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Effectiveness of treatment strawberry plants by lanthanum chloride LaCl3 and lanthanum nitrate La(NO3)3 on controlling whitefly *Bemisia tabaci* (Gennadius)

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Abstract
Current study aimed to explore and determine untraditional methods for controlling serious pest Whiteflies *Bemisia tabaci* (Gennadius) infesting strawberry plants under plastic greenhouses. These methods contain study comparison between effectiveness of treatment strawberry plants *Fragaria ananassa* (L.) by lanthanum earth element (La) in two forms (substances), Lanthanum Chloride LaCl3 and Lanthanum Nitrate La(NO3)3 -two concentrations for each substance - on controlling *B. tabaci*. Experiments were carried out at two different areas (Governorates), Perkash (Giza Governorate) and Nobariya (Behera Governorate) during season 2021/2022. Results obtained at both of the two successive arias indicated to that substance Lanthanum Chloride LaCl3 was higher effectiveness than Lanthanum Nitrate La(NO3)3 on controlling successive insect, *B. tabaci*. Whereas results obtained indicated to that mean numbers of *B. tabaci* infesting strawberry plants (treatment by LaCl3) was less than mean numbers which infesting strawberry plants - treatment by La(NO3)3 - compared to control plants (strawberry plants did not treat with any substance). Results obtained also indicated to that low concentration of both of the two successive substances led to positive effect on the controlling operation of the successive insect *B. tabaci* while high concentration of the same substances led to negative effect of that controlling operation.

Keywords: *Bemisia tabaci*, controlling, strawberry plants, Lanthanum Chloride LaCl3, Lanthanum Nitrate La(NO3)3, greenhouses

Introduction

Strawberry fruits *Fragaria ananassa* one of the most important and popular fruits all over the world. Strawberry plants are widely cultivated both in open fields and under greenhouses, Philip *et al.* (2005) [13]. Food and Agriculture Organization (F.A.O) 2017 [5] indicated to that Egypt ranks fifth in the world for strawberry production whereas it considers one of the largest producers of strawberry fruits all over the world and strawberry seedlings are grown on a large scale both of fresh seedlings and also freezing seedlings. Mahfouz and Abd-Elgwad (2019) [12] in Egypt referred to Egypt is experiencing a revival of the strawberry cultivation backed by its Mediterranean climate, fertile soils and geographic location which support high production and profitability of such a specialty crop.

Strawberry plants infested by many different insects which cause serious damage to plants. Whiteflies *Bemisia tabaci* (Gennadius) (Aleyrodidae: Hemiptera) is one of the most dangerous insects infesting strawberry plants. Sun *et al.* (2019) [15] indicated that whitefly pests including the sweet potato whitefly, *B. tabaci* and the greenhouse whitefly, *Ttialeurodes vaporariorum* (Westwood) are economically important insects in strawberry fruits and caused serious damages to strawberry crop. Gamila *et al.* (2021) [6] studied effect of the insect infestation by *Myzus persicae* and the greenhouse whitefly, *T. vaporariorum* on the annual production of strawberry fruits and indicated to the high infestation by the greenhouse whitefly, *T. vaporariorum* led to serious damage in the quantity of the annual production of strawberry fruits. Gamila *et al.* (2018) [7] studied seasonal fluctuation of main pests infesting strawberry plants in relation to certain weather factors at Sharkia Governorate, Egypt and indicated to that *B. tabaci* on strawberry plants recorded three peaks during the two seasons of the study and there was relationship between the daily mean temperatures with total number of *B. tabaci*

Lanthanum Earth Element (La) is one of Rare Earth Elements (REEs) which has great importance in many uses, Evgenios *et al.* (2018) [3] who studied the rare earth element (REE) Lanthanum (La) induces hormesis in plants and indicated also to Lanthanum is a rare earth element (REE) which has been extensively studied due to its wide application in numerous fields with a potential accumulation in the environment. Christian *et al.* (2015) [1] studied effects of Lanthanum on citrus plants and indicated to treatment *Citrus limonia* by Lanthanum Chloride LaCl3 (different doses) led to positive effects on these plants, and indicated also that the citrus plant physiology changed with the application of lanthanum depending on the dose there is a beneficial or a harmful effect on the growth. Ippolito *et al.* (2011) [10] studied responses of antioxidant systems to lanthanum nitrate La(NO3)3 treatments in tomato plants during drought stress and indicated to treatment of tomato plants with lanthanum nitrate led to positive effects on the antioxidant cellular defenses and that lanthanum effect is dependent on the way of treatment.

