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Efficiency of lanthanum nitrate La (NO3)3 on the physiological processes of tomato leaf miners *Tuta absoluta* (Lepidoptera: Gelechiidae) infesting tomato plants

Ayat, I. El-Kholy
Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

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Lanthanum nitrate La (NO3)3**,** *Tuta absoluta***,** tomato plants**,** physiological processes, and important enzymes.

Abstract

A current study was carried out to evaluate the efficiency of the earth element lanthanum (La) in a form Lanthanum nitrate La (NO3)3 on controlling the serious pest Tomato leaf miners *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) infesting tomato plants through its effectiveness on the physiological processes of *T. absoluta*. Experiments were carried out at two different zones (Governorates); Dokki zone (Giza Governorate) and Tokh zone (Qaliobya Governorate) during season 2022 under plastic greenhouses. Experiments were conducted on tomato plants *Lycopersicon esculentum* (var. Lopena) (Spring planting). Data obtained showed that tomato seedlings which were treated with low concentration of lanthanum nitrate La (NO3)3 (1ppm) had lower infestation by the successive insect *T. absoluta* compared to control. While tomato seedlings which are treated with a high concentration of lanthanum nitrate La (NO3)3 (5ppm) had higher infestation by the successive insect *T. absoluta* compared to the control. Laboratory analysis which was conducted on *T. absoluta* insects (Larvae) indicated to the effectiveness of La (NO3)3 on the physiological processes of *T. absoluta* especially the important enzymes secreting by that insect; (Alpha Esterase, Beta Esterase, Lipase Enzyme, Kinase Enzyme, Chitinase Enzyme, Phosphatase Enzyme, Oxidation Enzymes and Digestive Enzymes). And indicated also that the low concentration of La (NO3)3 had a negative effect on these enzymes and on the other hand the high concentration of La (NO3)3 had a positive effect on these enzymes. Statistical analyses showed that there were highly significant differences between the effectiveness of La (NO3)3 on the physiological processes of *T. absoluta* compared to the control.

Introduction

Tomato plants (*Lycopersicon esculentum*) are one of the most important vegetables plants and fruits all over most countries and it planted in a wide range both in open fields and under greenhouses (Goda *et al.*, 2015). The authors indicated also that tomato planted areas increased gradually especially during recent years and it is planted annually in Egypt in 2-3 plantations during the season. Also, Rudich and Atherton (2012) referred to the fact that tomato plants

are one of the most vegetables crops and fruits all over the world and it is grown and planted in a wide range in different climates both in the open fields and under greenhouses.

Tomato plants infested with different pests such as the serious pest tomato leaf miners, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) which is considered one of the most dangerous insects infesting tomato plants and causes many damages in tomato plants and fruits (Megido *et al.,* 2012). *T. absoluta* was recorded for the first time in Egypt at 2009 in Nubaria zone (Beheira Governorate) (Bekheit, 2011). Goda *et al.* (2015) in Egypt indicated that tomato leaf miner, *T. absoluta* is one of the most recent and serious pests attacking tomato plants in a wide range in Egypt in 2009.

Also, Marcela *et al*. (2005) in Argentina indicated that tomato leaf miner *T. absoluta* is one of the most serious pests of tomato plants since its appearance and dispersal in the 1970.

Lanthanum (La) element is one of the important earth elements (Stramare *et al.*, 2004), who indicated also to many crops response to different applications of some rare earth elements (REEs) such as lanthanum (La) element. Tandra *et al.* (2018) indicated that lanthanum nitrate La (NO3)3 is mainly used in agricultural research and indicated also it appears as white crystalline solid or white powder that is highly soluble in water and alcohols. Also, Wenwen *et al.* (2019) indicated the importance of the lanthanum element in improving the morphological and physiological adjectives of maize yield and other crops.

Current study aimed to evaluate the efficiency of the earth element lanthanum in a form Lanthanum nitrate La (NO3)3 on controlling the serious pest tomato leaf miners *T. absoluta* infesting tomato plants through its effectiveness on the physiological processes of *T. absoluta*.

