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PRODUCTION OF FERTILIZED LETTUCE WITH ROOSTERTREE IN DIFFERENT AMOUNTS AND INCORPORATION TIMES

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Abstract

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The objective of this work was to evaluate the production of lettuce manured with roostertree (*Calotropis procera*) under different amounts and times of its incorporation to the soil. The experimental design was of randomized complete blocks with treatments arranged in a 4 x 4 factorial scheme, with four replications, where the first factor was composed of four quantities of roostertree (5.4, 8.8, 12.2 and 15.6 t ha^{-1} on a dry basis), and the second factor by the incorporation times (0, 10, 20 and 30 days before lettuce transplanting – BLT). The lettuce cultivar planted was Tainá. The best productive performance of the lettuce was obtained in the amount of 15.6 t ha^{-1} of roostertree incorporated into the soil, in the time of 0 days before lettuce transplanting. The cultivation of the lettuce is agro-economically viable with the use of roostertree.

Key words: Lactuca sativa; organic agriculture; agricultura orgânica; green manuring
Abbrevations: UFERSA – Federal Rural Semi-Arid University, pH – hydrogen potential, P – phosphorus, K – potassium, Ca – calcium, Mg – magnesium, Na – sodium, M.O. – organic matter, N – nitrogen, C/N – carbon/nitrogen

Introduction

The production of vegetable crops in the organic system is a growing activity in the world, due to the need to protect the health of the producers and consumers and to preserve the environment (Sediyama et al., 2014).

In the production of this vegetables, several practices have been considered essential for the conduction of vegetable gardens, as well as for the production of inputs destined to the organic system, among them, we can highlight the green manuring.

In the Caatinga biome, several spontaneous species have the potential to be used as a source of green manure, such as *Merremia aegyptia* (hairy woodrose), *Senna uniflora* (one-leaf senna), *Waltheria indica* (velvet mallow) and *Calotropis procera* (roostertree). This practice may be of great importance to family farmers in the region, because it is a way of minimizing production costs, since this input would be obtained locally (Silva et al., 2015).

This fertilizing practice increases the percentage of organic matter in the soil and to reduce soil acidity and toxic aluminum, which are very important benefits for the sustainability of agricultural production systems (Bezerra Neto et al., 2014). In addition to promoting the improvement of soil structure and aeration and of its capacity to store moisture, it also has a regulatory effect on soil temperature (Silva et al., 2013). It delays the fixation of the phosphorus, increasing the cation exchange capacity (CEC), helping to hold potassium, calcium, magnesium and among several other elements, making them available to the roots of plants, protecting them

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from washing or leaching by water of rainfall or of irrigation (Batista et al., 2012).

The green manures help in the cycling of nutrients by bringing to the soil surfaces, nutrients that are in greater depth. Thus, green manuring provides numerous advantages to the cultivation of vegetable crops (Tivelli et al., 2010). Penteado (2007) emphasizes that the plant material, when returned to the soil, represents the return of 40 to 50% of the nutrients extracted by the production.

Thus, researches have been developed using these plants as green manure in the production of leafy vegetables, which presents characteristics that classify it as promising for use as green manure, with emphasis on high biomass production (Oliveira et al., 2011).

Some studies have been carried out successfully using this practice of fertilization in the production of vegetables, among them we can highlight: the work developed with lettuce (Góes et al., 2011), with beet (Silva et al., 2011), with the radish (Linhares et al., 2011; Linhares et al., 2013), and with coriander (Linhares et al., 2014).

With the intention of providing information on lettuce production with green fertilization, the objective of this work was to evaluate the production of lettuce fertilized with roostertree in different amounts and times of incorporation.

Materials and Methods

The study was conducted in the research area of the Rafael Fernandes Experimental Farm of the Universidade Federal Rural do Semi-Árido (UFERSA), located in the Alagoinha district, 20 km from the Mossoró municipality (5º 11′ S and 37º 20′ W, 18 m altitude). Before the installation of the field experiment, soil samples were collected to a 0-20 cm layer and then sent to be processed and analyzed in the UFERSA Water, Soil and Plant Analysis Laboratory, providing the following results: pH = 7.80; P = 13.8 mg dm^{-3}; K = 56.6 $cmol_c$ dm^{-3}; Ca = 2.00 $cmol_c$ dm^{-3}; Mg = 1.30 $cmol_c$ dm^{-3}; Na = 27.4 $cmol_c$ dm^{-3}; Organic matter = 2.82.