Current study was carried out to show effectiveness of treatment strawberry plants by Lanthanum Chloride (LaCl3) and Lanthanum Nitrate La(NO3)3 on controlling white fly, *B. tabaci*.

Materials and Methods

Experimental design

Current study was carried out under plastic greenhouses at two different areas (Governorates), Perkash (Giza Governorate) and Nobariya (Behera Governorate) during season 2021/ 2022. Experiments were conducted on strawberry plants *Fragaria ananassa* (var. Selva) which were cultivated in beginning of September month season 2021. Plastic greenhouse in each area was divided into three separate sections. In the first one strawberry seedlings left free of any treatment before planted, while the second section planted with strawberry plants which treated with Lanthanum Chloride LaCl3 (low and high concentration) whereas the third section planted with strawberry plants which treated with Lanthanum Nitrate La(NO3)3 (low and high concentration). Each section contains 50 (fifty) strawberry seedlings at the same age and variety. Strawberry seedlings at the second section were immersion in Lanthanum Chloride solution for 8 hours before planting (low and high concentration). While at the third section strawberry seedlings were immersion in Lanthanum Nitrate solution for 8 hours before planting (low and high concentration. All recommended agricultural operations were applied both in the two successive areas and no chemical control were applied during experiment. An artificial infestation with whitefly, *B. tabaci* was done at the same time in both of the two successive areas. Directly and laboratory counting of successive insect (adults and nymphs) was done weekly during the successive season 2021/2022

Statistical analysis

In current study effectiveness of treatment strawberry plants by Lanthanum Chloride LaCl3 and Lanthanum Nitrate La(NO3)3 on the infestation level by whitefly *B. tabaci* and mean numbers of *B. tabaci* were subjected to analysis of variance (ANOVA) and also compared by L.S.D. using SAS program (SAS Institute 1988) [14].

Results and Discussion

Current study was carried out to show effectiveness of treatment strawberry plants by both of Lanthanum Chloride LaCl3 and Lanthanum Nitrate La(NO3)3 on the infestation level by whitefly *Bemisia tabaci*.

Results obtained tabulated at Table (1) show population fluctuation (weekly mean number) of whitefly *B. tabaci* (adults and nymphs) on strawberry plants which treatment with the two successive substances LaCl3 and La(NO3)3 at both of Giza and Behera Governorates during season 2021/2022.

Table 1: Population fluctuation of whitefly *B. tabaci* on strawberry plants at both of Giza and Behera Governorates during season 2021/2022