Materials and methods

1. Experimental design:

Experiments were carried out to evaluate the efficiency of lanthanum nitrate La (NO3)3 in controlling the serious pest *T. absoluta* infesting tomato plants through its effectiveness on the physiological processes of that insect. Experiments were conducted on tomato plants *Lycopersicon esculentum* (var. Lopena) at two different zones (Governorates), Dokki zone (Giza Governorate) and Tokh zone (Qaliobya Governorate) during season 2022 (Spring planting) under plastic greenhouses. Each greenhouse was divided into three separate parts, first part was planted with tomato seedlings which did not treat with La (NO3)3 (Control), second part was planted with tomato seedlings which treated with low concentration of La (NO3)3 (1ppm) whereas its immersion in the La (NO3)3 solution for 12 hrs. before planting and third part were planted with tomato seedlings which treated with high concentration of La (NO3)3 (5ppm) whereas its immersion in the La (NO3)3 solution for 12 hours before planting. Each part contains one hundred 100 tomato seedlings. All tomato seedlings were planted in January month season 2022 (Spring planting) at both two successive zones. Agricultural processes were conducted similarly on tomato seedlings (Plants) and non-chemical control was applied during the study. An artificial infestation with tomato leaf miners, *T. absoluta* was done at both two successive zones at the same time. It is proven accurate observations and tomato leaves were taken separately from each part to the insect laboratory to count *T. absoluta* larvae. Counting was carried out weekly from the beginning of February month season 2022 at tomato seedlings (Plants) at both two successive zones.

2. Laboratory design:

Laboratory experiments were

conducted on *T. absoluta* larvae which were collected separately from the three parts of the greenhouse. The first group of insects that fed on tomato plants were not treated with La (NO3)3, the second group of insects that fed on tomato plants which treated with low concentrations of La (NO3)3, the third group of insects that fed on tomato plants that treated with high concentration of La (NO3)3. Insect Individuals (Larvae) were taken separately to the insect physiology laboratory to determine concentrations of eight important enzymes secreted by *T. absoluta*: (Alpha Esterase, Beta Esterase, Lipase Enzyme, Kinase Enzyme, Chitinase Enzyme, Phosphatase Enzyme, Oxidation Enzymes and Digestive Enzymes)

3. **Statistical analysis:**

Mean population numbers of *T. absoluta* larvae and concentrations of eight important enzymes secreted by *T. absoluta* were analyzed statistically using a one-way analysis of variance when ANOVA indicates that significant differences were found, ($P<0.05$) means were separated by a Least Significant Difference Test (LSD).

Results and discussion

1. Population fluctuation of *Tuta obsoluta* infesting tomato plants:

Results obtained in Table (1) and Figure (1) indicated the population fluctuation of the successive insect *T. obsoluta* infesting tomato plants at both of Dokki (Giza Governorate) and Tokh (Qaliobya Governorate) during 2022 season.

Results obtained show that in Giza Governorate the mean population number of *T. absoluta* individuals (Larvae) which infested tomato plants (Did not treat with La (NO3)3) (Control) was 30.2 individual/leaf while mean population number of *T. absoluta* which infested tomato plants (treated with low concentration of La(NO3)3) was19.0 individual/leaf and mean population number of *T. absoluta* which infested tomato plants (Treated with high concentration of La (NO3)3) was 32.5 individual/leaf.

Table (1): Population fluctuation of *Tuta absoluta* infesting tomato plants at Giza and Qaliobya Governorates during season 2022.

