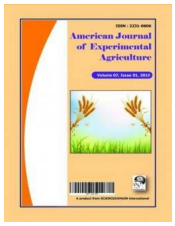

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Organic Fertilization: Answer in the Sugarcane Development (*Saccharum officinarum* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors KRLF, LPS and FM designed the study, wrote the protocol and wrote the first draft of the manuscript. Author JCM reviewed the experimental design and all drafts of the manuscript. Authors KRLF, LPS and FM managed the analyses of the study. Author FM identified the plants. Authors LPS and JDR performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The influence of different doses of organic and chemical fertilizers can provide better efficiency in nutrient availability to plants and reduce the application in large quantities. The objective of this study was to analyze the influence of different levels of organic manure and chemical fertilization on the development of plant cane plants. The experiment was conducted in a randomized block design with four replications, each block had 7 treatments (T1 Fertilizing organic 15 t ha^{-1} of cattle manure; T2 Organic Fertilization 30 t ha^{-1} of cattle manure; T3- organic manure 45 t ha^{-1} of cattle manure, fertilizer T4 Chemistry 50% according to the soil soil analysis, fertilizer T5- Chemistry 100% according to the soil analysis, fertilizer T6- Chemistry 150% according to soil analysis and T7- unfertilized control and evaluated on different days after planting. The results showed that the treatments corresponding to organic fertilization (T1, T2 and T3), allowed greater plant growth parameters for height, stem diameter, number of tillers and sugarcane leaves. The organic

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fertilization in different proportions, following the recommendations according to soil analysis, allows further development of sugarcane plants in sandy soil texture of the Piauí compared to chemical fertilizer.

Keywords: Saccharum officinarum; renewable waste; growth; sandy soil.

1. INTRODUCTION

The increased use of organic fertilizer in Brazil is mainly by increasing the supply of residues from animal production. These organic residues provide nutrients for plants and improve the physical, chemical and biological soil [1,2], resulting in better plant growth. The use of organic fertilizer presents a promising alternative capable of reducing the quantities of chemical fertilizers to be applied in agriculture, with a resulting reduction in costs and economic benefits to the producers [3,4]. The explanation of this economy is due to the use of organic residues generated in their own rural unit, or nearby, where its use as organic fertilizer allows both a correct way to dispose this residue [1].

Among the many benefits of adding to the soil organic residue, [5] points out that the use of organic fertilizer promotes increased stability of soil aggregates, besides being associated with reduced density and increased water infiltration and retention therein, thereby increasing the water content available to plants.

Regarding the improvement of the chemical soil condition, there is an increase in the availability of nutrients to the crop in particular nitrogen, and increased capacity for cation exchange, which when combined with the increase of organic carbon in the soil, have significant effects on crop yield, improving retention and nutrient supply, benefiting the root environment and stimulating the plants development [6,7].

So that the sugarcane plant expresses maximum production potential, several factors are important such as weather conditions, type of soil management that affect the physical, chemical and biological soil, farming, among others. All these variables will affect the final composition of sugarcane, that is, in quality [8]. The most critical element in fertilizers in sugarcane has been phosphor, because of the high degree of interaction with the ground, and although it is absorbed in smaller amounts when compared with N and K, P is an important role in initial formation and root development, with greater absorption and utilization of other nutrients [9].

The application of organic fertilizer reduces the high costs of fertilizer and allows the simultaneous supply of nutrients and organic matter. However, little is known about the influence of this source in the sugarcane production. Thus, the aim of this study was to evaluate different amounts of organic fertilizer and compare them with the recommended mineral fertilizer for the sugarcane cultivation in initial development initial (plant sugarcane), developing out under one Psamment soil.

2. MATERIALS AND METHODS

The experiment was conducted in the teaching module of the Federal University of Piauí- PI, Brazil, with 09° 06 '25.1' 'S, 44° 21' 55.2 " O and 270 m of altitude. The prevailing climate is the type AW, according to Koppen, is characterized by summer rains and average rainfall of 950 mm yr^{-1}, with an average of 26.5℃ and 68% relative humidity, the soil experimental area is a Psamment [10] with sandy texture.

Before the implementation of the experiment, soil sampling was carried out, representative of the area for chemical analysis and particle size characterization. In the analysis contents were found which are shown in (Table 1). The management NPK mineral fertilizer and the organic was performed according to the levels found in soil analysis.

