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Productivity of Lettuce Under Organic Fertilization

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Abstract

Organic fertilizersare a viable alternative to reduce the expenses associated with synthetic fertilizers, besides improving the chemical, physical and biological attributes of the soil and promoting the increase of productivity in the cultivation of vegetables. The aim of this research was to evaluate the effect of goat manure applicatiosn on lettuce yield, cv. Cristina. The experiment was conducted at the Center for Agri-Food Science and Technology, Federal University of Campina Grande in the municipality of Pombal, PB, Brazil. The experiment was conducted in randomized blocks with treatments composed of five goat manure percentages (0, 25, 50, 75 and 100%), considering 100% of the recommended dose being 36.50 ton/ha de goat manure, in five replications, using a spacing of 0.25 × 0.25 m between plants. Harvesting was performed 30 days after transplanting the seedlings. The following parameters were analyzed: aerial part height, plant diameter, number of leaves, aerial fresh weight, root fresh weight, total fresh weight, aerial dry weight, root dry weight, total dry weight, root volume and productivity. The data were submitted to polynomial regression analysis. When the lettuce plants cv. Cristina were fertilized with 75% of the N ratio required for maximum production, the goat manure application produced the greatest development and increase productivity.

Keywords: *Lactuca sativa*, nitrogen fertilization, manure

1. Introduction

The consumption of leafy vegetables, such as lettuce, is widely recommended, since these foods provide innumerable benefits to the body, such as organic development and regulation of the body, due to its high content of vitamins and minerals (Martins et al., 2008). The lettuce (*Lactuca sativa* L.), belonging to the Asteraceae family, stands out among the leafy vegetables, being the most consumed by the Brazilian population, besides being widely cultivated in all countries (Silva, Pinheiro, Paula, & Prigol, 2015). In Brazil, its cultivation is traditionally carried out at family farms, a factor that adds value to the field and increasing the labor which has potential sociological benefits.

Due to the large demand for lettuce, it is important in improve the production practices that will increase its availability. Mineral fertilization, despite its advantages, brings with it significant negative environmental impacts, such as increasing soil salinity, decreasing long term fertility, decreasing organic matter, and the accumulation of agrochemicals in soils (Pedrotti et al., 2015).

Organic fertilization appears to be a good option for reducing mineral fertilizers expenditures, due to the greater availability of nutrients, especially nitrogen, phosphorus, sulfur and micronutrients, increasing the pH, as well as the indirect benefits to the soil's physical, chemical and biological properties, and, thereby, increasing crop productivity (Kiehl et al., 1999; Santos et al., 1999; Santi et al., 2010).

Among the many sources of organic fertiliziers, we highlight the use of animal manure, the indirect effects that manure produce, due to its high organic matter content, and as a mean to improve a soil's physical, chemical and biological characteristics. In this context, goat manure is potentiallybeneficial because its lower carbon/nitrogen (C/N) ratio when compared to other manures (Souto et al., 2005). The lower C/N ratio results in a higher

mineralization speed of nutrients, an essential characteristic in the fertilization leafy vegetables, due to the rapid cycle of these crops.

The nutrient amounts excreted in the goat feces was evaluated by Orrico et al. (2007), where they obtained a dry matter mean of 1.39% N; 0.62% P and 0.29% K, They also found an increase in nutrient concentrations in feces, as the animals approached the adult stage and were fed diets rich in concentrate.

Studies that provide information on the management of organic fertilization by the application of goat manure in the lettuce crop are extremely important for the construction of technical subsidies that aim at raising productivity rates, reducing fertilizer costs, and greater profitability to the producer. However, there are few studies that have investigated the application of goat manure in lettuce these are examples, Figueiredo et al. (2012); Batista et al. (2012); Peixoto Filho et al. (2013).

The use of this type of organic fertilizer is seen as a useful and economical practical for producers, especially vegetable producers, since it offers innumerable benefits, increasing fertility and soil conservation and thus providing organic nitrogen accumulation in the soil, increasing its potential of mineralization and its availability to plants. However, higher or lower application rates will depend on the soil type, texture, structure and organic matter content, since each manure type is unique characteristics and therefore must be studied in a singular way (Santos & Trindade, 2010).

Thus, it is necessary to know the application rates of organic fertilizer that promotes the greatest crop production, because this factor directly relates with lettuce productivity indexes. Therefore, the objective of this work was to study the proportion of goat manure that will provide the maximum yield of lettuce, cv. Cristina.