Date	Giza Governorate			Qaliobya Governorate		
	1 ppm	5 ppm	Control	1 ppm	5 ppm	Control
1/2/2022	11.5 ^{c}	24.5 ^{b}	22.3 ^{a}	13.5 ^{c}	28.1 ^{b}	24.5 ^{a}
8/2/2022	13.8 ^{c}	26.3 ^{b}	24.5 ^{a}	15.3 ^{c}	29.3 ^{b}	25.3 ^{a}
15/2/2022	15.9 ^{c}	28.1 ^{b}	26.7 ^{a}	16.2 ^{c}	30.4 ^{b}	27.4 ^{a}
22/2/2022	17.5 ^{c}	30.5 ^{a}	28.5 ^{a}	18.1 ^{c}	32.1 ^{b}	30.2 ^{a}
1/3/2022	19.8 ^{c}	32.4 ^{b}	30.8 ^{a}	19.2 ^{c}	34.8 ^{b}	32.8 ^{a}
8/3/2022	21.7 ^{c}	35.0 ^{b}	33.5 ^{a}	21.7 ^{c}	37.7 ^{b}	35.3 ^{a}
15/3/2022	22.3 ^{c}	37.2 ^{b}	35.2 ^{a}	23.3 ^{c}	40.9 ^{b}	37.0 ^{a}
22/3/2022	24.5 ^{c}	39.0 ^{b}	37.5 ^{a}	24.2 ^{c}	42.8 ^{b}	39.4 ^{a}
29/3/2022	27.3 ^{c}	41.2 ^{b}	38.4 ^{a}	25.7 ^{c}	43.2 ^{b}	40.1 ^{a}
5/4/2022	23.1 ^{c}	39.0 ^{b}	35.1 ^{a}	22.1 ^{c}	41.5 ^{b}	37.0 ^{a}
12/4/2022	21.5 ^{c}	37.1 ^{b}	32.5 ^{a}	19.5 ^{c}	39.9 ^{b}	34.2 ^{a}
19/4/2022	19.3 ^{c}	33.2 ^{b}	28.4 ^{a}	17.3 ^{c}	37.7 ^{b}	30.1 ^{a}
26/4/2022	15.4 ^{c}	30.4 ^{b}	26.5 ^{a}	14.8 ^{c}	33.5 ^{b}	28.7 ^{a}
3/5/2022	13.0 ^{c}	27.5 ^{b}	23.0 ^{a}	13.7 ^{c}	30.3 ^{b}	25.8 ^{a}
Total	**266.6**	**461.4**	**422.9**	**264.6**	**502.2**	**447.8**
Mean	**19.0**	**32.5**	**30.2**	**18.9**	**35.9**	**32.0**
%	**37.1**	**8.4**	**-**	**40.9**	**10.9**	**-**
F(0.05)	**411.32**			**526.71**		
L.S.D	**1.031**			**1.047**		

Means within rows bearing different subscripts are significantly different (P< 0.05).

