the same letter. uppercase in the column and lowercase in the lines, do not differ by the Tukey test at 5% probability of error. CV = coefficient of variation.

In a study by Sousa et al. (2018), higher average growth for height of cowpea, variety butter, was verified when using 20 kg ha^{-1} of nitrogen fertilization. However, in the study of these same authors, the doses of biofertilizer showed values below the mineral fertilization, thus indicating that the nitrogen indices and the doses of biofertilizer may be below the recommended for the crop.

For the data referring to SAGR there was no significant interaction, with the doses of mineral fertilizer as the best results and for time T3 the highest growth rate, in the STAGR there was no statistical difference between the doses of biofertilizer and mineral fertilizer, when it took into consideration over time, SAGR averages do not present any degree of significance, with only STAGR with significant averages. The STAGR, in periods T1 and T2, was the one with the highest growth rate, with mineral fertilization presenting the highest values, from T3 onwards the growth decreases, until there is no difference between treatments, (Table 6).

According to Silva et al. (2007), the absorption of biofertilizer by the plants is faster, as it is a liquid product, but its efficiency may be reduced depending on the dose. However, the formulation used in the work was not efficient in the face of chemical fertilization. Besides that, according to Sá et al. (2013), there is not criterion for the elaboration of the biofertilizer, and its chemical composition varied according to the material used.

TABLE 6 - Absolute stem growth rate (SAGR) and absolute stem growth rate (STAGR), as a function of their respective times (T).

Treatments	SAGR (%)
Mineral fertilizer	49.06 A
50 mL	34.48 B
100 mL	31.34 B
150 mL	27.47 B
200 mL	30.41 B
T1	33.31 AB
T2	35.25 AB
T3	41.68 A
T4	30.78 B
CV (%) Dose	29.93**
CV (%) Time	31.84**

	STAGR (%)			
Treatments	T1	T2	T3	T4
Mineral fertilizer	25.53 Aa	20.53 Aa	11.17 Ab	8.96 Ab
50 mL	19.89 ABa	18.50 Aa	15.12 Aab	9.77 Ab
100 mL	20.03 ABa	14.45 Aa	16.43 Aa	7.27 Ab
150 mL	18.26 Ba	16.64 Aa	11.98 Aab	8.71 Ab
200 mL	23.89 ABa	14.86 Ab	12.39 Ab	9.73 Ab
CV (%) dose				19.10**
CV (%) time				7.64**

*Averages followed by the same letter, uppercase in the column and lowercase in the row, do not differ by the Tukey test, at 5% probability of error, CV = coefficient of variation, ** = transformed CV (square root x/100).

Figure 2 shows the regression curves for the plant's height as a function of AEDs. It is observed that in the doses of biofertilizers, there is a behavior of an encounter in its lines at 50 DAE. The linear regression model was the one that best adjusted to the plant's height data in all treatments, being possible to observe that the mineral fertilization presented the best results of plant's height. This suggests that the amount of biofertilizer applied was not adequated to promote growth to the cowpea's crop, indicating the lack or excess of nutrients. According to Neto et al. (2015), nitrogen is one of the nutrients that most responds to cowpea, however excessive applications can negatively influence the biological nitrogen fixation process. In addition, Orozco Corral et al. (2016), point out that the excessive use of mineral fertilizers changes the natural balance of the soil, its physical and chemical structure.

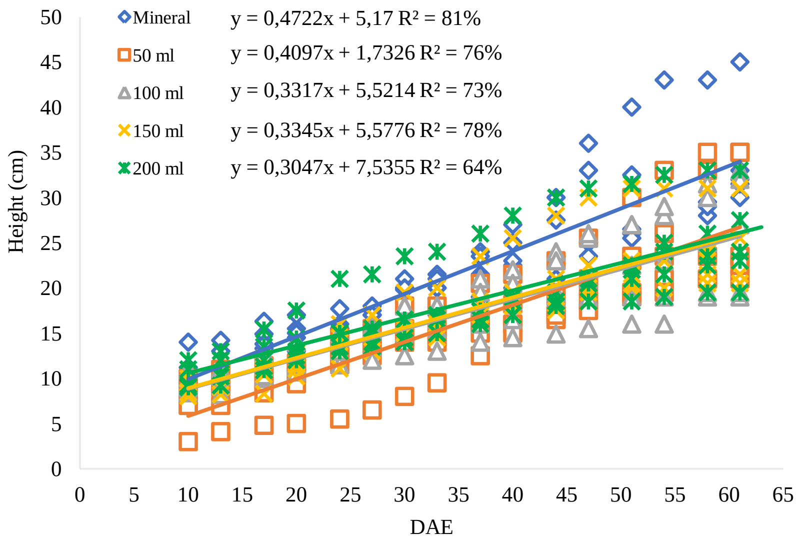

FIGURE 2 - Height of cowpea plants, depending on the days after emergence (DAE). *Significant at 5% probability of error, by the F test.

The regression curves for the plant diameter are shown in figure 3. Quadratic regression was presented for all treatments, with a tendency to stabilize at 50 DAE. In a study carried out by Pessuti et al. (2015), there was a positive correlation between doses of biofertilizer and growth, the higher the dose of biofertilizer the greater is the growth and the higher is the productivity of the soybean crop.In the work developed by Sevilla-Perea and Mingorance (2015), in order to recover a degraded area with high levels of Fe and Mn, organic compound plus liquid biofertilizer were used, besides the plant's species, thyme (*Thymus zygis*), rosemary (*Rosmarinus officinalis*) and capers (*Capparis spinosa*), where the biggest amount of biofertilizer compound improved the soil quality, reduced the nutritional deficiencies of P, N and Zn and the stress caused by Fe and Mn.

