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Effects of Lanthanum on Citrus Plant

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***Abstract*- This work focuses on the study of the effect of lanthanum application on Rangpur lime (Citrus limonia Osbeck). The experiment was carried out in a greenhouse. Four different doses of lanthanum chloride heptahydrate (50 mg, 100 mg, 200 mg, 400 mg) per citrus plants were applied ninety-eight days after the sowing. The plants were collected three weeks following the application of the lanthanum chloride the plants. The optimal dose was 50 mg. The results showed that the citrus plant physiology changed with the application of lanthanum, i.e., depending on the dose, there is a beneficial or a harmful effect on the growth.**

***Index Terms*— citrus, lanthanum, rare earth elements, toxicology.**

I. INTRODUCTION

Rare earth elements (REE) are a cohesive group [1] of 17 chemical elements. It includes the lanthanide series, scandium (Sc) and yttrium (Y). They are usually classified into two categories: light rare earth elements (LREE, from lanthanum to europium) and heavy rare earth elements (HREE, from terbium to lutetium, including yttrium) [2]. The definition of LREE and HREE is based on the electron configuration of each rare earth element. However, scandium properties are not similar enough to classify it as either a LREE or HREE [3].

REE can not be considered rare [4]. For example, cerium (Ce) concentration in nature is similar to the concentration of copper (Cu) and zinc (Zn) [5]. The concentration of REE in soils depends on the composition of source rocks, the weathering conditions, among other factors, but in general the LREE predominate over the HREE ones [5].

REE are present in all plants, but they are not considered essential or toxic [6]. They can be uptake through leaves [7]. China was in fact the first country in the world to use commercial REE-fertilizers applied to crops in the form of foliar sprays, seed treatments or as additions to solid or liquid root fertilizer formulations [8]. More than 100 crops responded to the application of REE with yield increases ranging from 5% to 10%. Use of adequate REE can promote the germination of seeds and roots development, increase plant biomass, and improve the quality of fruiting bodies [9]. Studies have reported effects of REE to plants, both beneficial [5, 8] and undesirable [10, 11, 12], and a possible relationship of REE with the physiology of plants [13, 14].

Normal concentration of lanthanum (La) in leaves is in the range 0.15 – 0.25 mg kg^{-1} [15]. However, some experiments [16] found La concentrations in citrus leaves similar to those found in the soil with soil-to-plant transfer factors of 0.65 to 1.05.

There are some works with La application in different cultures – tobacco [17]; corn and mungbean [18]; wheat [19]; corn, green gram and black gram seeds [20]. These effects of La application on plants depending on the dose, the type of plant and other conditions.

Agricultural supplies can have REE in your composition, mainly in fertilizers rich in P_2O_5 [21, 22] and citrus plants can accumulate these elements [16]. The Brazilian citriculture demands significant amounts of agricultural supplies to maintain satisfactory production.

REE are present in different parts of citrus plants. These elements were also determined in sweet orange fruit (seed, pulp, juice and peel) in Brazil [16]. However, there is no information about uptake by citrus plants and the possible effects of these elements in this culture. This work focuses on study of the lanthanum effect in the citrus plant. The lanthanum chloride heptahydrate ($LaCl_3.7h_2O$) was used as the REE source to experiment due to the high solubility in water and high lanthanum concentration (minimum 99.9%).

II. MATERIAL AND METHODS

Two seeds of Rangpur lime (Citrus limonia Osbeck) were sowing in each of 456 polypropylene tubes (50 cm^{-3}). The substrates used in the sowing were Plantimax (composted pine bark, expanded vermiculite, expanded perlite, peat, concealer and chemical fertilizer) and Vida Verde (composted pine bark, charcoal, phenolic foam and concealer). It was added Osmocote fertilizer (NPK 19 10 6) in the final substrate (2 g of Osmocote per kg of total substrate). The mixture was homogenized before sowing.

It was selected one plant per tube, thirty days after sowing. Ninety-eight days after sowing were applied different treatments in Rangur lime plants. Three weeks after treatments application, the plants were collected. Then citrus

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plants were washed and it determined the mass and the fresh height.

The experimental design was Randomized block with 4 treatments (four doses of lanthanum chloride heptahydrate - T50 = 50 mg, T100 = 100 mg, T200 = 200 mg, T400= 400 mg), 1 control (without lanthanum chloride heptahydrate) and 8 repetitions (Figure 1). All treatments were diluted in 100 mL of water – the same used in irrigation. It were used two borders on the entire contour of the treatments.

