https://www.seer.ufal.br/index.php/revistacienciaagricola/index
ISSN: 0103-8699
Doi: 10.28998/rca.21.11877



# EVALUATION OF ORGANIC AND MINERAL NITROGEN IN FOUR SUCCESSIVE LETTUCE CROP CYCLES

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**ABSTRACT:** The increase in the cost of mineral fertilizers and the growing environmental pollution make the use of organic residues in agriculture an attractive option from the economic point of view due to the cycling of C and nutrients. In this context, the aim of this work was to verify the best management of chemical and/or organic nitrogen in the productivity and mineral nutrition of lettuce in 4 successive crops. The experiment was carried out in greenhouse at the Department of Soil Science, Faculty of Agricultural Sciences of Botucatu, SP. The experimental design was as follows: T0 – without N; T1 – 0.54 grams of N (urea) per plant; T2 – 0.27 grams of N (organic compound) and 0.27 grams of N (urea); T3 – 0.54 grams of N (organic compound) per plant; T4 – 0.81 grams of N (organic compound) per plant; T5 – 1.08 grams of N (organic compound) per plant. Fertilization with organic compost to replace N from urea resulted in higher lettuce productivity in 4 consecutive cycles. Fertilization with organic compost provided higher amounts nutrients to lettuce (N, P, K, Ca, Mg, S) than fertilization with N from urea.

**KEYWORDS:** productivity, mineral plant nutrition, composting, poultry manure, eucalyptus bark, *Lactuca sativa* L.

## AVALIAÇÃO DO NITROGENIO ORGANICO E MINERAL EM QUATRO CICLOS SUCESSIVOS DA CULTURA DA ALFACE

**RESUMO:** O aumento do custo de fertilizantes minerais e a crescente poluição ambiental fazem do uso de resíduos orgânicos na agricultura uma opção atrativa do ponto de vista econômico, em razão da ciclagem de C e nutrientes. Em vista disto o objetivo deste trabalho foi verificar o melhor manejo do nitrogênio químico e ou orgânico na produtividade e nutrição mineral da alface em 4 cultivos sucessivos. O experimento foi realizado na casa de vegetação do Departamento de Ciência do Solo da Faculdade de Ciências Agronômicas de Botucatu em casa de vegetação. O delineamento experimental foi feito da seguinte maneira: T0 – sem N; T1 – 0,54 gramas de N (ureia) por planta; T2 – 0,27 gramas de N (Composto orgânico) e 0,27 gramas de N (ureia); T3 – 0,54 gramas de N (composto orgânico) por planta; T4 – 0,81 gramas de N (composto orgânico) por planta; T5 – 1,08 gramas de N (composto orgânico) por planta. A adubação com composto orgânico na substituição do N proveniente da ureia obteve maiores produtividades de alface em 4 ciclos consecutivos. A adubação com composto orgânico obteve maior quantidade de nutrientes da alface (N, P, K, Ca, Mg, S) do que a adubação com N proveniente da ureia.

**PALAVRAS CHAVE:** produtividade, nutrição mineral de plantas, compostagem, esterco de galinha, casca de eucalipto, Lactuca sativa L.

*Accepted on March 03, 2023.*
*Published on April, 2023.*

## INTRODUCTION

Lettuce, *Lactuca sativa* L., due to its dietary importance as source of vitamins and mineral salts, stands out among the most consumed leafy vegetables worldwide. In Brazil, it is among the main vegetables, both in terms of volume and marketed value (Porto et al., 1999).

According to (Katayama, 1993), it has low calorie content, and is one of the forms of fresh salad most consumed by all Brazilian social classes. However, its cultivation has limitations, mainly due to its sensitivity to adverse conditions of temperature, humidity and rainfall (Gomes et al., 2005). Regarding the disadvantages of its cycle, the difficulty of post-harvest conservation and transport stands out, a fact that limits its production to the green belts of large cities, forcing producers to obtain maximum productivity (Santos, 2001).