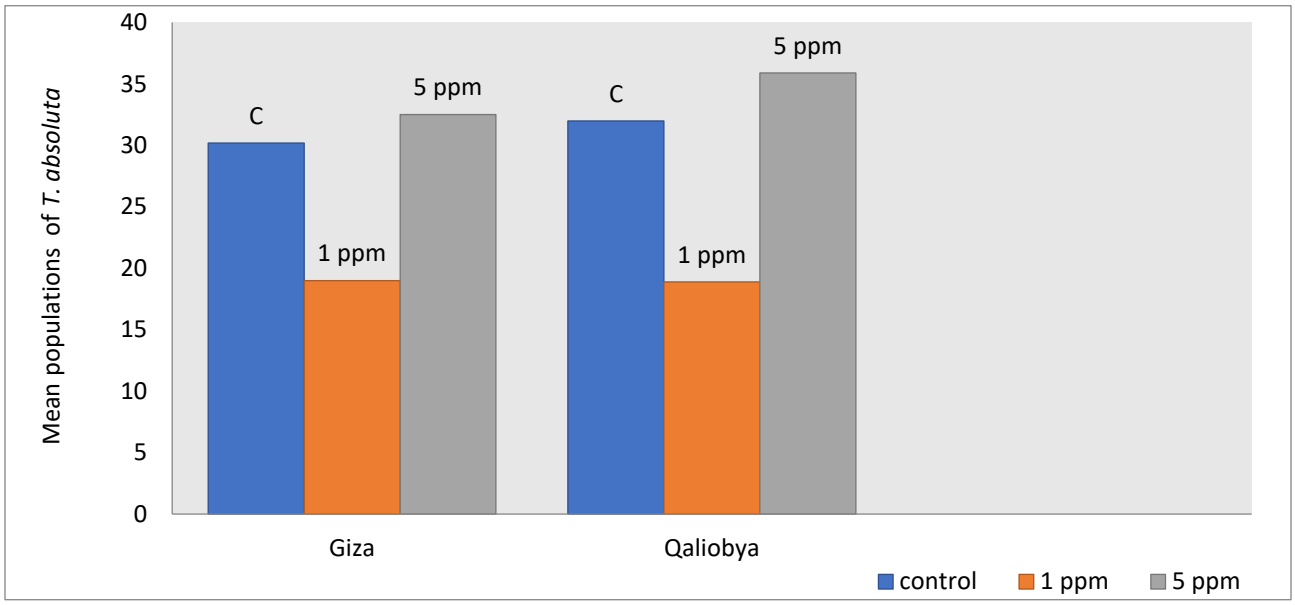


Figure (1): Mean population numbers of *Tuta absoluta* infesting tomato plants at Giza and Qaliobya Governorates during season 2022.

In Qaliobya Governorate the mean population number of *T. absoluta* (Larvae) that infested tomato plants (did not treat with La (NO3)3) was 32.0 individual/leaf while the mean population number of *T. absoluta* which infested tomato plants (Treated with low concentration of La (NO3)3 was 18.9 individual/leaf and mean population number of *T. absoluta* individuals which infested tomato plants (treated with high concentration of La (NO3)3) was 35.9 individual/leaf.

Results obtained also show that treatment of tomato plants with a low concentration of La (NO3)3 (1 ppm) led to a decrease mean population number of *T. absoluta* individuals infesting tomato plants while when treatment of these plants with a high concentration of the same material (5 ppm) led to increase mean populations number of *T. absoluta* individuals. Whereas at Giza Governorate when treatment tomato plants by a low concentration of La (NO3)3 the infestation by *T. absoluta* decreased by 37.1% compared to the control while when treated tomato plants by a high concentration of the same material the infestation by the successive insect increased by 8.4% compared to control. As the same trend was achieved at Qaliobya Governorate whereas when treated tomato plants by low concentration of La (NO3)3 the infestation by *T. absoluta* decreased by 40.9% compared to the control while when treated tomato plants by a high concentration of the same material the infestation by the successive insect increased by 10.9% compared to control.

Statistical analysis showed that there were highly significant differences between the mean population numbers of *T. absoluta* which infested tomato plants treated with low and high concentrations of La (NO3)3 compared to control at both Giza and Qaliobya Governorates whereas F(0.05) and L.S.D values in Giza Governorate were (411.32, 1.031) respectively, while the same values in Qaliobya Governorate were (526.71, 1.047) respectively.

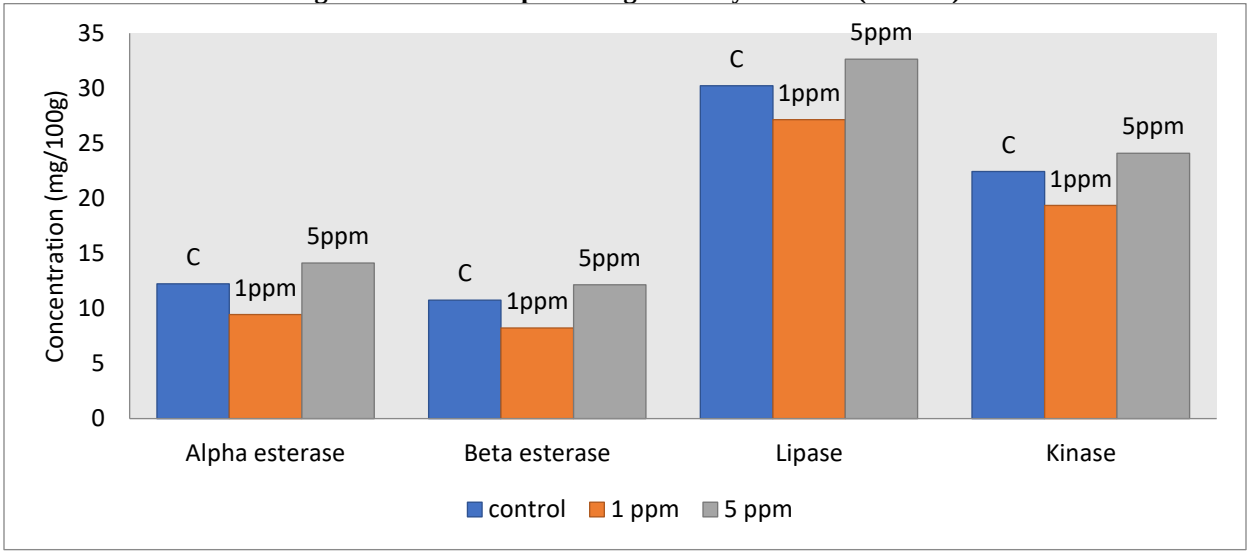
2. Effectiveness of La (NO3)3 on the physiological process of *Tuta absoluta*:

