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EMAMECTIN-BENZOATE AGAINST *Tuta absoluta* MEYRICK AND *Spodoptera littoralis* BOISDUVAL LARVAE

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The tomato borer or the tomato leafminer (TLM), *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) has invaded the Mediterranean basin recently from South America and it is becoming a major global pest of tomato. Additionally, the Egyptian cotton leafworm (ECLW), *Spodoptera littoralis* Boisduval (Lepidoptera: Noctuidae) is also a serious pest of various economic and non-economic crops in other Mediterranean countries. The excessive use of chemical pesticides is dangerous because these insect pests can develop resistance. The purpose of the present study was to evaluate the efficacy of emamectin-benzoate insecticide against two lepidopterous insects namely; *T. absoluta* and *S. littoralis* under laboratory conditions. Laboratory results showed that emamectin-benzoate was effective against larval stages of insects under laboratory conditions. All four concentrations of emamectin-benzoate caused a significant percentage of mortality after 24 hours of treatment as the percentage of mortality increased gradually with time. But almost all concentrations caused 100% mortality of larvae in both species on the 4th and 5th day of treatment. The obtained results showed that there were significant differences between insecticide concentrations, time of exposure and mortality percentage without any adverse effect on the tomato plants.
Keywords: Tomato leafminer, *Tuta absoluta*, Egyptian cotton leafworm, *Spodoptera littoralis*, Emamectin-benzoate.

INTRODUCTION

The tomato borer or the tomato leafminer (TLM), *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) is a native of South America (CABI, 2016) and is one of the top invasive insect pests around the world. This insect has invaded Middle East regions and is a major threat to tomato (*Solanum lycopersicum* L.) production as it caused the epidemic losses to tomato and other solanaceae plants (Amizadeh *et al*., 2015; Chidege *et al*., 2016; Materu *et al*., 2016). It was reported that *T. absoluta* can cause up to 100% losses of tomato crops even with the implementation of chemicals control (Korycinska and Moran, 2009). It has also a significant economic importance in tomato production worldwide (Bawin *et al*., 2014; Materu *et al*., 2016). *T. absoluta* is a micro lepidopteron moth, which has higher productive rates. *T. absoluta* has 10-12 generations/ year under favorable conditions and its life cycle completed within 30-35 days. Larval period (the most damaging stage) lasts for 12-15 days. The larvae feed voraciously upon tomato plants, make mines in leaves, bore the stalks and consume apical buds, green and ripe fruits.

T. absoluta larvae are able to destroy an entire tomato farm in the open field and greenhouses especially when effective control measures are not implemented (Retta and Berhe, 2015; Illakwahhi and Srivastava, 2017). Tomato farmers worldwide are suffering from severe losses in tomatoes production due to *T. absoluta* infestation (Reyes *et al*., 2012; Chidege *et al*., 2016; Materu *et al*., 2016). Once infestation occurred, *T. absoluta* spread from one field to another by seedlings, infested vines with tomato fruit, tomato fruit and used containers (Arnó and Gabarra, 2010; Amizadeh *et al*., 2015).

The Egyptian cotton leafworm (ECLW), *Spodoptera littoralis* Boisduval (Lepidoptera: Noctuidae) is one of the most devastating lepidopterous pests within its subtropical and tropical range. It can attack several cash rich crops throughout the year (Fanigliulo *et al*., 2012a). The pest may cause substantial harm to cotton by feeding on the leaves, fruiting points, flower buds and intermittently on bolls. When groundnuts are infested, larvae first choose young folded leaves for feeding, but in extreme cases, leaves of any age are peeled off. Sometimes, even the ripening kernels in pods in the soil may be under attack. Pods of cowpeas and the seeds they contain are also often badly affected. In tomatoes, larvae bore into the fruit, which is thus made unsuitable for consumption. Various other crops are attacked, mainly on their leaves.

On the other hand, several alternative control methods such as the use of the synthetic pheromone (e.g. sex pheromones; trap pheromones) are widely used to control a number of lepidopteran pests but the control of tomato leafminer infestations is difficult and challenging to control because of the protection of the leaf mesophyll or fruit shells due to the endophytic habit of larvae (Cocco *et al.*, 2013). Nevertheless, chemical insecticides are highly sought to be one of the most effective control measures to reduce *T. absoluta* and *S. littoralis* populations (Fanigliulo *et al*., 2012b). However, the need for alternative control methods is encouraged, considering that, the pests understudy have developed resistance to dozens of the pesticides and the negative side effects of pesticides due to over-use to the environment and other beneficial arthropods. Fanigliulo *et al.* (2012a) found that treatment with chlorantraniliprole-lambda-cyhalothrin mixture was notably more effective than the one with emamectin-benzoate in minimizing the attack of *T. absoluta* on tomato fruits. In the other side, Low heterogeneity was detected in *T. absoluta* populations tested with most insecticides in Greece (Roditakis *et al*., 2013). The variability of the LC_{50} values among the tested *T. absoluta* populations was low, except for indoxacarb. An evidence of possible failure of cypermethrin, chlorpyriphos and metaflumizone insecticide used in controlling *T. absoluta* was detected using probit analysis. In short, they demonstrated that cypermethrin would provide insufficient control of *T. absoluta*. Thus, it would be better to avoid using these insecticides for controlling *T. absoluta* for health and economic purposes. Moreover, Radwan and Taha (2017) tested nine insecticides against field populations of *T. absoluta* 2nd instar larvae. They found that both of Imidacloprid and Thiocyclam-H.O. were the most powerful insecticides and the insect had no resistance against both insecicides. Moreover, other pesticides like Lufenuron, Dinotefuran, Fenoxycarb, Diflubenzuron and Phenthoate gave moderate toxic effect and resistance level except Phenthoate and Fenoxycarb. They also tested two bio-insecticides *Bacillus thuringiensis kurstaki* and Nuclear Polyhedrosis Virus (NPV). In addition, they ascertained that both bio-insecticides were less toxic to larvae of *T. absoluta* compared with insecticides with a low resistance level. In Tunisia, Braham, *et al.* (2012) investigated the effectiveness of novel insecticides and plant extracts against *T. absoluta*. Their results indicated that the greenhouse trials showed good efficacy of the following products; Tracer, Biocatch, Nimbecidine, Voliam Targo, Vydate and Tutafort. However, laboratory trials had a good performance of Ampligo, Challenger, Armorex, Movento, Konflic and Deffort. They recommended that the integration among these products in an Integrated Pest Management (IPM) approach will be valuable.

