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ORIGINAL RESEARCH ARTICLE

Performance of Vanda lettuce in relation to the use of chemical fertilizer and organic compost

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ABSTRACT

Horticulture is a widespread activity in family farming in the Transamazonian region—Pará, with emphasis on production aimed at the family's own consumption. The lettuce cultivar Vanda (*Lactuca sativa* L.) represents a significant part of this production, which prioritizes the use of internal labor. The main objective of this work was to evaluate the development of lettuce CV Vanda grown in beds using organic compost and chemical fertilization (NPK). The criteria considered to evaluate this performance were: Root system development, plant height and total fresh mass production. The best averages in relation to root development occurred in the plots cultivated with organic compost in the proportion of 5 kg/m^2, due to its characteristics as a fertilizer and soil conditioner. The cultivation with the use of NPK provided the best averages in relation to the production of total fresh mass and plant height, results that were mainly attributed to the extra supply of nitrogen in the covering fertilization, which consisted in the addition of 10 g urea per square meter via soil. Statistical analysis showed no statistically significant difference regarding plant height for both treatments. And in relation to root development, the difference was statistically significant.

Keywords: Family Farming; *Lactuca sativa* L.; Composting; NPK

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1. Introduction

This work aims to evaluate the performance of lettuce CV Vanda grown in beds with the use of chemical fertilization (NPK) and organic compost.

Having a vegetable garden at home is not only a way to save money. It means having facilities to prepare meals with various products, enriching the table and varying the flavors. Vegetables are important sources of vitamins and minerals that, combined with the medicinal properties that many of them have, help to regulate and maintain the proper functioning of our body[1].

The production of vegetables for domestic consumption is currently one of the characteristics of family farming in the Transamazon region of Pará, through the use of internal labor with little or no mechanization and low use of chemical fertilizers.

The origin and characteristics of lettuce are cited by Henz and Suinaga[2].

> Lettuce (*Lactuca sativa* L.), which belongs to the Asteraceae family with more than 100 known species, is currently consid-

> ered the most important leafy vegetable in Brazil, with an annual cultivated area of approximately 35 thousand hectares. It originates from a temperate climate, and is certainly one of the most popular and consumed vegetables in Brazil and in the world.

On the economic importance of lettuce and morphology of the main varieties currently grown in Brazil, Sala and Costa[3] report:

> The predominant lettuce in Brazil is the curly type, leading with 70% of the market. The American type holds 15%, the smooth 10%, while others (red, mimosa, etc.) account for 5% of the market[3(p158)].

The cultivation of lettuce demands a lot of care due to the peculiarities in relation to the root system and the need for irrigation, as reported by Caetano[4].

As a vegetable with a short cycle and shallow root system, lettuce needs soil that is able to supply water and nutrients adequately for the development of the plant, i.e., ideal pH around 6.0, good fertility, and rich in organic matter.

Due to the constant production of organic waste from people's daily activities as well as from agriculture and animal husbandry, a greater participation of organic fertilizers in the production of healthier food becomes interesting. These materials are a source of nutrients and improve the quality of the soil. "Organic fertilization should be advocated as a possibility for lettuce production"[5].

The period between planting and harvest varies according to the variety of lettuce grown, and the weather is a factor that has a great influence on the lengthening or shortening of this period. Under ideal conditions, the harvest can occur up to 50 days after sowing, or 30 days after transplanting to the bed.

According to Henz and Suinaga[2], the most cultivated cultivars in Brazil can be divided into 5 groups, according to the shape of the head and leaves: Repolhuda Lisa, has smooth, delicate and soft leaves, with little protruding veins, with an oily "butter" aspect, forming a typical and compact head; Solta Lisa exhibits smooth and loose leaves, relatively delicate, without compact head formation; Solta Crespa has large and curly leaves, soft but consistent texture, without head formation and can have green or purple coloration; the Romana type that has typically elongated leaves, hard, with clear veins, with a fluffy and elongated head, cone-shaped, and finally, the Crespa type cultivars, exhibits frizzy leaves, consistent and crispy, large and well compact head, which includes the variety Vanda, target of this study.

According to Matos *et al*.[6], the Vanda cultivar has the following characteristics: Large plants, with wide, long and crunchy leaves. It can be grown throughout the year and its average cycle is 55 days, 25 days for seedling production and 30 days for cultivation, in which it is considered precocious. The resistance of the plant allows it to be handled and transported without causing much damage, making it ideal for situations where the consumer market is far from the production site.

