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PROMOTING GROWTH OF LETTUCE SEEDLINGS USING DIFFERENT DOSES OF FOLIAR MINERAL FERTILIZER

PROMOÇÃO DE CRESCIMENTO EM MUDAS DE ALFACE UTILIZANDO DIFERENTES DOSES DE FERTILIZANTE MINERAL FOLIAR

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Abstract: Lettuce (*Lactuca sativa* L.) is one of the most consumed leafy vegetables worldwide, known for its low production cost, high nutritional value, and broad market acceptance. In order to maximize its yield, the crop demands efficient management practices, such as fertilization. The objective was to evaluate the influence of different concentrations of the mixed mineral fertilizer Conductor (Biocross®), rich in organic carbon and essential nutrients, on the growth and quality of leaf lettuce seedlings. The experiment was conducted in a greenhouse using a completely randomized design with six treatments (0; 50; 100; 150; 200 and 300 mL/100L of water) and four replications. Variables such as plant height, stem diameter, number of leaves, and fresh weight were assessed through variance and regression analyses. Results showed that increasing fertilizer doses led to a linear increase in stem diameter, while fresh weight and number of leaves exhibited quadratic behavior. It is concluded that the use of Conductor at intermediate doses of approximately 200 mL increased the production efficiency and quality of leaf lettuce seedlings.

Keywords: *Lactuca sativa* L.; Leafy vegetable; Mineral fertilization; Plant nutrition.

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Resumo: A alface (*Lactuca sativa* L.) é uma das hortaliças mais consumidas no mundo, destacando-se pelo seu baixo custo de produção, alto valor nutricional e ampla aceitação comercial. Para maximizar sua produtividade, a cultura exige práticas eficientes de manejo, como a adubação. Objetivou-se avaliar a influência de diferentes concentrações do fertilizante mineral misto Conductor (Biocross®), rico em carbono orgânico e nutrientes essenciais, no crescimento e na qualidade de mudas de alface-crespa. O experimento foi conduzido em casa de vegetação, em delineamento inteiramente casualizado, com seis tratamentos (0; 50; 100; 150; 200 e 300 mL/100L de água) e quatro repetições. Foram avaliadas variáveis como altura da planta, diâmetro do caule, número de folhas e massa fresca, utilizando análises estatísticas de variância e regressão. Conclui-se que o uso do Conductor em doses intermediárias de 200mL aumentou a eficiência produtiva e a qualidade das mudas de alface-crespa.

Palavras-chave: *Lactuca sativa* L.; Hortaliça; Adubação mineral; Nutrição de plantas.



1 INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the leafy vegetables of greatest commercial importance and consumption worldwide. In Brazil, it is among the main vegetables in terms of production, marketing and nutritional value (SILVA; CRIVELARI and CORREA, 2021). From the nutritional perspective, its leaves contain high levels of vitamin A, besides being significant sources of calcium (Ca) and iron (Fe) (SCHERER et al., 2016). This crop is characterized by the low caloric value and reduced cost of production; as a consequence of these factors, it is the most consumed vegetable in the Brazilian diet, which ensures great economic and social importance (OLIVEIRA et al., 2018).

The increase in production and consumption of this vegetable has been boosted by technological advance, which allowed continuous cultivation throughout the years. Among the innovations are the use of protected environments for cultivation and improvements in management practices, such as more efficient techniques for fertilization and irrigation (RESENDE et al., 2016).

In Brazil, this vegetable is among the most consumed, especially the leaf lettuce variety, which represents more than 50% of consumption, followed by iceberg lettuce (MONTEIRO, 2024). According to Anuário Brasileiro de Hortifruti (2024), lettuce production in the country covers a wide area of cultivation, estimated at approximately 86,900 hectares. The state of São Paulo leads the national production of this crop. A 7.5% expansion in cultivated area was projected for the 2023/24 summer crop season, compared to the previous season (2022/23) (ANUÁRIO BRASILEIRO DE HORTIFRUTI, 2024).