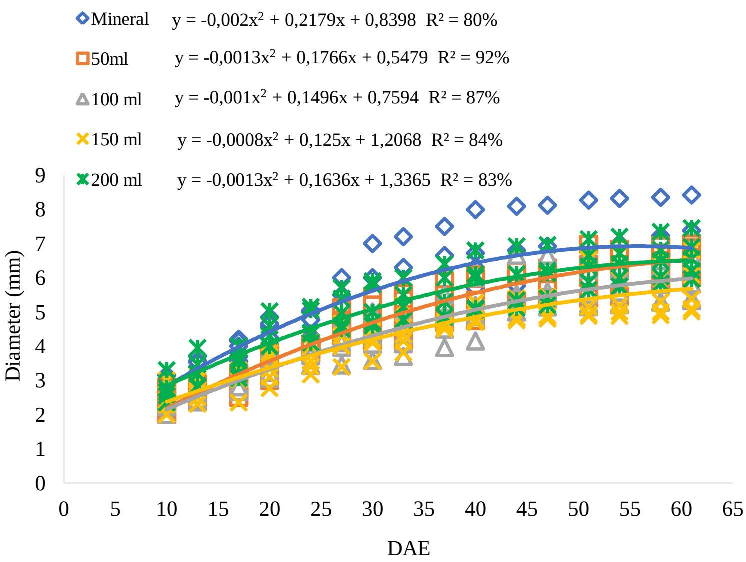

FIGURE 3 - Diameter of cowpea plants, depending on the days after emergence (DAE). *Significant at 5% probability of error, by the F test.

In Figure 4, the regression curve for the SAGR of the treatments is presented, where the doses 50 and 200 mL plant^{-1} of biofertilizer with better quadratic adjustment, with a slight increase in the growth rate in the stem diameter after 55 DAE. The other treatments received linear adjustment. However, a decrease in radial growth is observed in all treatments over time, indicating the peak of radial growth at 61 DAE.

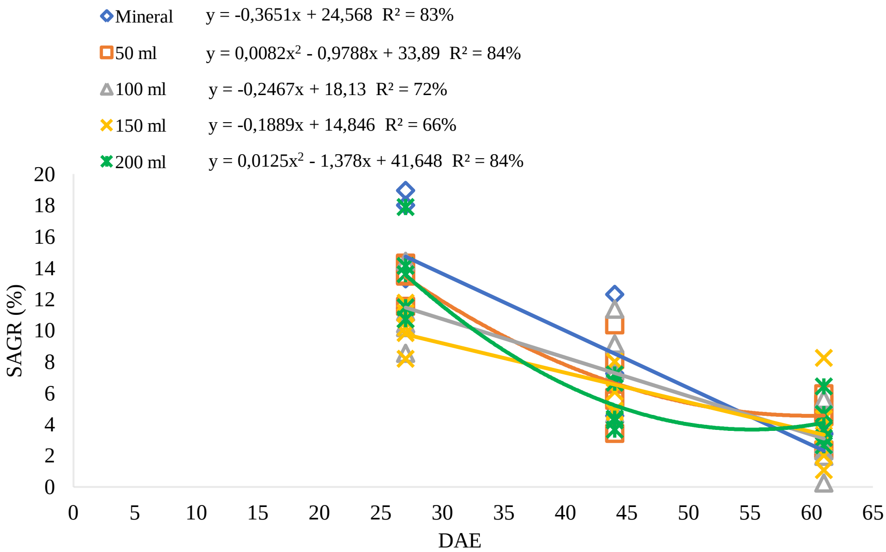

FIGURE 4 - Growth rate in stem thickness of cowpea plants as a function of days after emergence. Significant at 5% probability of error, by the F test.

Although the biofertilizer has shown good results in growth regressions in AP, DM and STAGR with R2> 0.60, however the product was not able to demonstrate superior growth performance compared to mineral fertilization. Despite this, Sousa et al. (2014) and Freire et al. (2015), affirm that the use of organic fertilizer benefits the growth of plants and Santos et al. (2014), point out that liquid biofertilizers provide to the plants, greater tolerance to the attack by pests and diseases when applied in the leaf shape.In a study by Fu et al. (2017), with the use of biofertilizer in the banana tree to suppress *Fusarium oxysporum* f. sp. *cubense* (Foc), it can be seen that, applications consecutive periods of biofertilizer in the soil, over three years, increased the levels of bacteria, contributing to this fact..

Regarding the productivity of cowpea, Silva et al. (2013), obtained an increase in the values of transpiration, dry matter of grain and productivity of the culture using foliar fertilization of bovine biofertilizer. In work developed by Galbiatti et al. (2011), an increase in productivity of common bean cv. Carioca, when the biofertilizer was used, compared to mineral fertilization. Martins et al. (2015), testing the use of biofertilizer, bovine manure and commercial inoculant containing (*Rhizobium tropici*) in common bean, concluded that the manure isolated or associated with the biofertilizer and inoculant could replace mineral fertilization.

Bearing in mind the socioeconomic importance of cowpeas for the North region, it is necessary to develop efficient and low cost agronomic techniques for maintaining the production and to guarantee the income for small farmers, in this sense the importance of this work stands out for the new advances in the production of biofertilizers and phytosanitary practices for the crop.

CONCLUSIONS

The greatest growth of cowpea was obtained in treatments with mineral fertilization.

The dose of 200 mL plant^{-1} of the biofertilizer showed results close to mineral fertilization, in different vegetative stages.

Cowpea plants, starting at 45 DAE, tend to stabilize their growth in diameter.

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