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Effectiveness of lanthanum chloride (LaCl3) on controlling the rose aphid, *Macrosiphum rosae* L. through effect on the insect physiology

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Abstract
This study was carried out to study effectiveness of the rare earth element, Lanthanum (La) in the form of Lanthanum Chloride (LaCl3) at two concentrations (1ppm, 5ppm) on controlling The Rose Aphid, *Macrosiphum rosae* L. (Homoptera: Aphididae) which infesting rose plants (*Rosa gallica*) through effect on the insect physiology**.** Experiments were carried out under plastic greenhouses during season 2020/2021 at two locations (Governorates), Al-Zohrya Garden (Cairo Governorate) and Antoniadis Garden (Alexandria Governorate). The results obtained indicated to the clear effect of treated rose plants by Lanthanum Chloride (LaCl3) on the population fluctuation of *M. rosae* through effect of the insect physiology and also through improving the plant healthy. Whereas the mean number of *M. rosae* infested rose plants (treated with low concentration of LaCl3) was smaller than the mean number of that insect infested rose plants (treated with high concentration of LaCl3) compared to control (rose plants did not treat with LaCl3). Also study included effectiveness of LaCl3 on the insect physiology (the main target of this study) which seems clear through the effect on the important substances produced by the insect such as total proteins, carbohydrates, total lipids and important enzymes (Chitinase, Lipase, Phosphatase, Kinase, Alpha esterase, Beta esterase, Oxidation enzymes and Digestive enzymes).Whereas the results obtained show those substances decrease in the successive insect *M. rosae* when fed on rose plants treated with low concentration of LaCl3 (1ppm) compared to control (insects which fed on rose plants did not treat with LaCl3), and vice versa whereas these substances increase in the successive insect *M. rosae* when fed on rose plants treated with high concentration of LaCl3 (5ppm) compared to control. This study also included effect of treated rose plants with LaCl3 on the internal components of these plants such as total proteins, carbohydrates, total lipids, amino acids, total phenols, tannins and flavonoids, whereas when treated rose plants with low concentration of LaCl3 led to improving the plant healthy through increasing these components compared to control (rose plants did not treat with LaCl3) and vice versa when treated rose plants with high concentration of LaCl3 led to decrease these internal components compared to control.

Keywords: lanthanum chloride (LaCl3), Macrosiphum rosae L., insect physiology, rosa gallica, greenhouses, internal components

Introduction
Rose (Rosa gallica) considers one of the most important flowers and ornamental plants in Egypt and all over the world. Rose is the favorite flower for human all over the world and man love for roses is constantly increasing, this is due to their beautiful colors, diversity of flower shapes, and their tolerance of different weather manifestations. Rose flowers are widely used for decorating purposes and making interior and exterior decorations. Rose plants are cultivated in a widely range in both the open fields and under greenhouses, Jaskiewicz (2005) [12].

The Rose Aphid Macrosiphum rosae L. (Homoptera: Aphididae) is a serious pest infesting rose plants in both open fields and under greenhouses. It infested rose plants in all stages of the plant and infested most parts of it such as: stems, leaves, buds and flowers (Emam 2009) [7]. And Atwal and Dhingra (2008) [2] indicated to that M. rosae is a serious pest infesting rose plants and other ornamental plants and strong infestation by it due to high deformation of stems, leaves, flowers and annual production of rose flowers. Also, Labanowski (2015) [15] in Poland referred to that M. rosae is a serious pest infesting rose plants (leaves and flowers), it feeds mainly on the recent leaves, flower-buds and flowers whereas the highly infestation with this aphid led to badly effects on flowering capacity of rose plants (annual production of rose flowers) about 20-40% losses.

Lanthanum (La) one of The important Rare Earth Elements (REEs) which include also another important elements such as scandium (Sc), yttrium (Y) and lutetium (Lu), Stramare *et al*. (2004) [21] who referred also to crop responses to application of some rare earth elements (REEs) that have only been documented recently in a few countries. Lanthanum Chloride is the inorganic compound with the formula LaCl3, it is a common salt of lanthanum which is mainly used in research. It is appears as white crystalline solid or white powder that is highly soluble in water and alcohols, Tandra *et al*. (2018) [22]. Also, Wenwen *et al*. (2019) [24] studied importance of Lanthanum chloride LaCl3 in improving the morphological and physiological characteristics of maize yield.