Consequently, lettuce crop is highly demanding in terms of nutrients due to its short growth cycle, so it is fundamental to ensure adequate availability of nutrients to promote healthy and productive development (MONCHELATO and FERNANDES, 2022). The nutrients most required for its development are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S); therefore, in order to ensure the availability of these nutrients, it is important to perform regular fertilizations (YURI et al., 2016).

Considering the importance of fertilization, lettuce is a plant with great dependence, and adequate application of fertilizers, based on nutrient concentrations in



the soil, is crucial to both the economic sustainability of the crop and the reduction of adverse environmental impacts associated with this process (CECÍLIO FILHO et al., 2018).

One of the main conditions that influence the quality of production for lettuce is its nutritional requirements, as the crop requires a large amount of nutrients due to its short cultivation cycle. Nutritional deficiency can be visually identified through symptoms such as changes in color, reduction in growth, burns and deformations in parts of the plants (DIAS et al., 2019).

As the leaves of lettuce constitute its marketable part, using high-performance fertilizers and inputs is essential for success in agricultural production (BORBA and FREITAS, 2023). In this context, the present study aimed to evaluate the development of leaf lettuce subjected to the use of the mineral fertilizer Conductor (Biocross®), so as to understand its effects on the yield and quality of plants.

2 MATERIAL NA METHODS

Experimental site

The experiment was carried out at the State University of Goiás - UEG, University Unit of Ipameri, GO, Brazil (17°43'04"S; 48°08'43"W; Alt. 789 m), in a greenhouse, covered with transparent plastic film and shade nets on its sides. According to Köppen's classification, the climate of the region is AW - Tropical with dry season in winter and humid summer, with average temperatures of 18 °C (winter), 30 °C (summer) and annual average of 20 °C (ALVARES et al., 2013).

Experimental design

The research consisted of the application of the commercial product Conductor (Biocross®) in the leaf lettuce crop. Conductor is a mixed mineral fertilizer, which has organic carbon in its formulation, allowing a better absorption of other nutrients by plants. Its formulation includes nutrients such as Calcium (Ca), Magnesium (Mg), Sulfur (S) and Boron (B) (BIOCROSS, 2023).

The experimental design was completely randomized (CRD), with six treatments and four replicates per dose of the product applied for 100 liters of water (Table 1).



Tabela 1 – Treatments with Different Concentrations of Conductor for Foliar Application in Lettuce

Treatment	Description	Concentration (mL/100L)
T1	Without product application (Control)	0
T2	Foliar application of 50 mL/100L of Conductor	50
T3	Foliar application of 100 mL/100L of Conductor	100
T4	Foliar application of 150 mL/100L of Conductor	150
T5	Foliar application of 200 mL/100L of Conductor	200
T6	Foliar application of 300 mL/100L of Conductor	300

Source: Prepared by the authors.

The sampling units consisted of 8 L pots filled with Latossolo Vermelho (Oxisol), rock powder and cattle manure (2:1:1). Regarding the soil used, chemical analysis was carried out to evaluate its fertility and capacity to provide nutrients for the crop (Table 2). Four seedlings of leaf lettuce were planted in each pot and, after seven days, thinning was carried out, leaving only one plant per pot.

Tabela 2 – Chemical analysis of the Latossolo Vermelho (Oxisol) used in leaf lettuce cultivation.

pH	Ca	Mg	Al	H+Al	K	K		P(Meh)
CaCl ₂	-----cmolc/dm ³ -----				-----mg/dm ³ -----			
5.0	2.3	1.0	0.0	2.0	0.46	178.3		23.4
Na	Zn	B	Cu	Fe	Mn	CEC	V%	OM
-----mg/dm ³ -----								g/dm ³
	1.5					5.76	65.28	21.0

Source: Prepared by the authors.



The product Conductor was foliar applied at three moments along the crop cycle. The first application was performed 15 days after thinning the seedlings, and the other two applications, every ten days, using a manual sprayer with capacity of 550 mL.

Variables analyzed

In the period after 48 days from transplanting, the following variables were analyzed: plant height (PH) – measured from the soil to the apex of the plant, in centimeters (cm), with a graduated ruler; stem diameter (SD) – measured with a digital caliper, in millimeters (mm); number of leaves (NL) – obtained by counting the leaves in each plant; plant fresh weight (PLFW – obtained by weighing the entire plant (stem and leaves) on a precision scale, expressed in grams (g) per plant.