The experiment design used was the randomized complete blocks, with the treatments arranged in a 4 x 4 factorial scheme, with four replications. The treatments consisted of the combination of four amounts of roostertree (5.4, 8.8, 12.2 and 15.6 t ha^{-1} on a dry basis) with four incorporation times (0, 10, 20 e 30 days before lettuce transplanting – BLT).

Each plot consisted of six rows of lettuce plants, with the lateral lines and bedside plants of each line of the harvest area, considered borders. The plots had a total area of 1.44 m^2 and the harvest area of 0.80 m^2 containing 16 lettuce plants per plot. The spacing was 0.20 m x 0.20 m. The lettuce cultivar planted was "Tainá", recommended for the semi-arid conditions of the Brazilian northeast.

The soil preparation of the area consisted of a harrowing followed by the lifting of the beds and a solarization of 45 days, in order to reduce the population of soil phytopathogens that would affect crop productivity. The roostertree used was collected in an area near Mossoró of approximately 2 ha, completely occupied by this green manure. After the harvests the plants were ground in a conventional forage machine, whereby particles of 2.0 to 3.0 cm were obtained which were dried at room temperature until reaching the moisture content of approximately 10% and analyzed obtaining the following results: 20.56 g kg^{-1} of N; 4.0 g kg^{-1} of P; 35.7 g kg^{-1} of K; 9.3 g kg^{-1} of Ca and 7.03 g kg^{-1} of Mg, with carbon/nitrogen ratio of 25:1.

Initially 100% of the quantities of roostertree were incorporated in the time of 30 days BLT. During the decomposition, daily irrigations were carried out in two shifts in order to favor soil microbial activity in this decomposition process; 10 days later the incorporation of 100% of the material in the plots with respect to the time of 20 days BLT was done, and the same occurred with the incorporations referring to the times of 10 and 0 day BLT, being realized, then the transplanting of lettuce.

The lettuce seedlings were produced in greenhouse, where their sowings were carried out in 100 mL disposable cups containing commercial type Solaris substrate. After 10 days of planting the thinning was done leaving one plant per cup.

Irrigations were performed by micro-sprinkling in two applications (morning and afternoon) providing a blade of approximately 8 mm. As cultural treatments, two weedings were performed manually. The lettuce harvest was carried out at 45 days after sowing, when the plants reached maximum vegetative development.

The following characteristics were evaluated: plant height (determined in a sample of five plants selected randomly from the harvest plot, through a ruler, from the ground level to the end of the highest leaves, expressed in centimeter); plant diameter (obtained in the same previous sample, measuring the diameters between the opposing edges of the leaf disc, then obtaining the mean and expressing the results in cm); number of leaves per plant (obtained by counting basal leaves to the last open leaf measuring more than 5 cm in the same sample); productivity (determined by the fresh mass of the shoots of all the plants of the harvest plot expressed in t ha^{-1}) and dry mass of the shoots (obtained in the same sample of five plants, in which the dried mass in greenhouse with forced circulation of air was determined at a temperature of 65°C until reaching constant weight, and expressed in t ha-^{1}).

The economic indices analyzed were: gross income (obtained from the product of the productivity of each treatment by the amount of lettuce paid in January 2011, which was R$ 1.50 per kilogram of lettuce, and expressed in Reals); net income (obtained from the subtraction between the gross income and the total cost of production); rate of return (obtained from the ratio of gross income to total cost of production) and the profit margin (obtained from the ratio of net income to gross income, expressed as a percentage). The methodology used in the calculation of these indicators was recommended by Lima et al. (2010).

Analyzes of variance were performed for the characteristics evaluated through the SISVAR application (Ferreira, 2011). Procedure for adjusting response curves for treatment factors was performed using the Table Curve software (Jandel Scientific, 1991).

Results and Discussion

Significant interaction was observed between the amounts of roostertree incorporated in the soil and the incorporation times, at the plant height, number of leaves per plant and lettuce productivity (Figures 1 and 2). This means that the behavior of the characteristics evaluated in the lettuce as a function of the amounts of roostertree was influenced by the times of incorporation and vice versa.