Date	Giza Governorate					Behera Governorate				
	Cont.	LaCl3		La(NO3)3		Cont.	LaCl3		La(NO3)3	
		1 ppm	5 ppm	1 ppm	5 ppm		1 ppm	5 ppm	1 ppm	5 ppm
1/10/2021	7.5	3.5	9.9	5.8	10.5	9.5	5.5	12.3	5.7	12.5
8/10/2021	9.3	4.1	11.6	6.9	12.3	11.3	6.8	14.5	6.5	14.9
15/10/2021	11.4	5.3	13.8	7.5	14.5	13.4	7.9	16.4	8.1	16.7
22/10/2021	13.5	6.7	15.4	8.7	15.0	15.7	8.8	18.8	9.7	18.3
29/10/2021	15.2	8.5	17.5	10.5	17.5	17.3	10.5	20.3	11.3	19.5
5/11/2021	17.0	10.3	18.6	11.8	18.3	19.8	12.3	21.6	13.1	21.4
12/11/2021	19.3	11.4	21.5	12.5	21.0	21.6	13.2	23.5	15.2	22.7
19/11/2021	20.5	13.5	22.2	14.3	22.1	23.8	15.1	25.9	17.5	25.5
26/11/2021	21.8	14.7	23.8	15.5	23.2	25.3	16.3	27.8	18.3	26.9
3/12/2021	19.5	11.5	21.5	12.3	21.0	22.8	13.5	26.5	16.7	25.3
10/12/2021	17.3	10.8	19.7	11.7	19.3	20.7	12.9	24.6	14.2	24.7
17/12/2021	15.5	8.6	17.9	10.5	17.3	18.3	10.8	20.5	12.7	20.3
24/12/2021	13.4	7.5	15.3	9.7	15.0	16.7	9.7	18.9	10.4	17.8
31/12/2021	12.2	6.4	14.6	8.5	14.2	14.9	8.9	16.5	9.5	15.9
7/1/2022	11.0	5.0	12.2	7.3	12.0	12.5	6.5	14.7	7.8	14.2
14/1/2022	9.5	4.3	11.5	6.8	11.2	10.9	4.9	12.6	6.0	12.5
21/1/2022	8.3	3.1	10.9	4.4	10.5	9.8	3.5	10.9	5.1	10.3
28/1/2022	7.5	2.8	9.8	3.7	9.3	8.1	2.9	9.7	4.2	9.5
4/2/2022	9.8	3.9	10.5	4.6	10.0	10.9	4.8	12.4	6.9	12.0
11/2/2022	11.7	5.1	13.7	6.8	13.5	13.5	6.5	14.5	8.3	13.9
18/2/2022	13.2	6.8	14.3	7.3	14.0	15.8	7.9	16.9	10.5	16.5
25/2/2022	14.8	7.9	16.2	8.5	16.1	17.5	9.3	18.7	11.5	18.0
4/3/2022	15.9	8.5	17.5	9.3	17.3	18.7	10.5	20.3	13.7	20.1
11/3/2022	17.3	10.3	19.1	11.7	18.5	20.5	12.4	23.5	15.2	22.9
18/3/2022	18.9	11.7	20.3	12.8	20.0	21.7	13.5	25.2	16.3	24.7
25/3/2022	20.3	12.5	22.7	13.0	21.3	23.9	14.7	26.1	17.8	26.0
1/4/2022	21.5	13.8	23.5	14.1	22.5	25.7	15.0	27.5	18.3	27.3
Total	393.1	218.5	445.5	256.5	437.4	460.6	264.6	521.1	310.5	510.3
Mean	14.5	8.1	16.5	9.5	16.2	17.1	9.8	19.3	11.5	18.9

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

Results obtained show that in Giza Governorate mean number of the successive insect, *B. tabaci* infested strawberry plants which treated with LaCl3 (low and high concentration) were 8.1, 16.5 individual/plant compared to control whereas it was 14.5 individual/plant. While mean number of *B. tabaci* infested strawberry plants which treated with La(NO3)3 (low and high concentration) were 9.5, 16.2 individual/plant compared to control whereas it was 14.5

individual/plant. Results were achieved as the same in Behera Governorate whereas mean number of *B. tabaci* infested strawberry plants which treated with LaCl3 (low and high concentration) were 9.8, 19.3 individual/plant compared to control whereas it was 17.1 individual/plant. While mean number of *B. tabaci* infested strawberry plants which treated with La(NO3)3 (low and high concentration) were 11.5, 18.9 individual/plant compared to control whereas it was 17.1 individual/plant. Results obtained also show that effectiveness of LaCl3 was higher than La(NO3)3 on decreasing population number of *B. tabaci* infesting strawberry plants compared to control (strawberry plants did not treat with any substance) at low concentration of both of the two substances. While at high concentration of both of the two substances led to negative effect on the controlling operation whereas it led to increasing population number of the successive insect *B. tabaci* compared to control.

Results obtained tabulated at Table (2) and Fig. (1 and 2) show Effectiveness of treatment strawberry plants by LaCl3 and La(NO3)3 on the infestation level by whitefly *B. tabaci* at both of Giza and Behera Governorates during season 2021/2022. Results obtained generally indicate that the successive substance LaCl3 was higher effectiveness than La(NO3)3 on decreasing the infestation by the successive insect *B. tabaci* . Whereas at Giza Governorate strawberry plants when treated with low concentration of LaCl3 (1 ppm) led to decreasing percentage% of the infestation by *B. tabaci* reach to 44.2% while when treated with low concentration of La(NO3)3 (1 ppm) led to decreasing percentage% of the infestation by *B. tabaci* reach to 34.5%. And also at Behera Governorate strawberry plants when treated with low concentration of LaCl3 (1 ppm) led to decreasing percentage% of the infestation by *B. tabaci* reach to 42.7% while when treated with low concentration of La(NO3)3 (1 ppm) led to decreasing percentage% of the infestation by *B. tabaci* reach to 32.7% . On the other hand, high concentration both of the two successive substances led to increasing percentage% of the infestation by *B. tabaci*, this appears evident from the average insect population which infested strawberry plants, whereas at Giza Governorate when treated strawberry plants with high concentration of LaCl3 (5 ppm) led to increasing percentage% of the infestation by *B. tabaci* reach to 12.2% while when treated plants with high concentration of La(NO3)3 (5 ppm)led to increasing percentage% of the infestation by *B. tabaci* reach to 10.5%. Results were achieved as the same at Behera Governorate whereas when treated strawberry plants with high concentration by both of the two successive substances LaCl3 and La(NO3)3 led to increasing percentage% of the population of *B. tabaci* reach to 11.4 and 9.5% respectively.