2. Material and Methods

The researchwas conducted at the Center for Agri-Food Science and Technology, Federal University of Campina Grande, in the municipality of Pombal, Paraíba, Brazil from June 18 to August 18, 2016. The municipality climate, according to Koopen classification adapted to Brazil (Coelho & Soncin, 1982), is of type BS h', which represents hot and dry climate with summer/fall rains, with an average precipitation of 750 mL by year. The experimental area soil was classified as Luvissolo Crômico Órtico typical (MAPA, 1972; Santos et al., 2013).

2.1 Production of Lettuce Seedlings

The lettuce seedlings cv. Cristina were produced in 200-cell expanded polystyrene trays, filled with commercial Hortplant® substrate, and allocated two seeds per cell. Ten days after emergence thye seedlings were thinned to one plant per cell. The seedlings were transplanted to the field beds on July 18, 2016, 30 days after sowing, when the majority seedlings had four leaves.

2.2 Treatments and Experimental Design

The experiment was a randomized complete block design and five goat manure treatments (0, 25, 50, 75 and 100%), which were determined by the nitrogen (N) recommendation for the crop. Prior to incorporating the manure, dry samples of the material were collected to determinethe chemical attributes according to the methodology of (Donagema et al., 2011). The analyzes were done at the Laboratory of Analyzes of Soil, Water and Plants of the Federal Institute of Paraíba-Campus Sousa (Table 1).

Table 1. Chemical characterization of goat manure used in lettuce fertilization. Pombal, UFCG/CCTA 2016

Sample	pH	Dry matter	N	P	K
		--------- % ---------	---------- g Kg^{-1} ----------		
Goat manure	7.7	93.73	9.5	1.68	3.66

After the determination of the nitrogenin the goat manure sample (Table 1), five ratios of goat manure (0, 25, 50, 75 and 100%) were determined based on the fertilization recommendation of Raij et al. (1997), with 100% (36.50 ton/ha) as the manure dose calculated based on the goat manure nitrogen content and the amount of N required for the crop.

2.3 Installation and Conduction of the Experiment

The experimental area was cleared and all undesirable materials were removed prior to cultivation The soil was then plowed whith plow of large discor, to depth of 20 cm using and the beds were raised, 0.30 m high. Each experimental plot was 1.2 m long by 1.2 m wide, resulting in 1.44 m² per plot.

The pre-established proportions of the goat manure treatments, in kg/ha, were distributed and incorporated into the 0-15 cm layer of the plot using, applying 40% of the total recommended manure 15 days before transplanting and 60% of the recommended dose one day before transplanting the lettuce seedlings. The amount of goat manure was calculated according to Furtini Neto, Vale, Resende, Guilherme, and Guedes (2001), using the following expression:

$$X = \frac{A}{\frac{B}{100} \cdot \frac{C}{100} \cdot \frac{D}{100}} \quad (1)$$

Where,

X = amount of organic fertilizer to be applied, kg/ha; A = dose of N required by the crop for a given yield, kg/ha (Raij, Cantarella, Quaggio, & Furlani, 1997); B = dry matter content of organic fertilizer, %; C = N content in dry matter of organic fertilizer, %; D = conversion index of N from the organic form to the mineral form, 50% (Furtini Neto et al., 2001).

The weeds were manually harvested from the emergence of weeds in order to avoid competition for water, light and nutrients. The irrigation system used in the area was of the micro sprinkler type with an emitter flow of 80 mL/h. Irrigation was done twice a day, with a duration of approximately 15 min each.

2.4 Characteristics Evaluated

The four center plants were used for data collection while the other plants were used as border plants. The day before the lettuce was harvested the plant heights and head diameters were measured, with values expressed in cm per plant.

On August 18, 30 days after transplanting, the lettuce plants, both the above gound plant and the roots, were harvested and then transported to the plant breeding laboratory of the Center for Agri-Food Science and Technology, Federal University of Campina Grande. The harvested plants were then washed and separated into the above ground plant material and the roots for evaluation. The number of leaves was obtained by counting all fully expanded leaves. The fresh weight of the aerial portion and the root were determined separately with the values expressed in grams per plant. The total fresh weight was the sum of the aerial portion and the roots expressed in grams per plant.