Statistical procedures

Field-collected data were tabulated and analyzed using statistical tests, including those to assess normality of residuals (Shapiro-Wilk) and homogeneity of variances (Bartlett). Then, analysis of variance (ANOVA) and regression analysis were performed using R-Studio software.

3 RESULTS AND DISCUSSION

Analysis of variance (ANOVA) revealed significant differences for all variables evaluated, except plant height, considering a probability level of 5% (Table 3). The coefficient of variation (CV), which ranged between 9.81% and 10.87% for the characteristics evaluated, is a measure widely used to estimate the experimental error and assess the precision of experiments (FONSECA and MARTINS, 2012). In agricultural experiments conducted in the field, according to Fonseca and Martins (2012), CV values below 10% are classified as low, indicating high degree of experimental precision.

Tabela 3 – Analysis of variance (ANOVA) for plant height (PH), stem diameter (SD), plant fresh weight (PLFW) and number of leaves (NL) of lettuce (*Lactuca sativa* L.) as a function of different doses of foliar fertilizer.

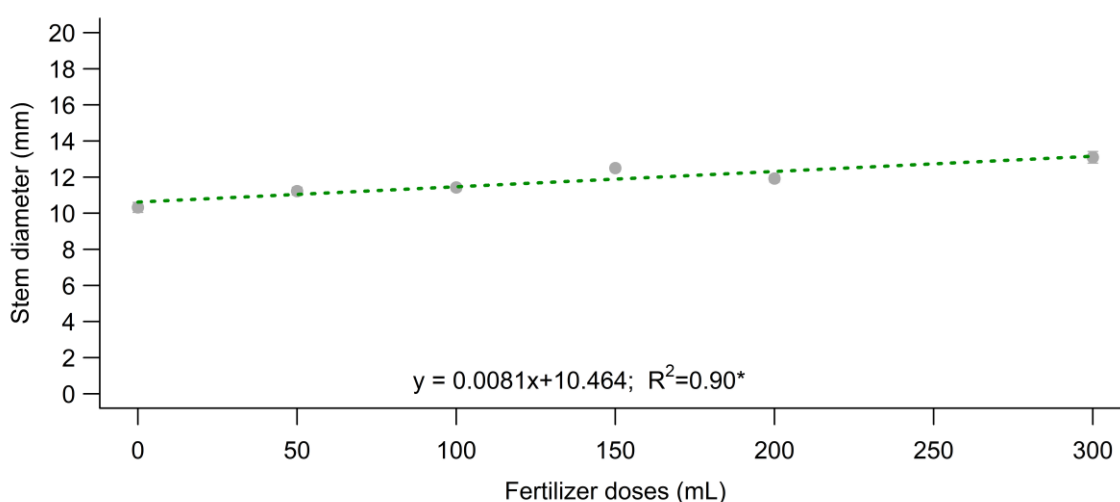


SV	PH (cm)	SD (cm)	PLFW (g)	NL
Doses	0.28**	0.0014*	3.975e- 16*	0.000001*
CV%	9.81	6.63	5.89	10.87
Overall mean	19	127	15.5	19.3

* significant by the F test at 5% probability level, ** not significant. **Source:** Prepared by the authors.

Increasing the concentration of mineral fertilizer had a positive linear effect on the stem diameter of lettuce plants, compared to the control group (Figure 1). The statistical analysis showed that the increment in the dose of the product is directly associated with a progressive increase in stem diameter, a result that is significantly described by a linear regression model ($p < 0.05$). The highest concentration of the product applied, corresponding to a dose of 300 mL, resulted in a significant increase, reaching approximately 13 mm for stem diameter.

Figure 1 – Stem diameter (mm) of lettuce (*Lactuca sativa* L.) plants as a function of different doses of the foliar fertilizer Conductor.