Table 1. Soil analysis of the experimental area before the implementation in the layer up to 20 cm deep

pH	O.M	P	K	Ca	Mg	Al	H+Al	BS	CEC	V	M	Ca	Mg	K
$CaCl_2$	g kg^{-1}	mg dm^{-3}	----------		cmol$_c$ dm^{-3}	----------			----------		%----------			
5.6	7.4	15	0.12	1.5	0.26	0	0.51	2	2.34	78	0	62	11.1	5

Legend: O.M = Organic Matter; BS = Basic Sum; CEC = Cation Exchange Capacity; V = Saturation by bases; m = saturation of the CEC by aluminum; Ca %= saturation of the CEC by calcium; Mg %= saturation of the CEC by magnesium; K %= saturation of the CEC by potassium

The experimental design was a randomized complete block design with four replications, each block had 7 treatments. Each plot had 3 lines, which the length corresponded two meters, the population was 12 buds per linear meter, with 0.50 m spacing between rows. The two wings of each plot and 0.50 m from the end of the center line formed to border, so that the useful area of the plot was 2 m^2 and a total area was 6 m^2.

The study found the following treatments:

T1- organic fertilization (50% according to soil analysis - 15 t ha^{-1} of bovine manure);
T2- organic fertilization (100% according to the soil analysis - 30 t ha^{-1} of bovine manure);
T3- of organic fertilizers (150% according to soil analysis - 45 t ha^{-1} of bovine manure); Chemical Fertilization
T4- (50% according to the soil analysis); Chemical Fertilization
T5- (100% according to the soil analysis);
T6- Fertilization Chemistry (150% according to the soil analysis) and T7- control without fertilization.

The fertilizers applications were carried out in the furrow at planting, observing the distance between the fertilizer and culms of 5 cm. Taking into account for organic fertilization there was a different preparation due to damage caused to the direct contact with the culm, its preparation was performed with fertilizer tanning, its deployment to 20 cm depth, followed by coverage 5 cm of soil and planting the culms.

The sugarcane planting was on 15 October 2014, and it was used the cultivar RB835486, because of the regional recommendation and the wide adaptability.

Growth analyzes were performed at weekly intervals 120, 126, 133, 139, 168, 180, 210 days after planting. The weekly assessments were adopted as a covariate, being repeated measures in time to make the averages adjustment.

The variables studied were performed in 5 plants in the useful area of the plot, as follows:

Number of leaves: We counted all the leaves of each plant, considering how true leaf fully expanded leaf blade, with collar and hem visible structures.

Plants height: they were measured with a graduated measuring tape, measuring the plant base to the insertion of the meristem.

Stem diameter: caliper was used to measure the diameter of the stem where the measurements were made in the stem base to 2 cm from the ground.

Number of tiller: The tiller number count was performed from the issuance of the tillers in the plants of the plot.

It was also conducted study on the economic cost in ha^{-1} ($) of the treatments evaluated in the research.

The data were submitted to analysis of covariance (ANCOVA), and the averages were compared by Tukey test at 5% probability. We used the statistical software R (version 3.2.0), to process the data of this experiment.

3. RESULTS AND DISCUSSION

The effect of different concentrations of organic and chemical fertilizer for the variables plant height, stem diameter, leaf number, and number of tillers, are shown in (Table 2).

Table 2. Analysis of variance for plant height (PH), stem diameter (SD), number of leaves (NL), number of tillers (NT) of sugarcane

Source of variation	PH (cm)	Square average SD (cm)	NL Unit $plant^{-1}$	NT Unit $plant^{-1}$
Covariance	2,162.75^{ns}	0.36^{ns}	27.36^{ns}	5.14^{ns}
Fertilizing	15,000.59**	231.18**	714.72**	59.05**
Blocks	27,165.63**	102.50**	227.72**	3.68*
Residue	600.79	13.53	24.56	1.34
Coefficient of variation (%)	21.35	19.54	46.59	59.04

*^{ns} no significant ; * Significant at 0.05; ** Significant at 0.10*

It is observed that the plant height, stem diameter, leaf number, and number of tillers showed a significant difference between the averages. The ANCOVA also shows a significant difference to the effect of the blocks, the variables, plant height, stem diameter and number of leaves.

The values referring to the average of the growth parameters analyzed are shown in (Table 3).

For plant height (PH) and number of leaves (NL), the highest values were observed treatment T3 and T2. The best results observed in the treatments with organic fertilizer, can be attributed to the ability of such residues to increase infiltration, retention and water availability in the soil and increase the availability of nutrients to plants. Working with bovine manure, [11] observed similarity in the variable plants height and the number of leaves up to concentration of 60 ton.ha^{-1} of organic fertilizer. [12] Evaluating organic sources and mineral fertilizer in corn, concluded that the increase in bovine manure to 40 ton.ha^{-1} provided plant height with 67.9 cm, as with increasing doses of poultry manure up to 61.3 cm with application 25.76 ton.ha^{-1}, 60 days after corn emergence.