The separate plant portions were placed in paper bags for drying in a oven using forced air circulation at a 65 °C until a constant weight was obtained (determined by oven drying during 72 h and reweighing). The total plant dry weight is the sum of the dry weight of the aerial portion and roots expressed in grams per plant.

Root volume was determined by placing the fresh roots in a 1,000 mL beaker, containing a known volume of water (500 mL), by the difference, the direct root volume response was obtained by the equivalence of units (1 mL = 1 cm^3), according to the methodology described by Basso (1999).

Productivity was obtained by multiplying the total fresh mass of the lettuce by the population of plants extrapolated to 7,500 m², considering the useful area of one hectare, expressed in ton/ha.

2.5 Statistical Analysis

The data were submitted to analysis of variance through the software SISVAR, version 5.6, according Ferreira (2011). The averages were adjusted in the linear and quadratic models through the simple polynomial regression analysis.

3. Results and Discussion

For aerial part height (Figure 1A), there is a positive response to the increasing use of goat manure doses, obtaining a higher performance of the variable when applied to the 100% dose (36.50 ton/ha of goat manure) resulting, according to the derivative of the equation, in a maximum average of 23.95 cm per plant, showing the significant effect of the availability of nutrients through manure. The various benefits of organic fertilization occur as a result of the release of nutrients as the organic waste is decomposed into the soil, thereby providing a higher production of plants.

Positive results in relation to the use of goat manure were found in experiments carried out with lettuce submitted to manure (bovine and goat) and nutrient concentration by Silva et al. (2011) goat manure provided greater efficiency in lettuce growth and yield.

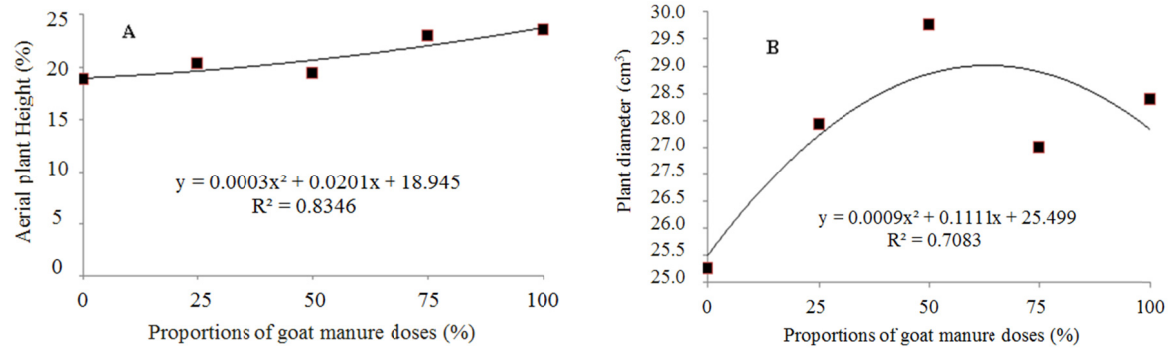

Figure 1. Aerial part height (A) and (B) plant diameter of the lettuce, according to different proportions of goat manure doses. Pombal, UFCG/CCTA 2016

For the plant diameter variable (Figure 1B), the best performance was observed in the amount of 22.50 ton/ha (61.66%), whose observed value was 28.92 cm. This behavior is associated with the amount of nutrients provided by the higher doses; where near the highest manure doses may have been sufficient for the development of the plants.

Nascimento et al. (2007) studied lettuce production with different bovine manure doses, found that the diameter of the plant tended to decrease with the increase of manure doses from the 12.5 ton/ha dose of bovine manure.

Figure 2A shows an increase in the average number of lettuce leaves as a function of the increase in goat manure up to 20.13 ton/ha (equivalent to the application of 73.55% of the recommendation), decreasing until the maximum amount incorporated in the soil. The doses provided promoted positive responses in the number of leaves produced by the lettuce, possibly providing the crop with greater nutritional availability and providing adequate conditions for a greater development of the plants. These results are similar to those found by Cruz et al. (2010), when they combined goat manure volume with hydrocorretent doses, and analyzed the effects of manure volumes in isolation, which confirmed that doses of 20 and 40% (volume in soil), caused the same behavior in the number of lettuce leaves.