Lettuce is the leafy vegetable most consumed in Brazil and has great response to N (Smith and Hadley, 1989) and high water content in the soil and great production potential with organic fertilizers. At the same time, organic fertilization is intended to the recycling of rural waste, which enables greater autonomy for producers in the face of the purchase of inputs, with large residual effect (Vidigal et al., 1995).

The increase in the cost of mineral fertilizers and the growing environmental pollution make the use of organic residues in agriculture an attractive option from the economic point of view due to the cycling of C and nutrients (Silva et al., 2010). This generates an increase in the demand for studies to assess the technical and economic viability of this use (Melo et al., 2008).

According to (Oliveira et al., 2010), leafy vegetables respond very well to organic fertilization and the use of mineral fertilizers promotes reduction in soil biological activity, which may affect the productive performance of crops.

According to (Silva et al., 2010) organic fertilization increases productivity and produces plants with better qualitative characteristics than those cultivated exclusively with mineral fertilizers and can therefore influence the nutritional quality of lettuce. Its use has provided increased production and nutrient content in lettuce plants (Rodrigues and Cassali, 1998).

N is the nutrient found in greater amounts in lettuce leaves (Tavares and Junqueira, 1999). Its deficiency slows down plant growth, compromises the head formation, and older leaves become yellow and detach easily.

According to (Maynard, 1976), N promotes good vegetative development in lettuce. This nutrient increases leaf growth, the leaf area index and consequently the levels of liquid photosynthesis, resulting in greater dry matter accumulation (Marschner, 1986).

The aim of this study was to verify the best management of chemical and/or organic nitrogen in the productivity and mineral nutrition of lettuce plants in 4 successive crops.

## MATERIAL AND METHODS

The experiment was carried out in greenhouse at the Department of Soil Science, Faculty of Agricultural Sciences of Botucatu, with geographic coordinates (22º50'S, 48º22'W, altitude of 815 m a.s.l.).

Lettuce 'Lucy Brown' cultivar was used. The experiment was carried out in pots with capacity of 5 liters in greenhouse.

The fertility characteristics of soil where the experiment was installed are shown in Tables 1 and 2. The methodology adopted was that proposed by (Raij et al., 2001).

**Table 1.** Chemical characteristics of soil where the experiment was carried out.

| pH $CaCl_2$ | O.M. g $dm^{-3}$ | P(res.) mg $dm^{-3}$ | H+Al | $Al^{+3}$ | $K^+$ | $Ca^{+2}$ | $Mg^{+2}$ | SB | CEC | BS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | mmol$_c$ $dm^{-3}$ | | | | | | | % |
| 4.1 | 23 | 2 | 57 | 11 | 0.4 | 2 | 1 | 3 | 60 | 6 |

CEC= Ca+Mg+K+H+Al; SB= Ca+Mg+K; BS= ((SB/CEC)*100 Raij et al.(2001)

**Table 2.** Chemical characteristics of soil where the experiment was carried out (micronutrient)

| B | Cu | Fe | Mn | Zn |
|---|---|---|---|---|
| | | mg $dm^{-3}$ | | |
| 0.30 | 0.7 | 77 | 0.4 | 0.1 |

Liming was carried out for V% elevation to 80 (Raij et al., 1996) using dolomitic limestone of PRNT 90%, using 12.25 grams for each 5-liter pot. It was well mixed with soil and then the soil was irrigated until reaching field capacity for the limestone to react in the soil, which was incubated for 60 days.

After the incubation period, P and K fertilization was carried out by mixing the soil well with a mixer. In the P fertilization, it was calculated to add 150 ppm of P, which corresponds to 9.8 grams of simple superphosphate (18 g $kg^{-1}$ $P_2O_5$) per pot. In the K fertilization, it was calculated to add 50 ppm of K, which corresponds to 0.5 grams of Potassium Chloride (60 g $kg^{-1}$ $K_2O$) per pot.

After P and K correction, fertilization with organic compost was carried out in treatments that received this fertilization.

Fertilization with organic compost was carried out for each lettuce crop cycle and P and K corrections were carried out only in the first crop cycle.