Surface responses were obtained for plant height, productivity and dry mass of shoots, where the maximum values of 16.37 cm, 18.85 and 2.92 t ha^{-1}, respectively, were observed in the amount of 15.6 t ha^{-1} of roostertree (Figure 1).

This increase in these characteristics is due to the conditions provided by this green manure in the chemical and physical attributes of the soil, among them the ion exchange capacity, which is responsible for the nutrient exchanges of the solid phase with the liquid phase (in the soil solution), thus promoting greater availability of nutrients to the plants and the stability of the soil aggregates, thus favoring a greater development of the root system of the plants, making them more skilled at absorbing nutrients, made available by the green manure incorporated into the soil.

Góes et al. (2011), using hairy woodrose in lettuce fertilization, observed an increase in lettuce plant height and diameters as a function of the amounts of this green manure

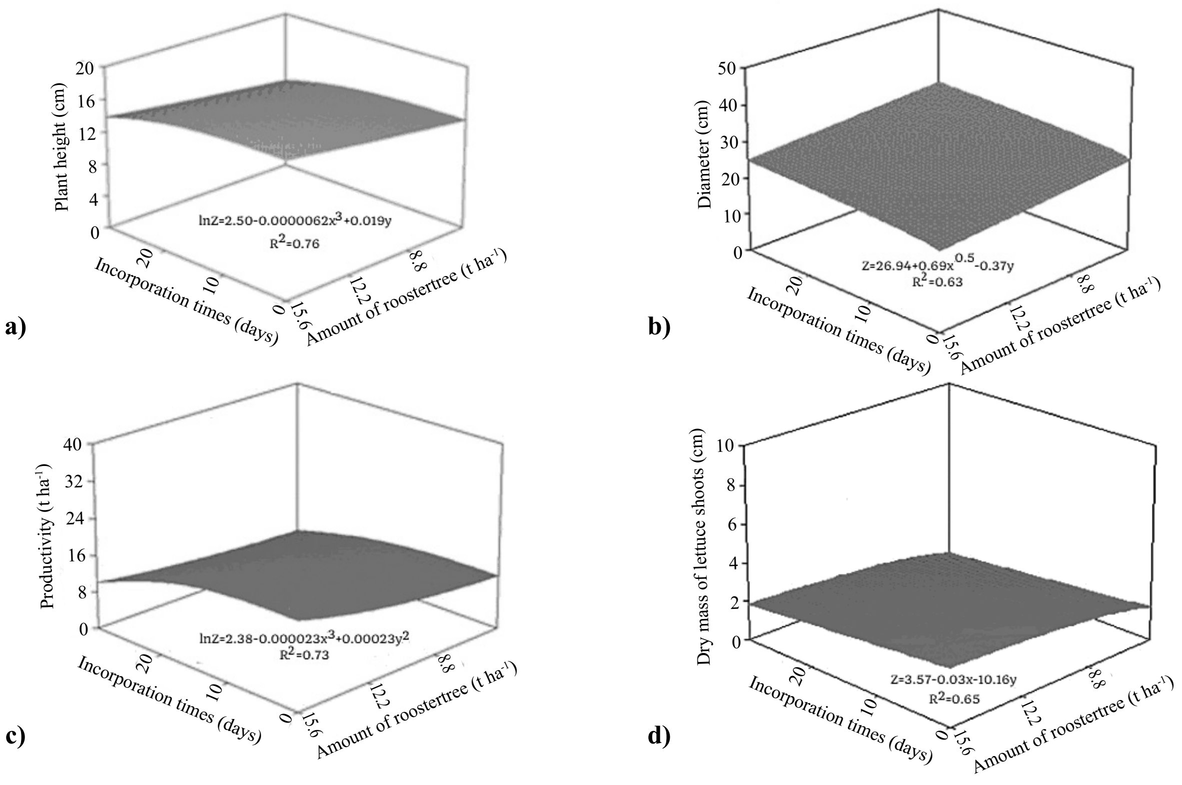

Fig. 1. Plant height (A), diameter (B), productivity (C) and dry mass of lettuce shoots (D) as a function of the amounts and times of incorporation of the roostertree into the soil