This study was carried out to study effectiveness of Lanthanum Chloride LaCl3 on controlling The Rose Aphid, M. rosae through effect on the insect physiology. In recent years there are many factors became very important in controlling different pests, among these factors none are more important than the physiological processes which occur in the species whose control is desired, Hoskins (2020) [11] who add also that insect physiology has an economic importance in the controlling operations of different pests.

Materials and Methods

Experiments were carried out to study effectiveness of Lanthanum Chloride (LaCl3) on controlling The Rose Aphid, Macrosiphum rosae through effect on the insect physiology. The present investigation includes effect of treated rose plants with two concentrations of Lanthanum Chloride LaCl3 (1, 5 ppm) before cultivation and during plantation on the infestation by M. rosae during season 2020/2021 at two locations (governorates), Al-Zohrya Garden (Cairo Governorate) and Antoniadis Garden (Alexandria Governorate) under plastic greenhouses.

Experimental Design

This study was conducted on rose plants, Rosa gallica (Carmen variety). Rose seedlings were prepared for cultivation during November month 2020 (the timely manner for rose seedlings cultivation) at both of the two successive locations. The plastic greenhouse in each garden with an area of 15x21 m. Each one was divided into three parts, first part left as control (rose plants did not treat with LaCl3), the second part contains rose plants which treated by low concentration of LaCl3 (1ppm) and the third part contains rose plants which treated by high concentration of LaCl3 (5ppm). Each part contains 3 plots (replects) with an area (5x7 m) for each one; these parts are isolated from each other by plastic wire with narrow openings (0.5mm). Rose seedlings with number135 in each location divided into three parts each part contains 45 seedlings. First part for control, second part for rose plants which treated with low concentration of LaCl3 and third part for rose plants which treated with high concentration of LaCl3. Rose seedlings in control (first part) cultivated directly without treated with LaCl3. Rose seedlings in second part immersion in LaCl3 solution (low concentration) for eight hours before cultivated, and rose seedlings in third part immersion in LaCl3 solution (high concentration) for eight hours before cultivated. Each part contains three plots (replects) with area 5x7m for each plot and each plot contains 15 rose seedlings. Successive area at both of the two locations was isolated from other plants in the garden and all normal and recommended agricultural operations were applied in both of the two locations, also no chemical pesticides were used in that area. After month from cultivated and when the first leaves of the rose plants were began to appear sprayed LaCl3 solution at low and high concentrations and repeat the spray again after 21 days. An artificial infestation with M. rosae was done at the same time in both of the two locations and in beginning of January 2021 directly counting of aphid numbers (adults and nymphs) was done biweekly on leaves and flowers during the period of plant life at both of the two successive locations.

Physiological Analysis of the Important Substances Produced by the Successive Insect the Rose Aphid M. rosae

Experiments (the main target of this study) were carried out to study physiological analysis of the important substances produced by the successive insect The Rose Aphid M. rosae such as (total proteins, carbohydrates, total lipids and important enzymes such as; Chitinase enzyme, Lipase enzyme, Phosphatase enzyme, Kinase enzyme, Alpha esterase enzyme and Beta esterase enzyme, Oxidation enzymes and Digestive enzymes).These analyses carried out on aphids which fed on rose plants both of treated and non-treated with the successive substance Lanthanum Chloride LaCl3. Aphids were collected and examined in the entomology lab, Faculty of Science, Ain Shams University.