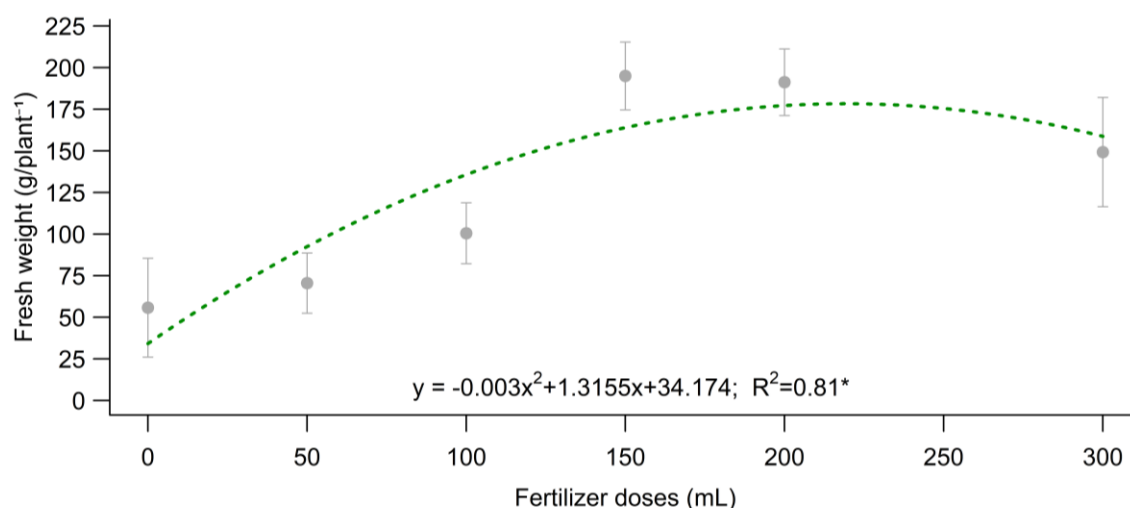


Source: Prepared by the authors.

Valeriano et al. (2016) highlight that the use of mineral fertilizers in agriculture has shown significant positive effects on plant structural growth, including the increase in stem diameter. Thus, according to the authors cited above, the application of mineral fertilizers increases the efficiency of water and nutrient transport, favoring uniform stem growth and strengthening the plant against environmental stresses.

For plant fresh weight, the point of maximum efficiency was reached at the estimated dose of 219.25 mL, resulting in an average yield of 178.38 g/plant (Figure 2). This performance represents a significant increase of 216.9% compared to plants grown without fertilizer application (dose 0).

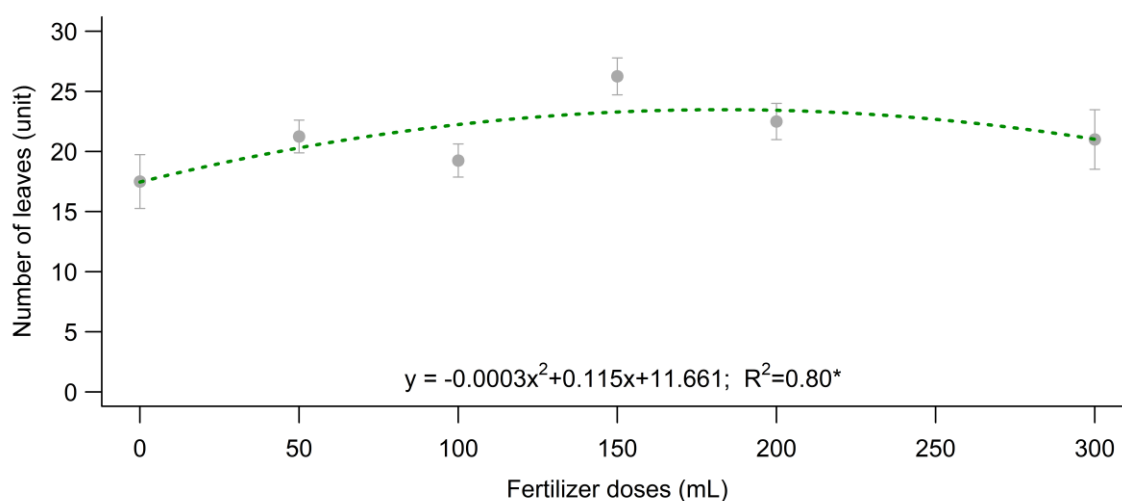
Figure 2 – Fresh weight (g/plant) of lettuce (*Lactuca sativa* L.) plants as a function of different doses of the foliar fertilizer Conductor.