Results obtained and tabulated in Table (2) and Figure (2) show concentrations of the most important enzymes secreted by the successive insect *T. absoluta* (Alpha Esterase, Beta Esterase, Lipase Enzyme, Kinase Enzyme, Chitinase Enzyme, Phosphatase Enzyme, Oxidation Enzymes and Digestive Enzymes). And also indicated that these enzymes secreted by *T. absoluta* insects that fed on tomato plants were not treated by La (NO3)3 (Control) were 12.25, 10.75, 30.32, 22.43, 16.31, 25.28, 7.92 and 10.53 mg/100g, respectively. Whereas concentrations of the same enzymes secreted by *T. absoluta* insects which fed on tomato plants treatment by low concentration of La (NO3)3 (1 ppm) were 9.45, 8.23, 27.15, 19.35, 14.82, 23.41, 5.25 and 8.35 mg/100g, respectively. While concentrations of the same enzymes secreted by *T. absoluta* insects that fed on tomato plants treatment with high concentrations of La (NO3)3 (5 ppm) were, 14.12, 12.15, 32.65, 24.11, 18.45, 27.64, 9.45 and 12.45 mg/100g, respectively. That means that treating tomato plants with a low concentration of La (NO3)3 (1 ppm) affected negatively the successive insect *T. absoluta* which fed on it whereas concentrations of the most important enzymes secreted by insect were decreased compared to control (concentrations of the same enzymes secreted by insects which fed on tomato plants did not treat with La (NO3)3. On the other hand, when treatment of tomato plants with a high concentration of La (NO3)3 (5 ppm) affected positively on the successive insect *T. absoluta* which fed on it whereas concentrations of the same enzymes secreted by that insect increased compared to the control.

Table (2): Concentrations of the most important enzymes secreted by the successive insect *Tuta absoluta* (Mg/100g).

Enzymes	Control	1 ppm	5 ppm	$F_{0.05}$	L.S.D
Alpha Esterase	12.25 [a]	9.45 [c]	14.12 [b]	325.11	1.022
Beta Esterase	10.75 [a]	8.23 [c]	12.15 [b]	289.77	1.034
Lipase Enzyme	30.22 [a]	27.15 [c]	32.65 [b]	412.32	1.027
Kinase Enzyme	22.43 [a]	19.35 [c]	24.11 [b]	372.33	1.082
Chitinase Enzyme	16.31 [a]	14.82 [c]	18.45 [b]	295.21	1.035
Phosphatase Enzyme	25.28 [a]	23.41 [c]	27.64 [b]	470.33	1.021
Oxidation Enzymes	7.92 [a]	5.25 [c]	9.45 [b]	372.51	1.039
Digestive Enzymes	10.53 [a]	8.35 [c]	12.45 [b]	381.44	1.066