For the root volume (Figure 2B), there is a growing increase between the lowest and the highest amount of goat manure applied to the soil. The dose of 27.38 ton/ha provided an environment conducive to further development of these, probably the greatest amount of nutrients and organic matter provided by that dose promoted favorable conditions for the roots to reach a larger volume through greater porosity, aeration and improvement in the other physical qualities of the soil, with this the roots obtained adequate conditions for greater exploitation of the nutrients available in the soil.

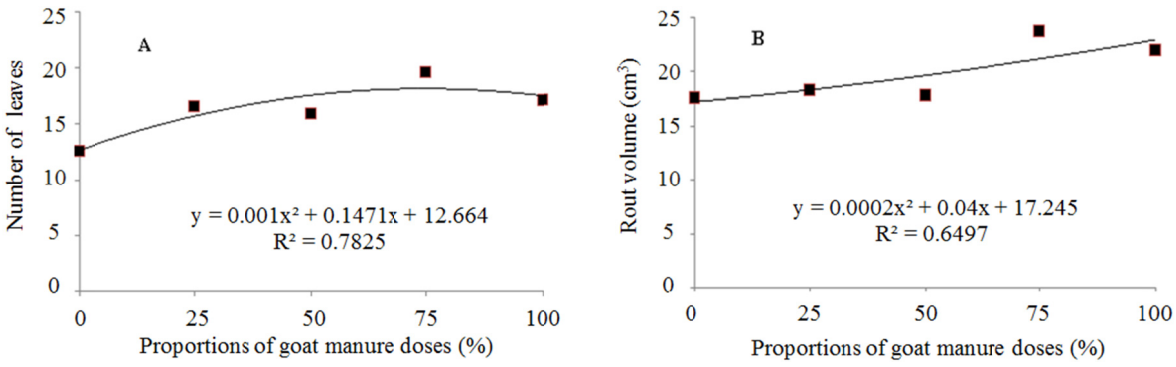

Figure 2. Number of leaves (A) and volume root (B) of the lettuce, according to different proportions of goat manure doses. Pombal, UFCG/CCTA 2016

Melo et al. (2015) believe that the benefits of goat manure on crop development and yield are due not only to the nutrient supply, but also to the improvement of other soil constituents, of water, in the aeration of its structure by means of formation of humus-clay complexes and, consequently, increase in the CTC, providing better

utilization of the nutrients. In addition, the results obtained in this research with goat manure confirms Filgueira (2012) regarding the importance of organic fertilization, especially with manure, to this crop of delicate and demanding roots regarding the physical aspects of the soil.

It is verified that to the fresh mass of the aerial portion (MFPA) (Figure 3A) when applying the equation, generated by the polynomial regression graph, increasing doses provided a growing line, however the best average was presented in the dose referring to 75% of the recommendation (27.38 ton/ha), generating favorable conditions for its higher production. The values ranged from 332.8 g per plant (0% dose) to 488.9 g per plant (100% dose) with this finding that said dose made the macros and micronutrients needed more efficiently and in an amount adequate for improved soil structure, promoting greater water retention, higher CTC, and increased biological activity of the same, through the greater addition of organic matter, where organic materials as sources of macro and micronutrients and because they provide innumerable beneficial physical, chemical and biological properties of the soil, are widely recommended in the production of vegetables.

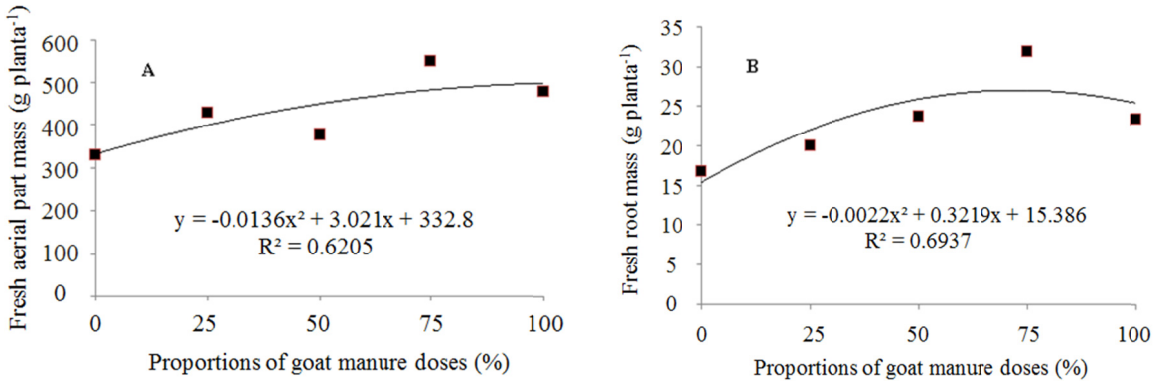

Figure 3. Fresh aerial part mass (A) and fresh root mass (B) of the lettuce, according to different proportions of goat manure doses. Pombal, UFCG/CCTA 2016