Lettuce used in this experiment was the 'Lucy Brown' cultivar, purchasing seedlings at a local retailer that had already been planted for 30 days. Seedlings were transplanted in the center of the pot, making a hole of 2.5 cm in depth and placing seedlings and then a slight compaction of seedlings was carried out.

The experimental design was as follows: T0 – without N; T1 – 0.54 grams of N (urea) per plant divided into three times (7, 14 and 28 days after transplanting), according to recommendation of (Reis et al., 2012), verified that splitting N in lettuce obtained better results; T2 – 0.27 grams of N (organic compost) and 0.27 grams of N (urea) divided into three times per plant (7, 14 and 28 days after transplanting); T3 – 0.54 grams of N (organic compost) per plant; T4 – 0.81 grams of N (organic compost) per plant – 150% of the N requirement; T5 – 1.08 grams of N (organic compost) per plant – 200% of the N requirement. Organic compost fertilization was carried out before each planting. This experiment consisted of 5 replicates of each treatment. Four consecutive lettuce cycles were performed.

The organic compost used in this experiment was made from the mixture of poultry manure with eucalyptus bark in the proper proportion to start the composting process with C/N ratio of 30/1, which lasted 120 days, turning and watering when necessary. The calculation of the amount of compost was based on the necessary amount of N, considering N mineralization of 20% (Conama, 2006). The analysis of compounds is described in Tables 3 and 4, adopting methodology proposed by (Embrapa, 2009).

**Table 3.** Macronutrient contents of the organic compost used in the four cultivation cycles

| cycle | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | C | C/N | pH |
|---|---|---|---|---|---|---|---|---|---|
| | g kg$^{-1}$ fresh | | | | | | | | |
| 1st and 2nd | 1.6 | 3.2 | 1.1 | 6.4 | 0.5 | 1.8 | 27 | 17 | 6.9 |
| 3rd and 4th | 1.5 | 3.3 | 1.7 | 9.8 | 0.4 | 0.9 | 24 | 16 | 6.9 |

**Table 4.** Micronutrient and Na contents in the organic compost used in the first and second cycle

| Cycle | Na | B | Cu | Fe | Mn | Zn |
|---|---|---|---|---|---|---|
| | mg kg$^{-1}$ fresh | | | | | |
| 1st and 2nd | 1.656 | 13 | 80 | 15.262 | 566 | 292 |
| 3rd and 4th | 2.369 | 13 | 76 | 1.144 | 529 | 202 |

Irrigation was carried out based on the calculation of the evaporation of class A tank, installed at the experiment site.

The parameters evaluated in this experiment were fresh and shoot dry mass and export of macro nutrients.

Total fresh mass was determined by weighing lettuce plants immediately after cutting close to the ground.

To determine the dry mass, 5 lettuce leaves were collected from each plot and weighed, then washed with running water, with detergent and deionized. Leaves were conditioned in identified paper bags and then placed in a forced ventilation oven at 65º C, until constant mass was obtained (72 hours). After this period, leaves were weighed again to obtain the dry mass. Wet mass and dry mass were used to calculate the % of dry mass of each plant representing the plot. The % of dry mass and the production of green mass were used to calculate the dry mass production per plant.