Statistical analysis show that were highly significant differences between means of population of the successive insect, *B. tabaci* infesting strawberry plants both treatment by LaCl3 and La(NO3)3 (two applied concentrations) compared to control (strawberry plants did not treatment by any substances). Whereas in Giza Governorate $F_{(0.05)}$ and L.S.D values for substance LaCl3 were (325.75 @ 1.025) respectively while these values for substance La(NO3)3 were (437.44@ 1.037) respectively. While in Behera Governorate $F_{(0.05)}$ and L.S.D values for substance LaCl3 were (471.82 @ 1.062) respectively, while these values for substance La(NO3)3 were (385.25@ 1.051) respectively.

Table 2: Effectiveness of treatment strawberry plants by LaCl3 and La(NO3)3 on the infestation by whitefly *B. tabaci* at both of Giza and Behera Governorates during season 2021/2022

Parameter	Giza Governorate					Behera Governorate				
	Cont.	LaCl3		La(NO3)3		Cont.	LaCl3		La(NO3)3	
		1 ppm	5 ppm	1 ppm	5 ppm		1 ppm	5 ppm	1 ppm	5 ppm
Total	393.1	218.5	445.5	256.5	437.4	460.6	264.6	521.1	310.5	510.3
Mean	14.5	8.1	16.5	9.5	16.2	17.1	9.8	19.3	11.5	18.9
Reduction %	-	44.2	12.2	34.5	10.5	-	42.7	11.4	32.7	9.5
F (0.05)	-	325.75		437.44		-	471.82		385.25	
L.S.D	-	1.025		1.037		-	1.062		1.051	

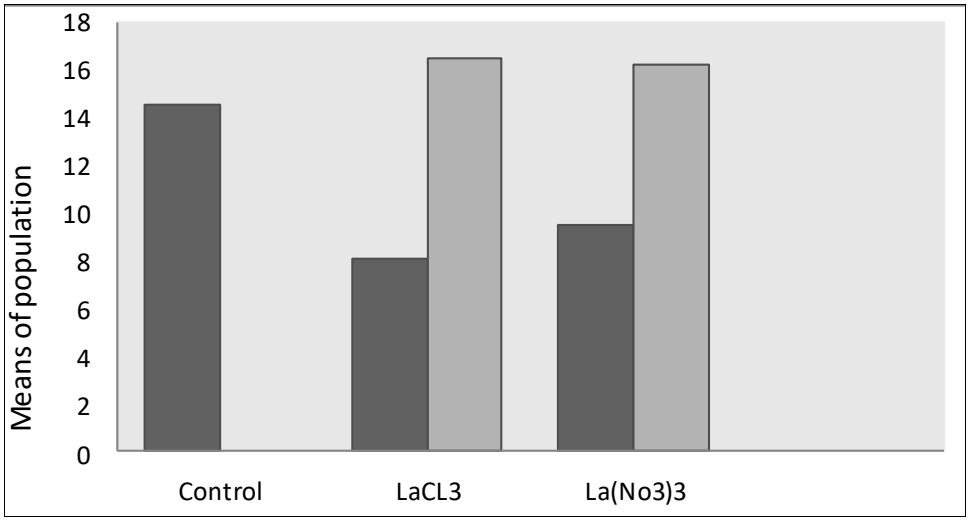

Fig 1: Effectiveness of treatment strawberry plants by LaCl3 and La(NO3)3 on the infestation by whitefly *B. tabaci* at Giza Governorate during season 2021/2022