1.1 Parameters for land use and composting

It is important to perform a soil analysis, so that the producer can identify the qualities and deficiencies of the soil. Only from the data obtained in the laboratory analysis will it be possible to calculate the need for fertilization or correction before and after planting.

> Other soil analysis parameters to be taken into account are: Base balance information of the nutrient holding capacity, called cation exchange capacity (CEC), calcium/magnesium, calcium/potassium, magnesium/potassium ratio, and soil electrical conductivity. These are essential components for the balance of the soil and the plants. For the producer to be always up to date about the soil conditions, it is important to do an analysis every two years[6(p7)].

Lettuce responds to organic fertilization, especially in low fertility and/or compacted soils. It is essential that the fertilizer is well tanned[6]. Dantas[7] found that the addition of humic material to the soil directly influences the increase in soil fertility, as well as its capacity to retain water, obtaining high productivity in lettuce cultivation.

Composting is a process of decomposing organic matter through the aerobic action of microorganisms. Through the addition of specific materials, a compost with distinct chemical characteristics can be obtained, according to the crop to be fertilized. The main microorganisms that develop in the process are bacteria, responsible for the decomposition, mainly of sugars and proteins, and fungi that act in the degradation of cellulosic material[8].

The items used in compost preparation can be of animal or plant origin. Materials such as twigs, logs, straws, dry wood and rice husks are rich in carbon. To obtain a nitrogen-rich end product, one should prioritize the addition of green leaves or animal waste, such as manure or urine. According to Cooper[9], it is of paramount importance to regulate the carbon to nitrogen (C/N) ratio. This ratio requires that materials rich in carbon be in an amount three times greater than the material rich in nitrogen, because it is the ratio that most favors the development of microorganisms in the decomposition of organic matter.

As composting is a controlled process, it is necessary to ensure special conditions for its proper development, paying attention mainly to the following factors: Temperature, humidity, aeration, carbon/nitrogen ratio, particle size, pH and diversity of microorganisms. The proper monitoring of these parameters prevents the development of undesirable processes, such as anaerobic degradation, which gives rise to foul odor and increased temperature, which can cause the death of decomposer microorganisms[8].

The turning of the compost is a way to guarantee good conditions for the development of this process. It can be done manually and solves all the problems that can occur and that can hinder the progress of composting. In the turning of the compost we eliminate the excess carbon dioxide that has accumulated and incorporate oxygen. In addition, we eliminate excess water that may eventually accumulate and decrease the temperature that increases due to the action of microorganisms[9].

Jasse *et al*.[10] found that the constant turning of the pile results in a better quality compost, reflecting in a better productivity of the lettuce crop, due mainly to a better mineralization of nutrients and their immediate availability to the plants.

The benefits of producing organic fertilizer on small properties go beyond finding a clean destination for residues that can be considered highly polluting, such as animal waste. The compost resulting from this process presents physical-chemical characteristics that favor the development of several types of plants and the maintenance of the microbial fauna in the soil.

Regarding the amount of compost recommended, Cooper[9] considers that the amount of compost applied changes according to the characteristics of the soil and crop, ranging from 5 to 50 tons of compost per hectare. In this case, 5 to 10 tons of compost per hectare would be considered a weak fertilization, 20 to 30 tons of compost as medium fertilization, and 40 to 50 tons characterizing a strong fertilization. As with the application of any fertilizer, the use of organic compost will be more efficient if preceded by soil analysis.

1.2 Seedling production and planting

The production of seedlings usually corresponds to half of the lettuce production cycle, taking around 25 to 30 days, or when they present four definitive leaves, indicating that they are ready for planting. This stage of cultivation is of paramount importance for the success of the enterprise, since the production of quality seedlings will reflect directly on the characteristics and commercial value of the final product.

The best way to save space and labor in vegetable seedling production is to use styrofoam or polystyrene trays, which can contain from 128 to 288 cells. These cavities are filled with substrate in order to provide the seedlings with a safe environment, nutrients for proper germination and efficient growth. Another advantage of using trays in vegetable production is related to transplanting the seedlings to the bed. Since each seedling will leave the cell with a small amount of substrate and its root system intact, it will suffer less stress during this operation, ensuring better and faster rooting in the soil.