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



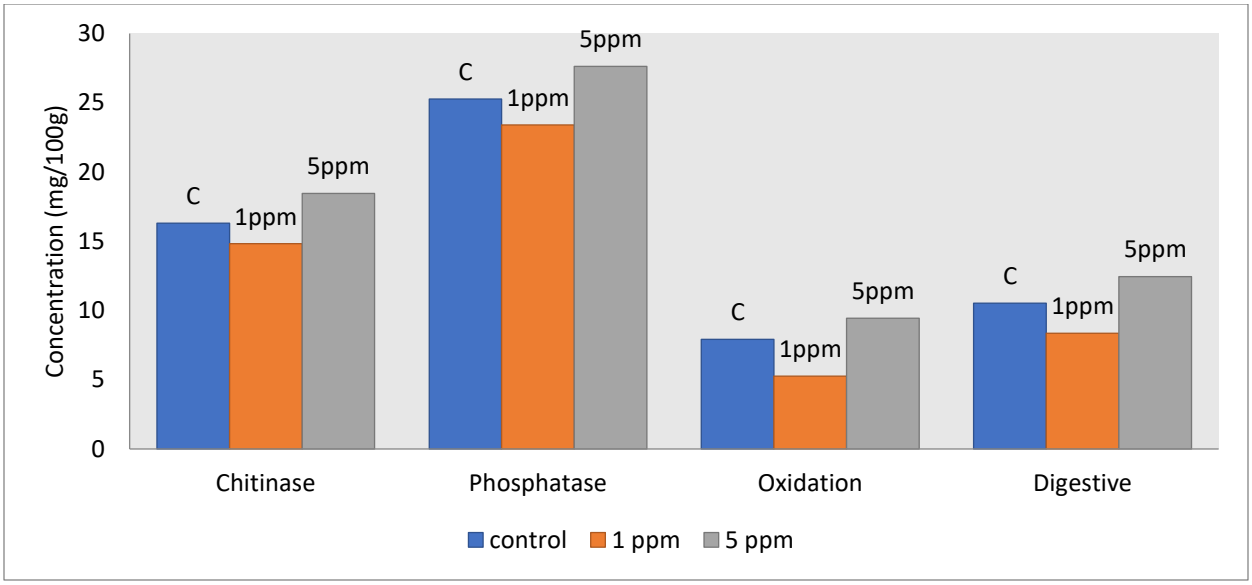


Figure (2): Concentrations of the most important enzymes secreted by the successive insect *Tuta absoluta* (Mg/100g).

Obtained results agreed with those obtained by Ippolito *et al.* (2011) who studied responses of antioxidant systems to lanthanum nitrate treatments in tomato plants during drought stress and indicated that lanthanum is one of the most abundant elements in rare earth enriched fertilizers and they indicated also to the effect of lanthanum nitrate on lipid peroxidation. Hong *et al.* (2000) in China indicated the positive effectiveness of lanthanum nitrate La (NO3)3 on seed germination of rice and improved the plant health. Leslie (2015) also indicated the effectiveness of lanthanum elements against different pests and stated that the element affected the nervous system of successive insects when used at a certain concentration. Fashui *et al.* (2003) indicated the effectiveness of lanthanum nitrate La (NO3)3 on seed germination and growth of rice plants and indicated the significant improvement of chlorophyll content and root growth when treated the plants by certain concentrations. Also, Yingli *et al.* (2017) studied the effectiveness of lanthanum nitrate La (NO3)3 on *Pseudostellaria heterophylla* whereas treated plants with a low concentration (2ppm) led to improving many vital processes such as photosynthetic processes while treated plants with a high concentration (7ppm) led to negative effectiveness on the photosynthetic processes. Also, Tandra *et al.* (2018) referred to the positive effectiveness of lanthanum element in cellular systems in different plants which leads to an improvement in the general health of the plants. Shan *et al.* (2017) investigated the clear effects of lanthanum nitrate on the different activities and the transcript levels of enzymes in the regeneration, biosynthesis, and degradation of vitamin C in strawberry plants at different periods of growth and development. Lastly, Nilima *et al.* (2014) studied different effects of lanthanum element on the growth and physiological activities of *Zea mays*, *Vigna radiata* and *Vigna mungo* and indicated to the positive effects of lanthanum nitrate on germination, growth and different vital processes in these studied plants.

A current study was carried out to evaluate efficiency of the earth element lanthanum (La) in a form lanthanum nitrate La (NO3)3 on controlling the serious pest tomato leaf miners *T. absoluta* infesting tomato plants through its effectiveness on the

physiological processes of *T. absoluta*. Results obtained show that treatment of tomato seedlings with a low concentration of La (NO3)3 (1 ppm) led to a decrease in mean population numbers of *T. absoluta* through its negative effectiveness on the physiological process of *T. absoluta* on the other hand when treatment of these plants by high concentration of La (NO3)3 (5 ppm) led to increase mean population numbers of *T. absoluta* through its positive effectiveness on the physiological process of *T. absoluta*.

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