Physiological Analysis of the Important Internal Components of Rose Plants

Experiments were carried out to study physiological analysis of the important internal components of rose plants which treated and non-treated with the successive substance Lanthanum Chloride LaCl3. Rose leaves were collected and examined in the plant physiology lab, Faculty of Science, Ain Shams University. Components were examined (total proteins, carbohydrates, amino acides, total phenols, tannins and flavonoids).Components was extracted from 0.5 kg fresh weight of rose leaves. Leaves were ground in liquid nitrogen with a mortar and pestle according to the method of Laemmli (1970) [16] and total soluble protein was extracted and estimated according to Daughaday *et al*. (1952) [4]. Amino acids extraction and estimation were carried out following the methods of Wasfi (1970) [23] and Muting and Kaiser (1963) [18]. The method applied for extraction and estimation of alcohol soluble phenolic compounds was that of Diaz and Martin (1972) [6] and recommended by AOAC (1975) [1]. Total Carbohydrates were extracted and estimated using the method of Homme *et al*. (1992) [10] and Fairbairn (1953) [8]

Statistical Analysis

Effectiveness of Lanthanum Chloride (LaCl3) on controlling The Rose Aphid, M. rosae through effect on the insect physiology parameters and the results of biochemical analysis were subjected to statistical analysis using Least Significant Difference (L.S.D.) as described by (Snedecor and Cochran, 1980) [20] at 5% levels of probability.

Results and Discussion

Population Fluctuation of Macrosiphum Rosae at the two Successive Locations During Season 2020/2021 on Rose Plants (Treated and Non-Treated) with LANTHANUM Chloride (LaCl3)

Experiments were conducted on rose plants (Rosa gallica) which cultivated its seedlings under plastic greenhouses at two locations (governorates), Al-Zohrya Garden (Cairo Governorate) and Antoniadis Garden (Alexandria Governorate) during season 2020/2021. Data tabulated in Table (1) show population fluctuation of M. rosae (adults and nymphs) on rose plants which treated with Lanthanum Chloride (LaCl3) at two concentrations (1ppm, 5ppm) compared to control (rose plants did not treat with the LaCl3). The results obtained tabulated in Table (1) show that in Cairo governorate the mean number of M. rosae infested rose plants in control plants was (12.4/leaf), (14.4/flower) and the mean number of the same insect was (8.7/leaf), (10.4/flower) in rose plants which treated with small concentration of Lanthanum Chloride LaCl3, while that mean number was (15.2/leaf), (17.2/flower) in rose plants which treated with high concentration of Lanthanum Chloride LaCl3. As the same trend were the results obtained in Alexandria governorate whereas the mean number of M. rosae was (14.0/leaf), (16.4/flower) in control plants, while that number was (10.1/leaf), (12.8/flower) in rose plants which treated with small concentration of LaCl3, and was (17.1/leaf), (19.0/flower) in rose plants which treated with high concentration of LaCl3

Table 1: Population fluctuation of M. rosae at both of the two successive locations during season 2020/2021 on the rose plants (treated and non-treated) with Lanthanum Chloride (LaCl3)

Date	Cairo Governorate						Alexandria Governorate					
	1 ppm		5 ppm		Control		1 ppm		5 ppm		Control	
	L	F	L	F	L	F	L	F	L	F	L	F
1/1/2021	3.7	-	7.9	-	5.3	-	4.5	-	10.5	-	7.2	-
15/1/2021	4.8	-	9.8	-	7.5	-	5.9	-	12.7	-	8.9	-
1/2/2021	5.2	2.7	12.4	8.3	9.6	5.5	7.8	4.5	14.8	10.5	10.2	7.3
15/2/2021	7.3	8.5	15.3	13.2	11.5	10.4	8.5	9.7	15.6	15.6	12.5	12.8
1/3/2021	9.8	11.6	17.5	18.4	13.4	15.7	10.6	12.5	18.5	19.5	14.3	17.2
15/3/2021	11.3	14.8	18.9	22.5	15.7	19.3	12.4	15.8	19.3	24.8	16.1	21.7
1/4/2021	13.4	17.4	19.3	26.7	16.8	23.5	14.8	19.5	21.5	28.7	18.5	25.9
15/4/2021	14.7	19.8	21.5	29.5	18.3	25.7	16.2	22.5	23.7	31.2	20.3	28.5
1/5/2021	12.6	17.3	19.2	27.4	17.5	23.5	14.5	21.4	22.4	29.5	19.1	26.6
15/5/2021	11.8	15.2	17.8	25.2	15.3	21.3	12.8	20.7	20.5	27.5	17.4	24.5
1/6/2021	9.3	13.5	15.4	22.1	12.5	18.4	10.9	17.5	17.8	24.2	15.8	20.7
15/6/2021	7.5	10.4	14.5	18.2	11.3	15.5	8.7	13.5	15.7	20.7	13.9	17.3
1/7/2021	5.9	8.3	12.3	15.4	9.7	12.6	7.9	11.8	13.9	18.4	11.7	15.2
15/7/2021	4.7	6.5	10.4	13.3	8.5	10.5	5.4	9.7	12.8	15.6	10.2	12.4
Total	122.0	146.0	212.2	240.2	172.9	201.9	140.9	179.1	239.7	266.2	196.1	230.1
Mean	8.7^{c}	10.4^{c}	15.2^{b}	17.2^{b}	12.4^{a}	14.4^{a}	10.1^{c}	12.8^{c}	17.1^{b}	19.0^{b}	14.0^{a}	16.4^{a}
$F_{0.05}$	Leaves (436.55) - Flowers (175.42)						Leaves (325.83) - Flowers (125.63)					
L.S.D	Leaves (1.093) - Flowers (1.075)						Leaves (1.087) - Flowers (1.066)					