The spacing used in the lettuce crop can vary, since the producer takes into account the availability of space, irrigation mode, type of soil and eventual consortium with other vegetables. Dantas[7] achieved optimal results by employing spacing of 0.25×0.25 m^2, while Queiroz *et al.*[11] using spacing of 0.30×0.30 m^2, obtained commercial production (CP) 174.99 g of every plant and number of leaves-(NF) 17.15 leaves of every plant.

According to Makishima *et al.*[1], the construction of the beds usually follows criteria such as one meter wide and 25 cm to 30 cm high. The length of the beds will be in accordance with the availability of the area, so as not to compromise the cultural treatments and harvesting. Other influencing factors in the characteristics of the beds are: Amount of available labor, use of mechanization, climate, type of crop, slope of the land, and finality of production. The use of machinery to build the beds and ridges ensures better standardization and optimization of the space used, but may become unfeasible for small horticulturists. According to Neto *et al.*[12(p789)], labor and irrigation represent most of the cost of production of lettuce in full sun and trellis. Based on this principle, the production of vegetables is an activity that generates jobs in the field, ensuring social sustainability to the production.

In this sense, this work aims to evaluate the performance of lettuce CV Vanda cultivated in beds with the use of fertilization with chemical fertilization and organic compost, through the evaluation of plant height, fresh mass and root size. The preparation of the organic compost will be through the use of carbonized rice husk, sawdust, cattle manure, shredded cocoa husk and forage peanuts. Statistical analysis will be used to validate the results.

2. Methodology

2.1 Carbon to nitrogen ratio (C/N)

The production of the fertilizer from the composting of organic waste was carried out at the Community School Rural Family House of Uruará (CSRFHU), located at near 185 kilometers South on the margins of the Transamazon Highway BR 230.

The selection of the materials used for the production of the organic compost, as well as their quantities, obeyed the criteria related to the percentage of carbon and nitrogen in its composition, in order to have a final quality compost. The products used in this work and their characteristics are presented in **Table 1**.

Table 1. Carbon/nitrogen ratio and quantity of materials used in the production of organic compost

Material	C/N	Quantity (Buckets)
Rice husk	39/1	3
Bovine manure	32/1	2
Wood sawdust	100/1	1
Peanut forage	30/1	4
Cocoa bark	38/1	3

Source: Adapted from Kiehl[13], Kiehl[14], Wutke *et al.*[15] and Massukado[8].

According to Massukado[8], the C/N ratio of a compost should be around 30/1, and is calculated by multiplying the amount of each item used by its C/N ratio. Then these results are added together and divided by the sum of the amount of each material. C/N ratio close to 50/1 will be deficient in N and its stabilization process will take longer, while a C/N ratio close to 10/1 will lose N in the form of ammonia and produce a bad smell.

Considering the C/N ratio and the quantity of each material shown in **Table 1,** the C/N ratio of this compost is calculated:

$$(3x\ rice\ husk + 2x\ bovine\ manure + 1x\ sawdust + 4x\ peanut\ forage + 3x\ cocoa\ bark)/(3 + 2 + 1 + 4 + 3) = C/N$$

2.2 Composting

To facilitate the decomposition process, the cocoa shells went through a grinding process, which consisted in breaking them with a piece of wood, since the reduction in the size of the particles facilitates the action of the decomposing microorganisms.

Figure 1. Rice husk carbonization process.

The rice husk was carbonized using an improvised oven, so that it was exposed to high temperature without contact with the flames, **Figure 1**.

The materials used in the composting were placed in layers in the form of a pile on an impermeable tarp on May 5, 2017, in the following order: Wood sawdust, cattle manure, forage peanut, shredded cocoa husk and carbonized rice husk. **Figure 2** shows all the materials used in this work in the following order: 1. ground cocoa husk; 2. forage peanut (aerial part); 3. wood sawdust; 4. carbonized rice husk; 5. cattle manure.

Figure 2. Materials used in the production of organic compost.

The compost pile was covered with canvas so that the constant rainfall would not bring leaching and consequent impoverishment of the mixture. For thermal stability an additional cover of coconut straw was added, because the exposure of the compost bin to direct sunlight could cause a rise in temperature that would be harmful to the development of the microorganisms.