Source: Prepared by the authors.

Regarding the number of leaves, the point of maximum efficiency was identified at the estimated dose of 191.66 mL, with an approximate average of 22 leaves per plant (Figure 3). This result reflects a significant increase of 62.96% compared to plants grown without application of the product. These data reinforce the effectiveness of proper nutritional management in optimizing crop yield.

Figure 3 – Number of leaves of lettuce (*Lactuca sativa* L.) plants as a function of different doses of the foliar fertilizer Conductor.



Source: Prepared by the authors.

According to Limberger and Gheller (2012), application of foliar fertilizer containing macro and micronutrients generated satisfactory results for the number of leaves in the lettuce crop. According to the authors, in the lettuce production system, the greater number of leaves promotes greater photosynthesis, consequently increasing the size and volume of the plant.

For lettuce cultivation, plants with higher number of leaves show greater biomass accumulation, being larger and more desirable in the market (MENDES et al., 2020). For marketing standards, the number of leaves is an important factor, as it determines whether or not a plant is viable for fresh consumption, as the leaves are the organs that will be marketed (BRZEZINSKI et al., 2017). These relationships were observed in the present study, since the treatments that promoted a higher number of leaves also resulted in the greatest increments in fresh weight production. This pattern suggests that treatments that boost leaf growth are directly associated with an increase in total plant biomass.

The individual weight of each plant, despite not directly determining consumer preference, has a direct impact on crop yield, especially in processed vegetables, for which a higher weight results in higher income for the producer (LIMBERGER and GHELLER, 2012). The mineral nutrients that make up the formulation of the Conductor product may have directly influenced the structural and yield characteristics of lettuce. This product has in its formulation nutrients such as Calcium (Ca), Magnesium (Mg),



Sulfur (S) and Boron (B) (BIOCROSS, 2023), essential nutrients that favor better plant development.

According to Prado (2020), calcium is essential for plant structure, integrating the cell wall and increasing tissue resistance, in addition to neutralizing organic acids in the cytosol. Boron contributes to cell wall formation, helping in the deposition of pectates and in the transport of sugars, in addition to activating enzymes important for plant metabolism (PRADO, 2020).

Magnesium plays a key role in the intracellular functions of plants, acting as an enzyme cofactor and regulator of metabolic activities (NEZARAT et al., 2018). In addition, it is indispensable for the formation of chlorophyll, a pigment essential for photosynthesis and responsible for the characteristic green color of plants (OLIVEIRA et al., 2024).

As for the macronutrient sulfur, it is indispensable for plants, mainly due to its essential presence in the sulfur amino acids cystine and methionine in plant proteins, besides being important in nitrogen metabolism in plants (MARSCHNER, 2012; OLIVEIRA et al., 2020).

It is important to highlight that fertilization efficiency can be influenced by the law of decreasing increments, according to which the responses to lower doses tend to be more expressive than the gains obtained at high doses, a phenomenon that occurs due to the saturation of the enzymatic systems and the possible limitation caused by the deficiency of other nutrients (MARTUSCELLO et al., 2018). This fact may explain the variations observed in the variables plant fresh weight and number of leaves, for which the increase in the concentration of mineral fertilizer initially promoted positive effects on the crop, but resulted in a negative effect at the highest dose.

Another factor that may have contributed to the decrease in growth at a critical point is toxicity in plant tissues. As discussed by Taiz et al. (2017), as the concentration of nutrients in tissues exceeds the appropriate range, plant growth or yield declines due to toxicity, a region of the response curve called the toxic zone. This condition suggests that there is an upper limit of nutrient uptake beyond which plants are unable to efficiently metabolize the additional elements, resulting in adverse effects.



4 CONCLUSIONS

The use of Conductor at intermediate doses of 200 mL increased the yield efficiency and quality of leaf lettuce seedlings.

On the other hand, doses higher than 200 mL had negative effects on the number of leaves and fresh weight.

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