Means within columns bearing different subscripts are significantly different (P> 0.05) L: Leaf F: Flower

Statically analysis showed that were highly significant differences between the mean number of M. rosae on leaves and flowers in the rose plants which treated with Lanthanum Chloride LaCl3 (at both of the two concentrations) compared to control plants in both of the two successive locations (governorates) Cairo and Alexandria. Whereas F0.05 and L.S.D values for leaves and flowers in Cairo Governorate were (436.55, 1.093), (175.42, 1.075) respectively. While in Alexandria Governorate F0.05 and L.S.D values for leaves and flowers were (325.83, 1.087), (125.63, 1.066) respectively.

Effect of Lanthanum Chloride LaCl3 on the insect physiology (M. rosae) and plant physiology (Rose plants) during season 2020/2021

The results obtained tabulated in Table (2) show laboratory analyses (the main target of this study) which conducted on the important substances produced by the successive insect The Rose Aphid (M. rosae) such as: total proteins, carbohydrates, total lipids and important enzymes such as Chitinase enzyme, Lipase enzyme, Phosphatase enzyme, Kinase enzyme, Alpha esterase enzyme and Beta esterase enzyme, also Oxidation enzymes and Digestive enzymes.

Data obtained showed that the successive insect (M. rosae) which fed on rose plants treated with low concentration of LaCl3 led to bad effect on that important substances produced by the insect, on the other hand aphids which fed on rose plants treated with high concentration LaCl3 led to positive effect on those substances produced by the insect compared to control (aphids fed on rose plants did not treat with LaCl3). Statically analysis show that were highly significant differences between that important substances produced by the insect

M. rosae which fed on rose plants treated with LaCl3 at both of the two concentrations compared to control (aphids fed on rose plants did not treat with LaCl3), whereas F0.05 and L.S.D values were (235.75, 1.0279) respectively.

The results obtained tabulated in Table (2) show also laboratory analyses which conducted on the internal components of rose plants (treated and non-treated with LaCl3), whereas rose plants which treated with low concentration of LaCl3 led to improve these internal component of these plants. And vice versa the rose plants which treated with high concentration of LaCl3 led to bad effect on these internal components of these plants compared to control (rose plants did not treat with LaCl3). Statically analysis show that were highly significant differences between internal components of the rose plants which treated with LaCl3 at both of the two concentrations compared to control (rose plants did not treat with LaCl3), whereas F0.05 and L.S.D values were (387.44, 1.0357) respectively.