These microorganisms also require special conditions regarding compost moisture. According to Massukado[8]:

> Microorganisms require water for the proper performance of their metabolic process. Thus, moisture control is a parameter to be monitored to evaluate the efficiency of the composting process. At the beginning, the humidity of the bed is higher (around 50%). As time goes by, it gradually decreases, reaching, at the end of the composting process, values below 30%[8(p28)].

The monitoring of the compost moisture was done manually. This method is shown in **Figure 3** and consists of taking a small part of the material from the pile and squeezing it with the hand. If the mixture crumbles, it means that more water is needed. If the portion of the material stays together, it means that the moisture is adequate, and if any liquid leaks out, it means that the moisture is too high and the bed needs to be turned.

Figure 3. Method for checking compost moisture.

Source: Massukado[8].

2.3 Seedling production and planting

The production of seedlings and the cultivation of lettuce were carried out at Sítio Floresta, located at the south near 180 km, rural area in the municipality of Uruará, in the state of Pará.

Figure 4. Seedlings on the 9th day after sowing.

The substrate used to produce the lettuce seedlings was composed of 50% soil + 50% babassu coconut humus collected in a virgin forest. According to Piccolo (at Dantas[7(p21)]) the use of humic and fulvic acids improve seed germination, rooting, development and plant production of lettuce and tomato. Maia[16] obtained significant results using the same measure by using vermicompost from earthworms in the production of lettuce seedlings. The mixture 50% vermicompost + 50% soil made it possible for the characteristics total fresh mass, aerial part fresh mass, root fresh mass and total dry mass, to obtain the highest averages of every plant. For the sowing of the seeds 100 disposable 50 ml cups were used. **Figure 4** shows the lettuce seedlings CV Vanda 9 days after sowing.

The beds were built in an open field with dimensions of 1 m x 1 m, and 25 cm high. In order to perform an efficient chemical fertilization, a soil analysis was performed. The report of this analysis, besides specifying the data obtained from the sample, provided recommendations for fertilization. As the chemical fertilizers commercially available contain in their formulation more than one element (macro and micronutrients), it is essential to calculate the participation of each element in the composition of this fertilizer, so that the fertilization effectively meets the nutritional requirements of the soil and the crop. For example, a crop's need for N can be supplied by applying Ammonium Nitrate, Ammonium Sulphate, Urea, among others, taking into account that they have 32%, 20%, and 44% of N in their composition, respectively. The quantity and variety of elements available in the formulation of each fertilizer should be taken into account when calculating the amount of fertilizer needed for each cultivated hectare.

The seedlings were transplanted to the beds 25 days after sowing, when they presented 4 definitive leaves. The spacing adopted was 25 x 25 cm^2, where it was possible to plant 16 seedlings/bed. This procedure was performed in the late afternoon to avoid the maximum stress caused to the seedlings and, as an additional measure, a trellis of coconut palms was built 80 cm high over the bed to protect the seedlings from sunlight on the first day after planting.

Silva *et al*.[17] acquires the conclusion: when cultivating crisp lettuce with spacing of 25 × 25 cm^2 in monoculture and intercropping with Japanese cucumber, the total operational costs (TOC) reduced by 57.62%. Thus, it can be seen that the choice of spacing used in the lettuce culture should take into account not only the availability of cultivation area, but also the possibility of optimizing its use by reducing production costs.

Irrigation was performed daily by sprinkling in the morning and afternoon, except on rainy days. The constant rainfall had a direct influence on the development of the crop and facilitated the daily treatments with it, by reducing the need for irrigation. As no attack of insects was observed, it was not necessary to apply any type of pesticide.

Covering fertilization is a fundamental step in lettuce cultivation. Matos *et al*.[6]:

> In conventional planting, complementary soil fertilization is used, commonly called top dressing. It aims to supply nutrients, mainly nitrogen based, in the stages when the plant needs them most, since this nutrient is easily out of reach of the roots. It is recommended to preferably use ammonium sulfate, at a dose of 20 g/m^2, at 15 days after the seedlings have taken root. Repeating this operation every 15 days, we can check the nutritional stage of the plants[6(p17)].

In this case, complementary fertilization was carried out 15 days after transplanting the seedlings, at a proportion of 10 grams of urea per square meter. This difference in the amount of fertilizer used is due to the fact that urea contains approximately twice as much nitrogen in its composition as ammonium sulfate, according to the Potash & Phosphate Institute[18].