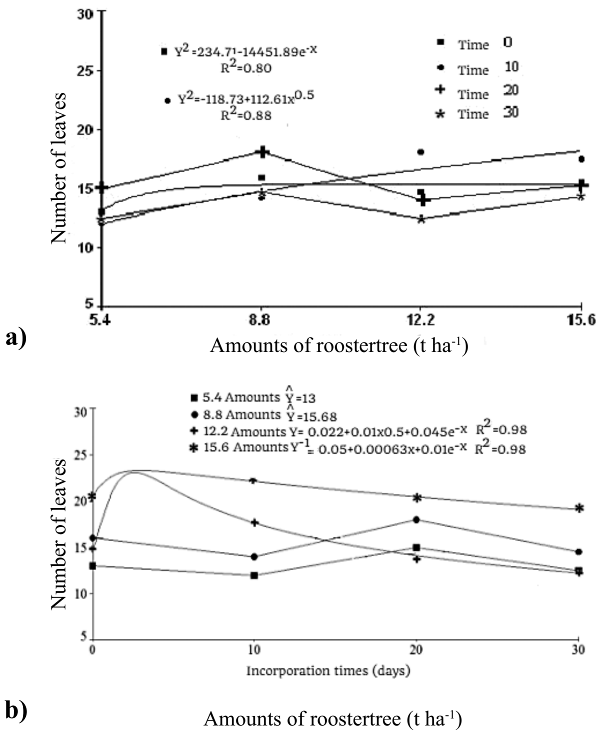

Fig. 2. Number of leaves per lettuce plant as a function of the amounts of roostertree (A) and of their times of incorporation to the soil (B)

incorporated into the soil, whose maximum values were 22.76 and 23.14 cm, in the amount of 8.96 and 9.22 t ha^{-1} of hairy woodrose incorporated into the soil. These values are very close to those observed in this study.

A growing response was observed in both productivity and dry mass of shoots with the amounts of roostertree added to the soil (Figures 1C and 1D), where the maximum productivity of 18.85 t ha^{-1} and dry mass of 2.92 t ha^{-1} were obtained in the amount of 15.6 t ha^{-1} in the time 0.

These increases can be explained by the better physical condition of the soil, provided by the incorporation of the green manure that contributed to a greater development of the plant root system. This root growth contributed to a greater absorption efficiency of the plants of the nutrients available to the soil by the green manure.

These observations are reinforced by Kiehl (1985) in stating that organic fertilizers applied to the soil always provide a positive response on the production of the crops, even equaling or even overcoming the effects of chemical fertilizers. Green fertilization benefits the soil through increased organic matter, biological activity, and aggregate stability. Another advantage of green manures is to increase the recycling of nutrients, which are accumulated during their growth and released during their decomposition.

These results are explained by the greater availability of nutrients in the period of higher nutritional requirement of the plants, although the roostertree has a low C:N ratio, the probable supply of nutrients readily available to the plants, mainly the N, occurred during the decomposition period, whose mineralization predominated in relation to immobilization and the N available in the soil to the plants was also higher than the losses mainly by leaching or volatilization.

Contradictory results were obtained by Linhares et al. (2009), who evaluated the speed of decomposition of the roosertree in the arugula crop, observed a significant increase in the characteristics evaluated in the incorporation times of the organic fertilizer on the day of sowing and at 15 days before sowing.

This productivity occurred during this period because the lettuce presented a greater nutritional demand. The results show that knowing the quality of the organic material to the mineralization is essential to ensure that the phases of higher nutritional demand of the crop are synchronized with the release of mineralized nutrients by the organic fertilizers.

Oliveira et al. (2006) also obtained an increase in the average head weight of lettuce with the addition of increasing doses of bed of poultry applied in cover.

Similar results were also obtained by Linhares et al. (2009), which evaluated the different times of roostertree (*C. procera*) decomposition in the arugula culture, observed that the time of decomposition from 0 and 15 days of incorporation were those that presented the greatest increase of the characteristics evaluated, and the results resembled that of other studies with different species. Zárate et al. (1997) observed increases in lettuce yield, with the use of 14 t ha^{-1} of bed of poultry in cover.

A decreasing response to dry mass was observed with increasing incorporation time (Figure 1D), with a maximum value obtained of 2.92 t ha^{-1} at time 0 day. This decrease can be explained by the low availability of nutrients in the soil in the initial period of plant growth, when the green manure was added while still decaying. Linhares et al. (2009) evaluating different times of roostertree incorporation in the arugula culture observed that the times of incorporation of 0 and 15 days were those that presented greater increase of the characteristics evaluated and the results resembled that of other studies with different species.