These obtained results were agreement with those obtained by Kohler and Biesalski (2019) [14] in Thailand who studied protein, amino acids, total lipids and mineral composition of some edible insects from Thailand and found its protein ranged from 27-54 mg/100gm body weight, and total lipids ranged from 10-18 mg/100gm body weight. Chen *et al*. (2010) [3] who referred that insects produced fatty acids and carbohydrate ranged from 2-10 mg/100gm body weight. Also, Heba and Azza (2020) [9] in Egypt studied effect of treated Vigna ungiculata seeds by two different concentrations (1 and 5 ppm) of lanthanum nitrate on the susceptibility of the plants to pathogen infection during germination stage, and found that only the low concentration applied of La-nitrate (1ppm) led to high defensive mechanisms of V. ungiculata

Table 2: Effect of Lanthanum Chloride LaCl3 (1, 5 ppm) on the insect physiology (M. rosae) and plant physiology (Rose plants) during season 2020/2021

Parameters	1 ppm	5 ppm	Control	$F_{0.05}$	LSD
Insect Physiology					
Total proteins (mg/100g)	26.35 ^{c}	31.12 ^{b}	29.35 ^{a}	235.75	1.0279
Carbohydrates (mg/100g)	5.32 ^{c}	10.71 ^{b}	8.44 ^{a}		
Total Lipids (mg/100g)	11.89 ^{c}	17.34 ^{b}	14.23 ^{a}		
Chitinase Enzyme (mg/100g)	15.33 ^{b}	19.87 ^{b}	17.25 ^{a}		
Lipase Enzyme (mg/100g)	28.35 ^{b}	35.22 ^{a}	32.75 ^{b}		
Phosphatase Enzyme (mg/100g)	23.78 ^{c}	29.11 ^{b}	27.54 ^{a}		
Kinase Enzyme (mg/100g)	18.11 ^{b}	23.56 ^{a}	21.75 ^{b}		
Alpha Esterase (mg/100g)	10.98 ^{c}	15.61 ^{b}	13.42 ^{a}		
Beta Esterase (mg/100g)	8.59 ^{c}	13.22 ^{b}	11.83 ^{a}		
Oxidation enzymes (mg/100g)	6.98 ^{b}	10.21 ^{a}	8.75 ^{b}		
Digestive enzymes (mg/100g)	7.50 ^{c}	11.25 ^{b}	9.42 ^{a}		
Plant Physiology					
Total proteins (mg/100g)	19.37 ^{c}	14.71 ^{b}	16.25 ^{a}	387.44	1.0357
Carbohydrates (mg/100g)	27.35 ^{c}	21.45 ^{c}	24.72 ^{a}		
Amino acids (mg/100g)	14.23 ^{b}	9.87 ^{b}	11.78 ^{b}		
Total phenols (mg/100g)	15.11 ^{c}	10.45^{a}	12.75 ^{a}		
Tannins (mg/100g)	10.27 ^{c}	5.98 ^{b}	7.55 ^{a}		
Flavonoids (mg/100g)	10.85 ^{b}	6.71 ^{b}	8.93 ^{b}		

Means within columns bearing different subscripts are significantly different (P> 0.05)

seeds against pathogens and although led to successfully germinated seeds, the reverse was true in case of applying high concentration of La-nitrate (5ppm). Also, Diatloff (2008) [5] studied effect of some Rare Earth Elements (REEs) on physiological and biochemical adjectives and responses of selected crops to REEs, and referred to the high effect of the low concentrations of these compunds.

Also, the results obtained were agreement with those obtained by Tandra *et al*. (2018) [22] who mentioned that Lanthanum belong to group of elements known as "Lanthanons" which also includes cerium, europium, promethium and thulium, and also indicated to the positive effect of lanthanum in the cellular systems in some plants at certain concentrations. Yingli *et al*. (2017) [25] who studied stimulatory effect of lanthanum nitrate on the root tuber yield of Pseudostellaria heterophylla via improved photosynthetic characteristics, and found that used this substance with low concentration (2ppm) led to improve most photosynthetic characteristics of the tested plants, and via verse happen when using high concentration of the same substance whereas using it with (7ppm) led to bad effect on most photosynthetic characteristics of the tested plants. Leslie (2015) [17] studied the effects of ionic lanthanum on some insects and found that element had bad effects on the nervous systems of larval and adult stick insects when treated by certain concentrations.

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