At the harvest of the various treatments, the height of each plant was initially recorded while still in the bed by measuring the distance from the ground to its upper extremity, using a 30 cm ruler, the same technique and tool used by Carvalho[19]. The dimensions of the roots were obtained after careful removal of the soil, aiming to cause the least damage to the root system of each plant. So that the total fresh mass weight would not be affected by excess moisture, all plants were washed and left to drain for 30 minutes. Since moisture loss would be detrimental to the quality of the plants, all harvesting, including washing and weighing all material was carried out in the early evening.

2.4 Statistical analysis

After comparing plant height (PH), fresh mass (FM), and root size (RS), the results obtained were statistically treated for all plots under study, being the lettuce beds that received commercial NPK fertilizers and the beds that received organic compost, with the purpose of analyzing the existence or not of differences between them with the results obtained for the different types of fertilization.

In a first analysis, normality and homogeneity of variance were evaluated. If these occur, analysis of variance (ANOVA) was performed with randomized blocks. The experimental design in randomized blocks was used because the removal of samples within each comparison was entirely random. In the comparison throughout the production cycle, it will be considered that the plots may suffer alterations due to the type of fertilization adopted. The F-test will be performed with significance α of 5%, in which the null hypothesis H_0 is rejected if the value of F-test is greater than the tabulated value of critical $F(f_e)$. Tukey's test for testing any and all differences between two treatment means will be used if the null hypothesis H_0 of equality of treatment means is rejected.

3. Results and discussions

Figure 5 shows the carbonized rice hulls ready to be incorporated into the compost, where a significant reduction in volume and change in coloration can be seen. This process had the additional effect of reducing the weight of the rice husk, due to moisture loss and carbonization due to exposure to heat.

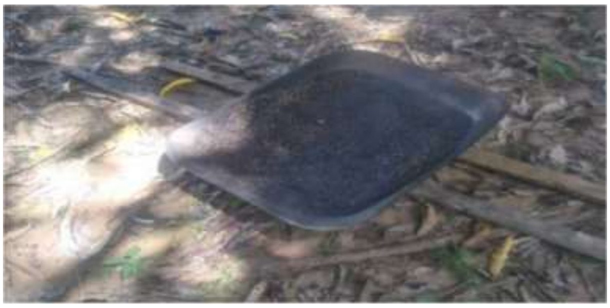

Figure 5. Charred rice husk.

The organic compost shown in **Figure 6** was considered stabilized at 120 days after the beginning of the process, when it no longer presented temperature and humidity variances. According to Souza and Alcântara[20], the compost will be ready for use when temperatures are below 35 °C; reduction of 1/3 in relation to the initial volume; homogeneous mixture of the degraded constituents not being able to identify them with musty earthy smell.

Figure 6. Organic compost ready for use in agriculture.

For quantification of the nutrients obtained in this process, a sample of the compost was submitted to analysis at the Tapajós Laboratory located in the municipality of Santarém—Pará. In order to obtain data to calculate the amount of fertilizer needed for chemical fertilization, a sample of the soil to be used in the lettuce crop was sent to the aforementioned laboratory. There was no need to apply lime due to the acidity levels identified in the soil analysis being at acceptable levels for this crop.

The organic fertilization performed in the plots cultivated with compost consisted of adding 5 kg of compost per square meter in 2 beds.

In relation to the plots cultivated with NPK, the laboratory analysis of the soil showed the need for chemical fertilization in the proportion explained in **Table 2**.

Table 2. Recommended amounts of nutrients in laboratory soil analysis

Nutrients	Quantity (kg/ha)
Nitrogen	20
Phosphorus	60
Potassium	40
Sulfur	30
Copper	0.7
Manganese	2
Zinc	2
Molybdenum	0.13

Source: Tapajós Environmental and Laboratory Solutions.

Table 3. Fertilizers used in the plots cultivated with NPK

Nutrient	Commercial name	Qty/ha	Qty/m²
N	Urea	20 kg/ha	4.55 g/m²
P_2O_5	Simple superphosphate	60 kg/ha	33.3 g/m²
K_2O	Potassium chloride	40 kg/ha	8.99 g/m²

* ha: Hectare.

The amount of fertilizer recommended in the soil analysis per hectare (Qty/ha) and per square meter (Qty/m^2) are shown in **Table 3**.