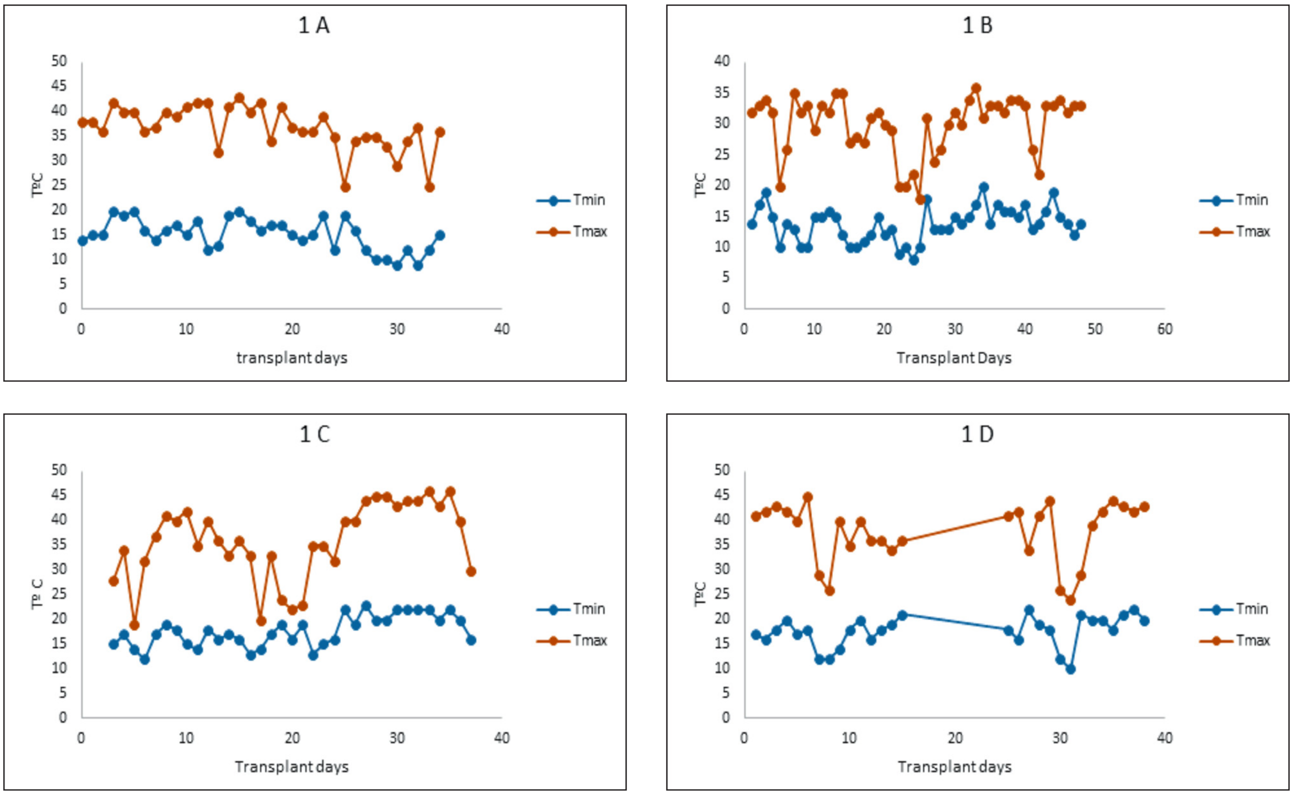
The same plants harvested for dry mass calculation were ground and packed in paper bag. These samples were sent for analysis according to methodology described by (Malavolta et al., 1997).

Nutrient export was calculated by multiplying the contents with the dry mass production.

Data were submitted to analysis of variance and comparison of means using the Scott Knott test at 5% probability.

The minimum and maximum temperature data in the four lettuce cycles are shown in Figures 1.

**Figure 1.** Minimum and maximum temperature in lettuce development 1A – first cycle, 1B – second cycle, 1C - third cycle, 1D - fourth cycle.




## RESULTS AND DISCUSSIONS

In the first cycle production, plants that received the highest dose of organic compost representing 200% of the N needs in the form of organic compost obtained the highest green mass productivity compared to the other plants. Plants that received 150% N in the form of organic compost had higher green mass productivity than lettuces with 100% N in the form of organic compost, 50% of organic N and 50% of chemical N, 100% of chemical N and plants that did not receive N. Lettuce plants that received organic fertilization obtained higher green mass productivity than plants not fertilized with organic compost already in the first cultivation cycle. Martins et al., (2017) obtained greater green mass production with the use of organic compost compared to the use of chemical N. The treatment that received chemical nitrogen fertilization (T1) showed higher green mass production than treatment (T0) that did not receive N (Table 5). (Rezende et al., 2017) verified increase in lettuce fresh mass production using N doses (9, 54, 90, 126 and 171 kg ha$^{-1}$) showing that N has direct effect on production.