The decrease in production at higher doses may have occurred due to excess nitrogen (N), a result of mineralization by the material. This behavior is similar to that found by Silva et al. (2010), when studying different compounds and application rates in lettuce production, they observed a linear increase of the MFPA production, but the best results were found in the doses 100% (compounds 1 and 2) and at doses 75% (compounds 3 and 4), according to the analyzes of compounds 3 and 4, observed that the total N value in compound 3 is on average 1.6 times greater than in the others, promoting in higher dose excess N supply, resulting in reduced production.

For the total fresh weight (MFT) (Figure 4A), it was observed that the increment provided by the 75% concentration of the recommended dose (27.38 ton/ha) relative to the control (0% dose) was 40.32%, reaching the maximum estimated value for MFT of 525.4 g per plant. It can also be observed that all the treatments that received manure exceed the one that did not receive the application, that is, the control (0%), thus favoring the use of goat manure in lettuce fertilization. Rodrigues et al. (2008) obtained similar data for the fresh weight by studying the amounts of bovine manure in the arugula crop, and observed a tendency to increase both fresh and dry weight from 20 to of manure per hectare up to 60 ton of manure per hectare, from which a decrease in the production of freash weight begins to occur.

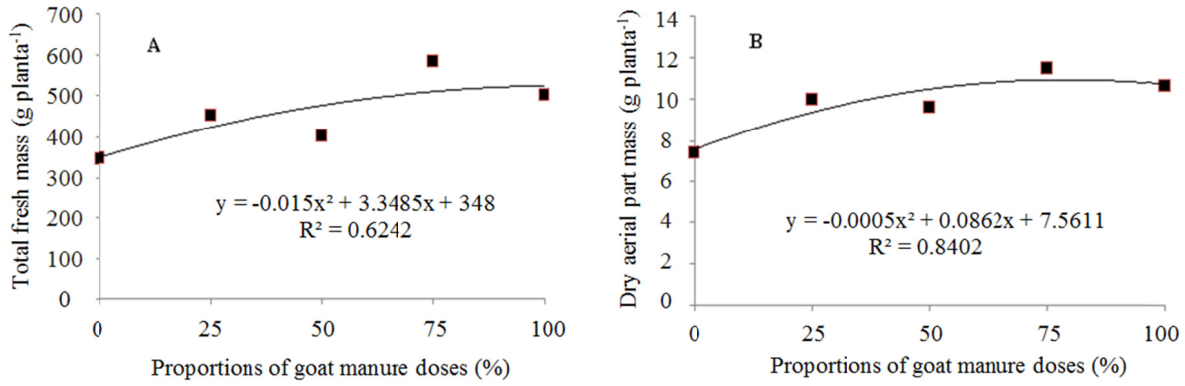

Figure 4. Total fresh mass (A) and dry mass of aerial part (B) of the lettuce, according to different proportions of goat manure doses. Pombal, UFCG/CCTA 2016

For the dry mass of the aerial portion (Figure 4B), it was observed that the proportion of 75% (27.38 ton/ha) presented the best results, providing a higher shoot dry weight production (11.21 g per plant), whereas the lowest result was obtained in the treatment without addition of manure (7.56 g per plant), a fact that may be associated to the greater increase of organic matter to the soil, providing greater nutrient demand to the plants, in addition to maintaining a good soil structure, with greater water retention and a nutrient replacement in the soil solution, maintaining the nutritional balance with the nutrient mineralization provided by the goat manure. These results are similar to those found by Silva et al. (2010) studying lettuce response to different doses of compounds showed that three of the four compounds studied presented better results for MSPA at a dose of 75% of the recommendation.