To supply the soil N requirement, 4.55 g/m^2 of urea was used. The application of simple Superphosphate and Potassium Chloride in the proportion of 33.3 g/m^2 and 8.99 g/m^2, respectively. Such applications were necessary to correct the deficiencies of the soil, thus supplying the nutritional requirements of the cultivated species in relation to the other macronutrients and micronutrients.

Subsequent care after preparation of the substrate and the start of seedling preparation through sowing consisted of irrigation in the early morning and afternoon throughout the process. It should be emphasized that there was no insect infestation at this stage of the work. The site for seedling production was planned in order to avoid the attack of domestic animals and birds. For this purpose, a table was improvised on a one-meter high stake. To avoid infestation of the nursery by ants, slugs, snails and others, the foot of the table was wrapped with a piece of cloth soaked in lubricating oil. The surroundings of the nursery and the site of the beds were fenced with wire mesh to a height of 2.5 m to ensure the safety of the enterprise. **Figure 7** shows the lettuce seedlings ready for planting, with four definitive leaves.

Figure 7. Seedlings ready for transplanting 25 days after sowing.

Figure 8. Root system of a seedling ready for planting.

Figure 8 shows the significant development of the root system of a lettuce seedling grown in a 50 ml glass. The choice of using this system for seedling production is due to the fact that the cups have a greater volume compared to the cells of conventional trays, providing the seedlings with a better development of the root system and facilitating the addition of a greater amount of substrate per seedling.

For data reliability, both experiments were conducted under the same conditions, such as light, irrigation, mulching and seedling production. The treatments were harvested at 30 days of cultivation, which is the average cultivation time for the Vanda variety. **Figure 9** shows the beds cultivated with compost **(A)** and NPK **(B)** ready for harvest.

Figure 9. Bed cultivated with compost (A) and with NPK (B), at 30 days of cultivation.

The evaluation of the efficiency of the different fertilization methods was done by comparing 16 samples of plant height (PH), fresh mass (FM), and root size (RS), and these results are presented in **Table 4**.

Statistical analysis was also performed to evaluate the difference between the different types of fertilizers. The total fresh mass weight was obtained by weighing 16 randomly chosen samples from each bed.

Weighing each plant individually was not possible due to the unavailability of a precision scale suitable for this purpose. Thus, it was not possible to perform statistical analysis for this item.

Morphologically, there was no significant difference between the different treatments until day 18 after planting, with leaf coloration and plant height showing similar developments.

The application of complementary nitrogen fertilization on the 15th day was decisive for greater production of fresh mass (FM) in the plot treated with chemical fertilization compared to organic fertilization, presenting greater leaf growth and darker

Table 4. Measurements obtained after the lettuce harvest

	Vanda					
	RS (cm)[1]	**Tukey**[2]	**PH (cm)**[1]	**Tukey**[2]	**FM (g)**	**Total weight (kg)**
NPK	10.28 ± (1.29)	A	15.41 ± (1.52)	A	91.8	1.47
Composite	13.75 ± (3.49)	B	14.37 ± (1.62)	A	56.25	0.9

1: Mean values ± standard deviation (SD).
2: Averages followed by the same letter are not significantly different (Tukey α = 5%).

coloration from the 3rd day after application. In addition, chemical fertilization also favored the attainment of higher plant height (PH).

Marchesini *et al*.[21] (at Santos *et al*.[22]) report that the increases in productivity provided by organic fertilizers, although less immediate and marked than those obtained with mineral fertilizers, are longer lasting, probably because of the more progressive release of nutrients and the stimulation of root growth; the same authors also concluded that the use of compost not only supplies plants with considerable quantities of nutrients, but contributes to maintaining natural fertility, which involves the biological cycles of nutrients in cultivated land, preventing their exhaustion. Since some of the nitrogen present in organic fertilizers does not mineralize quickly, it remains in the soil throughout the cycle of a crop, becoming available for subsequent crops, Smith and Hadley (at Santos *et al*.[22]). Thus, the application of top dressing fertilizer becomes unnecessary in crops using organic fertilizer, especially in the case of short duration crops such as alfalfa, which may have caused the lower production of fresh mass compared to lettuce treated with chemical fertilizer. Almeida *et al*.[23], observed that with nitrogen deficiency, the lettuce crop is harmed in relation to plant height, in the number of leaves, in the indirect measurement of chlorophyll and in the dry mass of the plants.