**Table 5.** Lettuce fresh mass production in the four cultivation cycles according to the different treatments

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 22.40 e | 17.20 b | 13.60 c | 20.00 c |
| T1 | 130.00 d | 56.00 b | 21.00 c | 16.00 c |
| T2 | 314.00 c | 169.40 a | 329.20 a | 339.00 b |
| T3 | 269.20 c | 199.60 a | 318.00 a | 387.00 b |
| T4 | 370.80 b | 175.60 a | 306.00 a | 437.40 a |
| T5 | 450.00 a | 228.40 a | 200.80 b | 348.80 b |
| F | 56.25 | 24.80 | 66.55 | 57.76 |
| Mean | 259.47 | 141.03 | 198.10 | 258.03 |
| CV | 18.15 | 26.87 | 20.39 | 21.56 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second lettuce production cycle, all treatments that received organic fertilization obtained higher green mass production than treatments not fertilized with the organic compost (Table 5).

In the third cycle, lettuces fertilized with 50% organic N + 50% chemical N, 100% organic N and 150% organic N obtained higher green mass production than treatments with 200% organic N, 100% chemical N and without N. Nunes et al., (2017) also observed increase in lettuce fresh mass production up to the dose of 6.3 kg $m^{-2}$ of the organic compost, above this dose, decrease in productivity was observed. Lettuce plants that did not receive organic compost had lower production (Table 5).

In the fourth cycle, lettuce plants fertilized with 150% organic N obtained higher green mass production compared to the other lettuce plants. Lettuce plants that received organic compost regardless of dose obtained higher green mass production than plants that did not receive this type of fertilization (Table 5). According to (Peixoto Filho et al., 2013). fertilization with poultry, cattle and sheep manure obtained higher fresh mass production compared to mineral fertilizer in the third and fourth cultivation cycles, showing that the lettuce crop responds very well to organic fertilization.

In the first cycle, treatments that received organic compost had higher dry mass production than treatments that did not receive organic fertilizers. Lettuce fertilized with chemical N obtained higher dry matter production than treatment that did not use N. The treatment that received the highest organic compost dose obtained the highest dry mass production, compared to the other treatments (Table 6).

**Table 6.** Lettuce dry mass production in the four cultivation cycles according to the different treatments

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g $plant^{-1}$ | | |
| T0 | 1.81 d | 0.72 c | 1.1 b | 0.42 b |
| T1 | 6.32 c | 3.09 c | 1.32 b | 0.36 b |
| T2 | 14.06 b | 7.74 b | 13.83 a | 11.83 a |
| T3 | 12.21 b | 9.52 b | 13.37 a | 13.45 a |
| T4 | 15.40 b | 9.39 b | 15.36 a | 15.02 a |
| T5 | 19.43 a | 13.07 a | 11.41 a | 12.75 a |
| F | 34.36 | 24.39 | 35.61 | 50.95 |
| Mean | 11.54 | 7.26 | 9.40 | 8.97 |
| CV | 21.22 | 28.44 | 25.79 | 23.49 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second cycle, no statistical difference between treatment with chemical N and without N was observed. Treatments fertilized with organic compost had higher dry mass production than treatments that did not receive the organic compost. The treatment that received the highest organic compost dose obtained the highest dry mass production, compared to the other treatments (Table 6).

In the third and fourth lettuce cycle, treatments fertilized with the organic compost obtained higher dry matter production than treatments not fertilized with the organic compost (Table 6).

According to (Maynard, 1976), N is a nutrient that promotes good vegetative development in lettuce. This nutrient increases leaf growth, leaf area index and consequently the levels of liquid photosynthesis, resulting in greater dry matter accumulation (Marschner, 1986). (Fontes et al., 1997) obtained positive effect for dry mass of lettuce ‘Regina 440’ and ‘Brasil 202’ cultivars, in response to the addition of N.