Analyzing the stem diameter in Table 2, it is observed that both the T2 and T3 treatment with organic fertilizer directly influenced the stem diameter when compared to other treatments, followed by T1 which showed a similar efficiency to better treatments (T2 and T3). This can be explained by the efficiency of organic material that improves the physical condition of the soil and promotes increased total organic carbon, providing a greater quantity of nutrient to the plant. The increase in organic matter content is important for sandy soils, because it has advantages such as improved soil structure, water retention increase and increased cation exchange capacity [13].

The stem diameter is a characteristic of great importance, because plants with higher basal diameter are less prone to tipping and breakage, and correlate with productivity, due to the fact that it is a reserve organ [14].

Regarding the number of leaves, the treatment T3 (45 t ha^{-1} of organic fertilizer) provided greater number of leaves for sugarcane when compared to chemical treatments. It was also noted that T1 and T2 treatments provided similar income, with average of about 12 leaves per plant. Evaluating the sugarcane productivity per hectare in terms of filter cake doses, [15] found that 2 ton.ha^{-1} significantly increased productivity sugarcane.

The use of organic fertilizer provided increased sugarcane tillering, showing that the treatments T1, T2 and T3 had better results than other treatments, and similar means, with average production of 3.4 units/plant, differing from the other treatments. This effect of organic fertilizer at tillering culms can be attributed to the chemicals and nutrients found in it. Analyzing the effect of phosphorus in sugarcane, [16] concluded that the element is of great importance for the rooting and tillering and therefore on the final productivity and the sugar yield. It is known that the organic fertilizer is rich in calcium, phosphorus, nitrogen and potassium.

Table 3. Average values of Plant height (PH), stem diameter (SD), number of leaves (NL) and number of tillers (NT) of sugarcane

Treatments	Adjusted means			
	PH (cm)	SD (cm)	NL Unit plant^{-1}	NT Unit plant^{-1}
T1 – Org.fert. 15 ton.ha^{-1}	85.94 bc*	15.83 bc	10.87 b	3.04 a
T2 – Org.fert. 30 ton.ha^{-1}	101.25 ab	18.84 a	14.50 ab	3.34 a
T3 – Org.fert. 45 ton.ha^{-1}	113.03 a	18.03 ab	17.01 a	3.83 a
T4 – Chemical fertilizer 50% of recommendation	68.65 cd	13.58 ce	5.38 c	0.63 b
T5 – Chemical fertilizer 100% of recommendation	54.56 d	11.25 e	5.25 c	1.21 b
T6 – Chemical fertilizer 150% of recommendation	62.62 d	14.91 cd	4.57 c	0.58 b
T7 – Control	55.34 d	11.98 de	6.08 c	0.58 b

** Means followed by the same letter (a, b, c, d or e) in the column do not differ significantly by Tukey test at 5% probability*

Even with the best results in the plants development, organic fertilization showed the highstr cost compared to chemical fertilizer (Table 4). However, it is an excellent alternative to the farms that generate such organic residues, in this case, fertilization will have zero cost therefore is a byproduct generated in the property. Moreover, it is an interesting option for regions where there are large supplies of such residues, in this case the cost of the purchase of the organic residues is lower. The use of residue originating on the property directly reflected in economic conditions of the property, therefore, increased profits, with the savings in the chemical fertilizers purchase and generated lower environmental impacts [17], with the appropriate use of organic residues.

Table 4. Costs for area of the different fertilizers applied in sugarcane experiments

Treatments	Costs ha^{-1}($)
T1 – Org.fert. 15 $ton.ha^{-1}$	4,200
T2 – Org.fert. 30 $ton.ha^{-1}$	8,400
T3 – Org.fert. 45 $ton.ha^{-1}$	12,600
T4 – Chemical fertilizer 50% of recommendation	1,318
T5 – Chemical fertilizer 100% of recommendation	2,635
T6 – Chemical fertilizer 150% of recommendation	3,953
T7 – Control	0

Making joint analysis of the variables, shows the organic fertilizer, following all the requirements and demands of organic farming is a viable practice for the sustainable production of sugarcane, of economic, social and environmental point of view [18] were able to replace chemical fertilizers by organic fertilization, without loss of records in the raw material quality, the stems yield, and in the production of handmade brown sugar in two varieties of sugarcane (SP79-1011 and RB72454).

4. CONCLUSION

Organic fertilizer improves the initial development in the parameters evaluated with plant height, stem diameter, number of leaves and number of tillers (NT) of sugarcane plant.

The organic fertilization with residues from animal production may be a way to facilitate the sugarcane cultivation in Psamment soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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