For the plant diameter and dry mass of shoots no significant interaction was observed between the amounts of roostertree incorporated in the soil and the incorporation time (Figures 1A and B). The maximum value for the observed diameter was 28.71 cm recorded in the amount of 5.4 t ha^{-1} of roostertree at the time of 30 days BLT (Figure 1B).

For the number of leaves per plant it was not possible to adjust any response surface as a function of the amounts roostertree incorporated in the soil and of the incorporation times.

By unfolding the interaction of roostertree amounts at the incorporation times, the largest number of leaves per plant can be observed in the amount of 8.8 t ha^{-1} (Figure 2A). This can be attributed to the influence of the organic cultivation system on lettuce leaf productivity, due to the influence of the organic fertilizers on the physical, chemical and biological properties of the soil, since they have conditioning effects and increase the capacity of the soil to store nutrients needed for the development of plants (Oliveira et al., 2010).

On the other hand, by unfolding the interaction, incorporation times as a function of the amounts roostertree, one can observe the largest number of leaves of 23 and 18 in the green manure amounts of 12.2 and 15.6 t ha^{-1} in the time of 3 days (Figure 2B).

Some authors have observed that the release of nutrients from organic residues also depends on nutrient behavior, for example, K being an element that is not associated with any structural component of the plant tissue, is an element that is not metabolized in the plant and forms bonds with organic complexes of easy reversibility. Therefore, as the shoots of the plant begin the drying process and degrades, the concentration of this nutrient in the tissue decreases dramatically, since it is easily washed by water, after the rupture of the plasma membranes (Malavolta et al., 1997).

In this experiment it is possible to infer that the mineralization of the organic matter occurred in a timely manner to supply nutrients to the production of the leaf numbers of lettuce plants at 20 days of incorporation before planting, and the results can be explained by Taiz and Zeiger (2006), who observed that the release of nutrients by organic fertilizers added to the soil, are not released in a similar way, depending on the quality of the material.

By unfolding the amounts of roostertree incorporated into the soil within its decomposition times (Figure 2B), it was observed that the maximum average value of the number of leaves per plant obtained occurred at 10 days of decomposition before transplanting, with the incorporation of 12.2 t ha^{-1}.

Góes et al. (2011), evaluating green fertilization with dry hairy woodrose (*M. aegyptia*) in looseleaf lettuce, verified that the greatest increases in the number of leaves per plant occurred 30 days after the incorporation.

In the economic indexes it was observed that there was a significant interaction between the factors roostertree amounts and their incorporation times (Figures 3 and 4).

Surface responses were obtained for gross income, net income and rate of return, where the maximum values of R$ 27,873.74, R$ 19,356.34 and 3.14, respectively, were observed in the amount of 15.6 t ha^{-1} of roostertree in the time 0 (Figure 3). For the profit margin it was not possible to adjust any response surface as function of the amounts roostertree incorporated in the soil and of the incorporation times.