Some authors associate the increase in the dry mass of leaf tissues with N (Vidigal et al., 1997). The deficiency of this nutrient causes reduction in photosynthesis, lower growth and higher dry mass content in plant shoots (Primavesi, 1985).

In the first cycle, lettuce that accumulated the most N was fertilized with 200% organic N. Lettuce fertilized with 50% organic N combined with 50% mineral N and those fertilized with 150% organic N accumulated greater amounts of N than plants not fertilized with N, 100 % urea N and 100% organic N (Table 7). (Silva et al., 2010) tested organic composts at different doses and concluded that composts satisfactorily supplied the N needs of “Veronica” lettuce, not requiring the use of mineral fertilizer.

**Table 7.** Lettuce N exportation in the four cultivation cycles according to the different treatments

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.23 c | 0.17 c | 0.20 b | 0.14 c |
| T1 | 2.18 c | 0.87 c | 0.43 b | 0.12 c |
| T2 | 4.02 b | 2.79 b | 4.37 a | 3.49 b |
| T3 | 2.94 c | 3.04 b | 4.18 a | 3.68 b |
| T4 | 4.59 b | 3.17 b | 5.04 a | 4.79 a |
| T5 | 6.31 a | 4.58 a | 4.03 a | 4.51 a |
| F | 35.87 | 28.21 | 40.03 | 30.73 |
| Mean | 3.38 | 2.44 | 3.04 | 2.79 |
| CV | 23.18 | 28.09 | 24.88 | 30.61 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second cycle, the highest dose of organic compost (T5) obtained greater N accumulation and plants that did not receive organic fertilization accumulated less N than plants fertilized with organic compost (Table 7).

In the third cycle, treatments fertilized with organic compost obtained greater N accumulation than treatments not fertilized with organic compost (Table 7).

In the fourth cycle, plants that received the highest dose of organic compost 150% N and 200% organic N accumulated more N than the other treatments and plants that did not receive organic compost fertilization accumulated less N than plants fertilized with the organic compost (Table 7).

Table 7 shows that what made the difference in the amount of N in lettuce plants was not the N from urea, but N from the organic compost, which can be explained because it is not a protected urea, and losses may have occurred due to leaching than when the organic compost was used, which gradually released N for plant absorption.

In the first and second cycles, lettuce fertilized with higher amount of organic compost accumulated more P than the other treatments, and plants that did not receive organic fertilization accumulated less P (Table 8). For being rich in P (3.2% of $P_2O_5$), the compost used in this experiment was responsible for the great difference in P accumulation. (Santos et al., 2001) compared organic and mineral fertilizers applied in lettuce and observed that the use of organic fertilizer increased the base and phosphorus content and the soil cation exchange capacity and that the continuous release of N by the mineralization of organic material was more adequate for lettuce needs than supplying readily available soluble formulations.

**Table 8.** Lettuce P exportation in the four cultivation cycles according to the different treatments.

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.050 c | 0.017 c | 0.014 c | 0.006 c |
| T1 | 0.130 c | 0.050 c | 0.013 c | 0.004 c |
| T2 | 0.370 b | 0.181 b | 0.292 b | 0.251 b |
| T3 | 0.390 b | 0.260 b | 0.334 b | 0.305 b |
| T4 | 0.414 b | 0.229 b | 0.402 a | 0.413 a |
| T5 | 0.544 a | 0.372 a | 0.382 a | 0.392 a |
| F | 30.21 | 19.36 | 41.69 | 26.83 |
| Mean | 0.315 | 0.185 | 0.239 | 0.229 |
| CV | 24.34 | 36.66 | 25.91 | 34.50 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the third and fourth cycles, lettuce fertilized with 150 and 200% of organic N accumulated greater amounts of P than the other plants and lettuce not fertilized with the organic compost (T0 and T1) accumulated less P than the other plants (Table 8).

It can be observed in Table 8 that in the 4 cultivation cycles, plants that did not receive fertilization with the organic compost obtained smaller amounts of P, which can be explained by the amount of the organic compost containing P and the fact that the organic matter of the compost decreases the P fixation on the soil.