Statistical analysis showed that there is no statistically significant difference for plant height between lettuce grown with organic compost and with commercial fertilizer (NPK), despite the higher mean plant height (PH) obtained for lettuce grown with commercial fertilizer.

Fertilization via organic compost provided greater development of the root system of the plants (RS), obtaining greater average per plant. The organic compost acts principally as a conditioner and improver of the physical, physical-chemical and biological properties of the soil, providing nutrients, favoring rapid rooting and increasing the resistance of the plants[20].

Plants with better development of the root system tend to present greater efficiency in nutrient absorption and adaptation to the environment, an effect optimized by the use of organic compost[24].

Statistical analysis showed a significant difference between root size obtained in beds fertilized with organic compost compared to those fertilized with chemical fertilizer.

Because the crop is composed basically of leaves, it responds well to the supply of nitrogen, a nutrient that requires special management regarding its application, because it leaches easily and because the lettuce absorbs a greater amount in the final phase of the cycle. Deficiency of this nutrient slows the growth of the plant[23].

Filgueira[25] describes that adequate doses of nitrogen provide good growth and leaf production, reflecting in a better quality of the lettuce crop.

The average height (AH) obtained in the treatment grown with organic manure was 13.4 cm, a result similar to that obtained by Dantas[7] by using coffee grounds, sheep manure and humic material as fertilizer for iceberg lettuce in different treatments. Obtaining averages (PH) of 14.73 cm, 15.99 cm and 14, 24 cm, respectively, a result superior to that obtained in the present work. The production of fresh mass (FM) lower than that obtained by Dantas[7], can be attributed to soil waterlogging due to constant rainfall during the second half of the experiment. Paulino *et al*.[26], studying the effects of excess irrigation on alfacicultura proved that an increase in the water supply in the cultivation area reduces the quality of the crop, causing a decrease in productivity and profitability of production.

The plot grown with organic fertilization had significantly higher root production compared to the production obtained with the use of chemical fertilizer. Similar data were found by Teixeira *et al*.[5], who grew Kaesar variety lettuce with organic compost alone, organic compost combined with chemical fertilization and compost based on calcined brown seaweed. The organic fertilization showed high root production, while the mineral fertilization combined with organic fertilization exhibited higher production of fresh mass in the aerial part of the plant and an increase in the number of leaves. For Souza and Alcântara[20]:

> Organic compost acts as a conditioner and improver of the physical, physicochemical, and biological properties of the soil, provides nutrients, promotes rapid rooting, and increases plant resistance[20(p2)].

Massukado[8] highlights the qualities of organic compost as a soil conditioner due to its large amount of organic matter.

This function increases soil permeability, decreases the risk of erosion, and helps control moisture. These changes in soil structure are reflected in a better development of the plant root system. Maia[16] when using vermicompost as a substrate in the production of lettuce seedlings recorded a correlation in the increase of vermicompost with an increase in the production of fresh root mass.

4. Conclusions

The carbonization of the rice husk and grinding of the cocoa husk was essential for its degradation and total incorporation into the compost, in which its realization in the standards presented in the methodology was successfully obtained.

The production of organic compost through the use of carbonized rice husk, sawdust, cattle manure, shredded cocoa husk and peanut forage resulted in a compost with potential as a soil conditioner and fertilizer, a fact evidenced by the results obtained in the analysis of the development of lettuce. It is worth mentioning that it took 120 days for the organic fertilizer to be ready for use.

The root yield averages were statistically different, with the best results obtained for lettuce grown with organic compost. In relation to the height of the plants grown with chemical fertilizers and organic compost, there were no statistically significant differences according to the Tukey test.

The total fresh mass production was 91.8 g of every plant with chemical fertilization, and with the use of organic compost it was 56.25 g of every plant.

Based on the parameters presented, the viability of growing lettuce CV Vanda in beds through the use of compost and chemical fertilizer was demonstrated. The cultivation of Vanda lettuce, in general, demonstrated efficiency in the use of commercial fertilizer and also through fertilization via organic compost in the production of fresh mass, root growth and plant height.

For future work it is recommended that other lettuce varieties be used, and that there be a control bed with no compost or chemical fertilizer.

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Conflict of interest

The authors declared no conflict of interest.

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