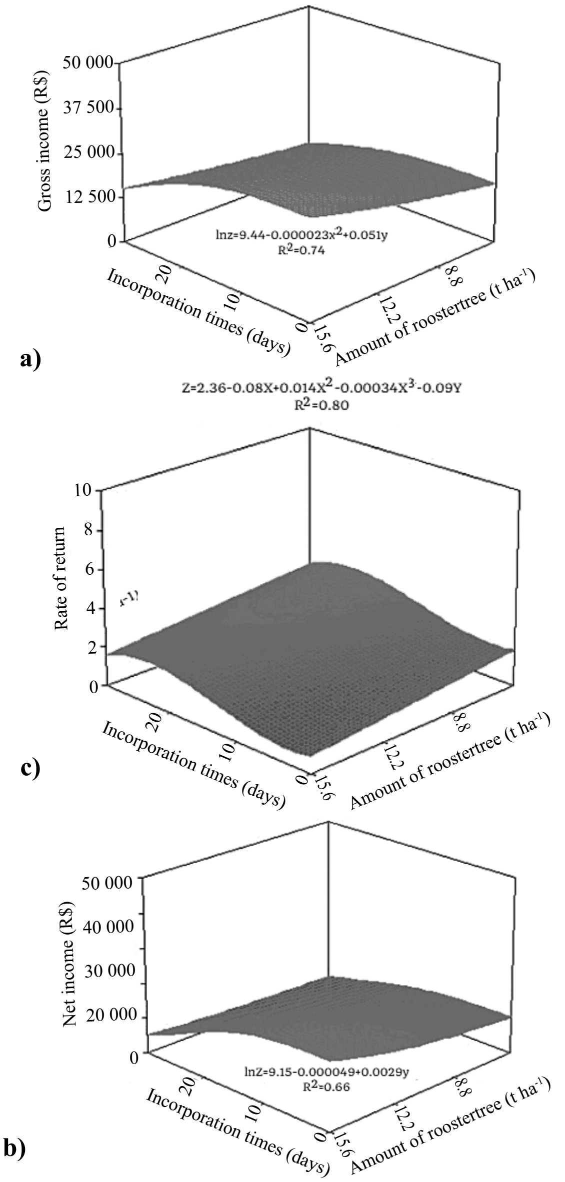

Fig. 3. Gross income (A), net income (B) and rate of return (C) as function of the amounts and times of incorporation of roostertree to the soil

Regarding the profit margin when unfolding the roostertree amounts within the incorporation times, it was observed a better profit margin of 69.58% in the largest amount of roostertree of 15.6 t ha^{-1} at the incorporation time of 0 days before transplanting (Figure 4A). On the other hand, when unfolding incorporation times within the roostertree amounts, a higher profit margin was observed in the time of incorporation of 10 days BLT in the amount of roostertree 15.6 t ha^{-1}, obtaining the highest value of 71.59% (Figure 4B).

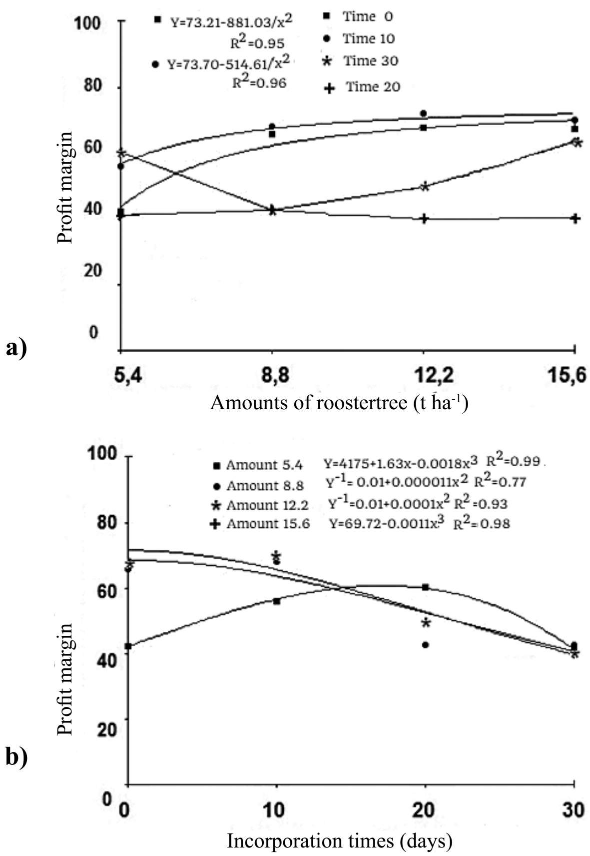

Fig. 4. Profit margin of the roostertree amounts (A) and of their incorporation times (B) to the soil

These results probably occurred because of the greater availability of nutrients provided to the soil with the increase of the amounts of green manure, which besides being excellent suppliers of nitrogen, also provide it by the recycling of nutrients. In addition, organic fertilization serves as a source of energy for useful microorganisms, improves structure and aeration, the ability to store moisture, as well as regulating soil temperature, helps to hold potassium, calcium, magnesium and other nutrients in forms available for the roots (Batista et al., 2012).

Thus, it is possible to have an adequate synchrony between the decomposition and the mineralization of the roostertree added to the soil, at the incorporation time of 10 days before planting in the amount of 15.6 t ha^{-1}, evidencing an adequate nutritional supply of carrot and cowpea-vegetable plants (Fontanettti et al., 2006).

Conclusions

The best productive performance of the lettuce was obtained in the amount of 15.6 t ha^{-1} of roostertree incorporated into the soil, in the time of 0 days before lettuce transplanting.

The cultivation of the lettuce is agro-economically viable with the use of roostertree.

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