In the first lettuce cycle, it was observed in Table 9 that as the organic compost dose increases, there is an increase in the K accumulation and plants not fertilized with organic compost accumulated much smaller amounts of K. Plants fertilized with organic compost showed increase in organic matter, and as a result of this increase, there was an increase in negative charges in soils fertilized with organic compost, and as negative charges increased in soil, there is lower loss of K by leaching and the compost itself had $K_2O$ content of 1.1%, which also provided greater increase in K. (Resende et al., 2009) reported that there is a significant and complementary effect on N and K absorption, and that the most important aspect is the need for adequate level of K to increase productivity, with addition of N.

In the second cycle, plants fertilized with greater amount of organic compost accumulated greater amounts of K than the other plants and plants that received organic fertilization showed greater K accumulation compared to plants that did not receive this type of fertilization (Table 9).

In the third and fourth cycle, treatments that did not receive organic fertilization showed lower K accumulation than treatments that used organic fertilization (Tables 9).

In the first cycle, treatments that received fertilizers with organic compost showed greater Ca accumulation than treatments that did not receive organic fertilization. Treatment that did not receive N had lower Ca accumulation than the other treatments (Table 10).

**Table 9.** Lettuce K exportation in the four cultivation cycles according to the different treatments.

| **Treatments** | **1st cycle** | **2nd cycle** | **3rd cycle** | **4th cycle** |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.70 d | 0.67 c | 0.49 b | 0.22 b |
| T1 | 3.58 d | 2.42 c | 0.53 b | 0.15 b |
| T2 | 13.156 c | 9.02 b | 14.95 a | 11.01 a |
| T3 | 11.42 c | 11.57 b | 15.02 a | 13.76 a |
| T4 | 16.68 b | 12.50 b | 16.93 a | 14.88 a |
| T5 | 24.95 a | 18.33 a | 12.66 a | 13.77 a |
| F | 69.63 | 31.15 | 27.82 | 35.91 |
| Mean | 11.75 | 9.08 | 10.10 | 8.96 |
| CV | 20.13 | 29.17 | 31.70 | 28.80 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

**Table 10.** Lettuce Ca exportation in the four cultivation cycles according to the different treatments.

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.13 c | 0.07 b | 0.09 c | 0.04 c |
| T1 | 0.97 b | 0.35 b | 0.22 c | 0.05 c |
| T2 | 2.14 a | 1.22 a | 2.18 a | 2.25 a |
| T3 | 2.00 a | 1.22 a | 1.70 a | 2.25 a |
| T4 | 2.17 a | 0.99 a | 1.63 a | 2.09 a |
| T5 | 2.02 a | 1.30 a | 1.12 b | 1.41 b |
| F | 26.09 | 14.63 | 17.42 | 44.02 |
| Mean | 1.57 | 0.86 | 1.16 | 1.35 |
| CV | 23.28 | 35.48 | 39.13 | 26.33 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second cycle, treatments fertilized with organic compost accumulated more Ca than the other treatments (Table 10).

In the third and fourth cycles, plants that accumulated the highest amount of Ca were those that received 50% organic N combined with 50% N (urea), 100% organic N and 150% organic N. Plants that received 200% organic N accumulated more Ca than plants not fertilized with organic compost (Table 10).

Ca levels were high in the organic compost used in this experiment, which made the difference in treatments with organic compost, presenting high amounts in lettuce plants.

In the first cycle, plants fertilized with 50% organic N combined with 50% N (urea), 150% organic N and 200% organic N accumulated more Mg than plants that did not receive this type of fertilization. Plants fertilized with N accumulated more Mg than plants not fertilized with N (Table 11). (Koo & Reese, 1977) claim that N and Mg in leaves are positively related, with a synergistic relationship between them.