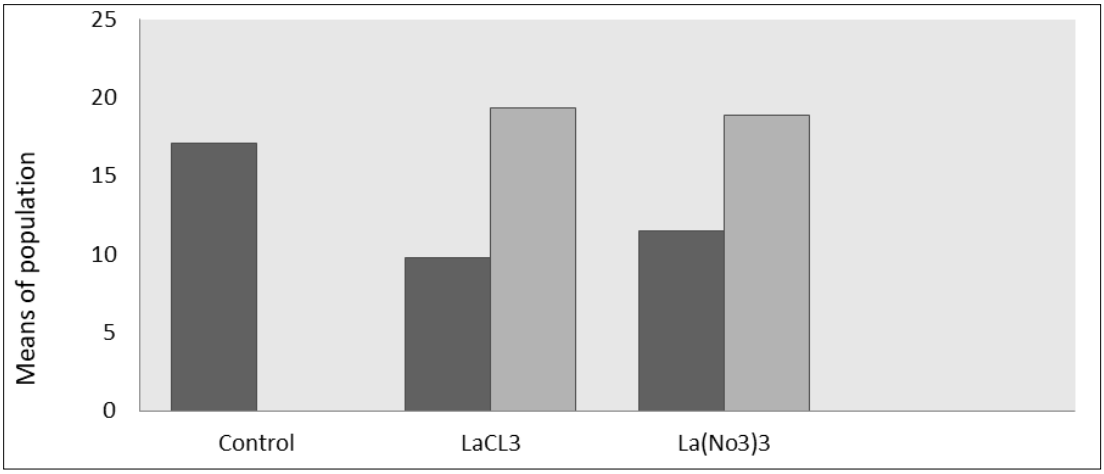

Fig 2: Effectiveness of treatment strawberry plants by LaCl3 and La(NO3)3 on the infestation by whitefly *B. tabaci* at Behera Governorate during season 2021/2022

Obtained results were agreement with those obtained by Yingli *et al.* (2017) [17] who studied stimulatory effectiveness of lanthanum nitrate compound on *Pseudostellaria heterophylla* whereas when treated by low concentration of this compound (2ppm) led to improved most of vital processes specially photosynthetic characteristics while when treated these plants by high concentration of the same compound (7ppm) led to bad effect on most photosynthetic adjectives of successive plants. Also Tandra *et al.* (2018) [16] who studied effect of lanthanum element in cellular systems in some plants and indicated that Lanthanum element which belongs to "Lanthanons group" has positive effects in the cellular systems in some plants at special concentrations which lead to an improvement in the general condition of the plant. Leslie (2015) [11] studied the effectiveness of lanthanum rare earth element against many pests and indicated that plants when treatment by this compound led to bad effects on the nervous system of larval stages and adults of successive insects when uses by certain concentrations. Emam *et al.* (2022) [2] studied effectiveness of Lanthanum Chloride (LaCl3) on controlling The Rose Aphid, *Macrosiphum rosae* L. through effect on the insect physiology and indicted to the clear effect of (LaCl3) on reducing population of *M. rosae* on rose plants through its positive effect on rose plants and negative effect on the successive insect *M. rosae* specially its physiological functions. Also Hong *et al.* (2000) [9] in China studied effect of lanthanum nitrate La(NO3)3 on aged seed germination of rice and indicated to the positive effect of treated rice seeds by that substance on germination and plant healthy. Hai *et al.* (2000) [8] studies positive changes in lipid peroxidation in rice seedlings when treated by lanthanum chloride and indicated to the positive effects of lanthanum chloride (LaCl3) on lipid peroxidation when treated rice seedlings by certain low concentrations of (LaCl3). Fashui *et al.* (2003) [4] studied effectiveness of lanthanum nitrate La(NO3)3 on seed germination and growth of rice and referred to the significantly increase seed vigor and chlorophyll contents and improve root growth when treatment with certain concentrations.

Conclusion

Current experiments aimed to study comparison between effectiveness of treatment strawberry plants, *Fragaria ananassa* (L.) by Lanthanum Chloride LaCl3 and Lanthanum Nitrate La(NO3)3 - two concentrations for each substance - on the infestation by white fly *Bemisia tabaci* (Gennadius) infesting strawberry plants under plastic greenhouses at two areas (Governorates), Perkash (Giza Governorate) and Nobariya (Behera Governorate) during season 2021/ 2022. Results obtained at both of the two successive arias indicated to that substance Lanthanum Chloride LaCl3 was higher effectiveness than Lanthanum Nitrate La(NO3)3 on controlling successive insect *B. tabaci* ,this is appears clearly through decreasing the mean numbers of *B. tabaci* (adults and nymphs) infesting strawberry plants. Results obtained also indicated to that low concentrations both of the two successive substances led to positive effect on the controlling operation of *B. tabaci* while high concentrations of the same substances led to negative effect on that operation.

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