Border	Border	Border	Border	Border	Border	Border	Border	Border
Border	Border	Border	Border	Border	Border	Border	Border	Border
Border	Border	T 50 C	TEST H	T 200 C	T 400 E	T 100 A	Border	Border
Border	Border	TEST A	T 100 G	T 50 H	T 200 E	T 400 B	Border	Border
Border	Border	T 400 A	T 200 A	T 100 H	T 50 A	TEST B	Border	Border
Border	Border	T 200 H	T 100 B	T 50 D	TEST G	T 400 C	Border	Border
Border	Border	T 100 D	T 50 E	TEST C	T 200 G	T 400 D	Border	Border
Border	Border	TEST D	T 400 H	T 50 B	T 100 C	T 200 D	Border	Border
Border	Border	T 100 E	T 200 B	T 400 G	T 50 G	TEST E	Border	Border
Border	Border	T 400 F	T 100 F	T 200 F	TEST F	T 50 F	Border	Border
Border	Border	Border	Border	Border	Border	Border	Border	Border
Border	Border	Border	Border	Border	Border	Border	Border	Border

Figure 1. Diagram of randomized block design

III. RESULTS

Table 1 shows the wet weight of Rangpur lime (Citrus limonia Osbeck) in the end of experiment.

Table 1. Average concentration (mg kg^{-1}) and standard deviations (n = 8; g) of Rangpur lime plants mass of different treatments and control

Control	T 50	T 100	T 200	T 400
3.06 b	3.21 a	2.71 c	2.67 c	2.56 d
0.50	*0.44*	*0.47*	*0.27*	*0.51*

Means with same letters in the column do not differ (p<0.05) by Tukey test

There was significant difference among the mass of plants. The highest mass was found to T 50 treatment that showed concentration significantly higher than the other treatments (Table1). There was mass decreasing from T 100 treatment when compared to control.

According to Figure 2, there is the tendency (regression) simple linear with R2 = 0.6587.

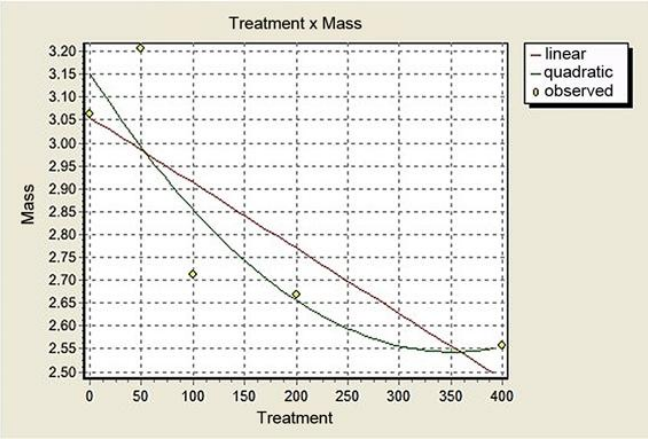

Figure 2. Polynomial regression of treatments with lanthanum chloride in relation to mass of plants

The Table 2 shows the average height of Rangpur lime plants of different treatments and control in the start and the end of experiment. There was significant difference ($p < 0.05$) between T50 and T 400 treatments by Tukey test.

Table 2. Average height (cm) and standard deviations (n = 8) of Rangpur lime plants of different treatments and control in the start and the end of experiment

Steps	Control	T 50	T 100	T 200	T 400	Average
Start	8.5b *0.78*	8.7b *1.01*	8.5b *0.85*	9.0b *0.44*	9.06b *0.77*	8.7b
End	11.3a *1.16*	12.5a *1.71*	11.2a *1.20*	11.4a *0.67*	10.4a *0.93*	11.3a

Means with same letters in the column do not differ (p<0.05) by Tukey test

According to [17] concluded that the application of lanthanum chloride stimulated the growth of seedlings of tobacco and accelerated the photosynthetic rate, considering that the optimal concentration for the plant was 20 mg L^{-1} of $LaCl_3$. A study was carried out with corn (Zea mays 'Hycorn 82') and mungbean (Vigna radiata 'Berken') grown in continuous flowing nutrient solutions containing La or Ce [18]. These elements did not increase the growth of corn or mungbean. La and Ce had similar effects on plant growth.

Corn (*Zea mays*), green gram (*Vigna radiata*) and black gram (*Vigna mungo*) seeds were grown in Hoagland half strength solution containing 5, 10, 15 up to 50 µM La in order to assess the effect of La on growth and physiological activities of these plants [20]. La did enhance the growth of V. radiata, V. mungo as well as Z. mays. It was which showed best results among the three plants.

In this study, the results of Tukey test and polynomial regression of treatments with lanthanum chloride showed that T 50 treatment increased the mass and the height of the plants. As for T 100 treatment, there was a saturation tendency with decreasing of the mass and the height of the plants. As showed by [23], if the concentration of REE exceeds the optimum level, they can inhibit the plant growth.

IV. Conclusion

The dose of 50 mg of lanthanum chloride resulted in an increase in the mass and the height of citrus plant with a consequent increase of dry matter. The Rangpur lime (Citrus limonia Osbeck) physiology has changed with the application of lanthanum, i.e., depending on the dose; there is a beneficial or a harmful effect on the growth, suggesting its potential use as fertilizer in citriculture.

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