**Table 11.** Lettuce Mg exportation in the four cultivation cycles according to the different treatments.

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.05 c | 0.02 b | 0.05 b | 0.02 b |
| T1 | 0.42 b | 0.15 b | 0.12 b | 0.03 b |
| T2 | 0.67 a | 0.41 a | 0.86 a | 0.68 a |
| T3 | 0.49 b | 0.38 a | 0.69 a | 0.73 a |
| T4 | 0.67 a | 0.36 a | 0.69 a | 0.83 a |
| T5 | 0.77 a | 0.51 a | 0.54 a | 0.62 a |
| F | 25.66 | 16.14 | 22.28 | 26.01 |
| Mean | 51.06 | 0.30 | 0.49 | 0.48 |
| CV | 23.89 | 32.92 | 31.88 | 32.94 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second, third and fourth cycles, treatments that received the organic compost, regardless of dose, accumulated more Mg than plants that did not receive this type of fertilization (Table 11).

In the first cultivation cycle, lettuce fertilized with 200% organic N obtained greater S accumulation than plants fertilized with less amount of organic compost and plants that did not use this type of fertilization. Lettuces fertilized with organic compost accumulated more S than plants that did not receive organic fertilizers. Lettuce fertilized with urea accumulated more S than plants that did not receive nitrogen fertilization (Table 12). Greater S absorption with the application of N can be explained in part by the synergistic effect reported by (Plessis and Agenbag, 1994); (Sharma et al., 1994).

**Table 12.** Lettuce S exportation in the four cultivation cycles according to the different treatments.

| Treatments | 1st cycle | 2nd cycle | 3rd cycle | 4th cycle |
|---|---|---|---|---|
| | | g plant$^{-1}$ | | |
| T0 | 0.026 d | 0.011 c | 0.016 b | 0.009 c |
| T1 | 0.122 c | 0.038 c | 0.021 b | 0.009 c |
| T2 | 0.236 b | 0.131 b | 0.267 a | 0.194 b |
| T3 | 0.191 b | 0.146 b | 0.234 a | 0.217 b |
| T4 | 0.228 b | 0.145 b | 0.265 a | 0.267 a |
| T5 | 0.296 a | 0.205 a | 0.218 a | 0.247 a |
| F | 24.16 | 24.22 | 46.48 | 64.28 |
| Mean | 0.183 | 0.113 | 0.170 | 0.157 |
| CV | 23.89 | 29.66 | 22.90 | 20.85 |

Means followed by the same letter do not differ from each other by the Scott Knott test at 5% probability. T0 – 0% N; T1 – 100% N (urea); T2 – 50% N (organic compost) + 50% N (urea); T3 – 100% N (organic compost); T4 – 150% N (organic compost); T5 – 200% N (organic compost).

In the second cycle, lettuces fertilized with the highest organic compost dose accumulated more S than plants fertilized with lower compost dose and those that did not receive organic fertilization. All plants fertilized with organic compost accumulated more S than plants that did not receive this type of fertilization (Table 12).

In the third cycle, plants fertilized with organic compost obtained greater S accumulation than treatments that did not receive organic fertilization (Table 12).

In the fourth cycle, plants fertilized with 150% organic N and 200% organic N were those that accumulated greater amount of S. All plants fertilized with organic compost accumulated more S than plants that did not receive this type of fertilization (Table 12).

Table 12 shows that the amount of S in plants fertilized with organic compost was higher than in plants that did not receive this fertilization in all cultivation cycles. This fact can be explained because both organic compounds used in this experiment present C/S ratio of 15/1 in the first two crops and 27/1 in the last two, favoring the S mineralization process in the soil. C/S ratio below 200/1 favors this process, which consists of the conversion of organic S to mineral S (SO4), which means that the plant will absorb this nutrient (Sakadevan et al., 1993).

Fertilization with organic compost to replace N from urea resulted in higher lettuce productivity in 4 consecutive cycles.

Fertilization with organic compost obtained more nutrients in lettuce (N, P, K, Ca, Mg, S) than fertilization with urea N.


## ACKNOWLEDGMENTS

The authors would like to thank CNPQ for the postdoctoral scholarship granted to carry out this experiment.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