In figure 5A, it is again verified that the proportion of 75% stood out in relation to the others, providing the lettuce culture adequate conditions for a greater production of root dry weight. The higher dry matter acquisition is related to the water content present in the soil, as well as the greater availability of nutrients to the plants, this fact associated to the addition of organic matter in the soil, will retain a greater amount of water, and through its decomposition, will provide nutrients to the plants, resulting in improved soil structure, building their fertility and providing the roots of the lettuce suitable conditions for a greater production of dry mass through the greater exploitation of soil resources provided by the dose that is equivalent to 75% of the dose in its entirety.

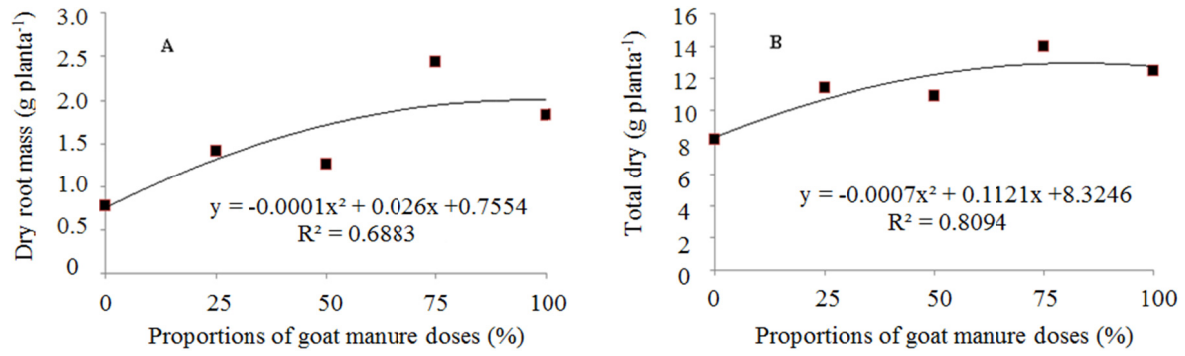

Figure 5. Dry root mass (A) and total dry mass (B) of the lettuce, depending on the different doses of goat manure. Pombal, UFCG/CCTA 2016

In the results of the total dry mass (Figure 5B), there is a constant growth as there is a higher amount of goat manure, with a drop after the proportion of 75% (27.38 ton/ha), thus providing a greater amount of organic matter to the soil, providing better physical, chemical and biological characteristics, thus increasing the macro and micronutrient contents, favoring adequate conditions for a greater production of the dry mass and a greater exploitation of the available nutrients. These results are consistent with those found by Rodrigues et al. (2008), which, by evaluating the performance of arugula as a function of the increasing dose of bovine manure, observed

an increasing effect under the dry matter of the plants until the dose corresponding to 60% of bovine manure, point from which a fall begins to occur dry mass.

For the productivity (Figure 6), the highest average (7.12 ton/ha) was obtained in the proportion of 75% (27.38 ton/ha), giving an increase of 33.94 %, relative to the control. It can be seen that the proportions of 75 and 100% (27.38 and 36.50 ton/ha, respectively) lead, according to the equation of the graph, to equal production values (6.51 ton/ha). Similar results were observed by Mendonça & Reis (2010), when studying lettuce yield under different doses of pig manure, that lettuce yield increased until the 40 ton/ha dose.

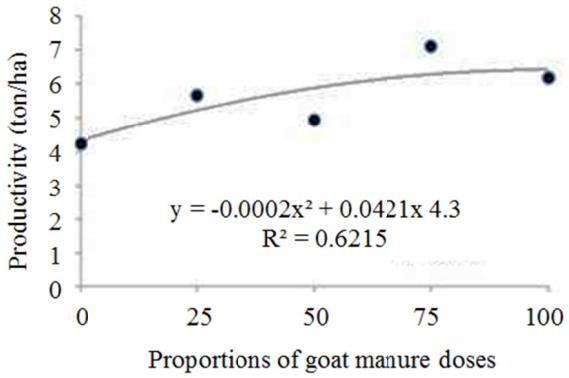

Figure 6. Productivity of the lettuce, according to different proportions of goat manure doses. Pombal, UFCG/CCTA 2016

4. Conclusions

The use of increasing proportions of goat manure promotes increases in developmental characteristics in relation to the control until the proportion of 75% of the N recommended dose (27.38 ton/ha of goat manure).

The fertilization with 27.38 ton/ha of goat manure provided higher efficiency, favoring a consequent increase in lettuce productivity.

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