To control these pests effectively, it is important to combine all available control measures including cultural methods, biological control agents and the correct use of effective pesticides (Haddi *et al*., 2012). Thus, an IPM strategy that employs chemical, biological, physical and cultural methods was found to be the only best option for controlling *T. absoluta* (Cherif *et al*., 2018).

Moreover, there are several insecticides that have been extensively used for controlling *T. absoluta* and *S. littoralis* including emamectin-benzoate. Emametin-benzoate is the 4”-deoxy-4”-methylamino derivative of abamectin, a 16-membered macrocyclic as shown in the following picture. In general, it is prepared as the salt with benzoic acid, emamectin benzoate (Waddy *et al*., 2007). It is used widely in the US and Canada as an insecticide because of its chloride channel activation properties (Andersch *et al.*, 2011). In addition, it widely used in controlling lepidopterous pests (butterflies and moths) in agricultural production in the US, Japan, Canada, and recently Taiwan. The low-application rate of the active ingredient needed (~6 g/acre) and broad-spectrum applicability as an insecticide, emamectin-benzoate has attained considerable popularity among farmers (Waddy *et al.*, 2007). It is also being used by Ministry of Agriculture, Saudi Arabia in various control programs. Therefore, the aim of this study is to evaluate the efficacy of emamectin-benzoate against *T. absoluta* and *S. littoralis*.

MATERIALS AND METHODS

Insects: Adults of *T. absoluta* were collected from infested and non-treated tomatoes in greenhouses at Qassim regions to establish a colony in order to perform laboratory bioassays. Adults were reared on honey solution. Infested leaves were incubated under laboratory conditions until the emergence of adults. Then adults were immediately transferred to glass jars lined with filter papers. Jars were covered with muslin cloth fixed with rubber bands. After mating, females laid the eggs in the jar. Thereafter, eggs were collected daily by using a fine paintbrush and incubated at 27 ± 2°C and 55% RH until hatching. Newly hatched larvae were fed on tomato seedlings until they reached the 2nd instars.

S. littoralis; Eggs of *S. littoralis* were obtained from the Entomology Lab in the Plant Production and Protection Department, Collage of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia. Eggs were incubated at 27 ± 2°C and 55% RH until hatching. Newly hatched larvae were fed on tomato seedlings until they reached the 2nd instar.

Chemicals and solutions: Emamectin-benzoate (Mectin 5.7% WG, emamectin-benzoate) was obtained from Altaleb Group Company. Recommended application rate for direct spray is 250g/ha.

Treatments: The experiments were conducted during September 2018. The 2nd instar larvae of *T. absoluta* and *S. littoralis* were used to perform experimental bioassays. The reason behind the selection of 2nd instar larvae in this experiment is because the 2nd instar larvae are considered as a stage of total larval stages. The larvae of 1st instar are more sensitive stage and may give results, while larvae from 3rd instars to the last one are more tolerant to the pesticide, which may make the results misleading and unrealistic. This is why the 2nd instar larvae were selected (Abdel-Baky and Al-

Soqeer, 2017). Four different concentrations of emamectin-benzoate (0.5, 1, 2 and 3 gm/L) including a control (distilled water) were applied to insects under laboratory conditions. Apical application of the insecticide (direct sprays) was applied using a hand sprayer (1L), so the larvae were directly sprayed with insecticide from the top.

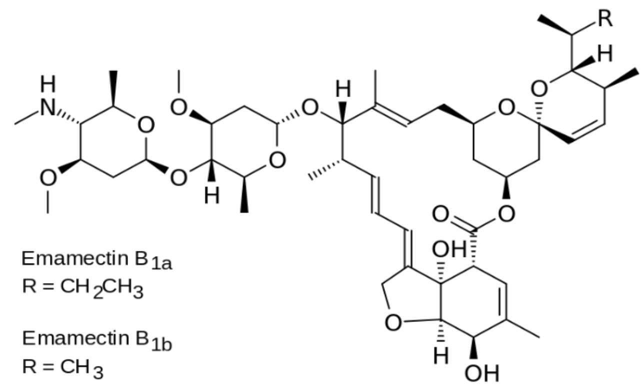

Figure 1. Chemical structure of emamectin-benzoate.

The 2nd instar larvae of *T. absoluta* and *S. littoralis* were carefully transferred by using zero brush to the newly un-infested tomato leaves in Petri dishes (15 cm in diameter). Five larvae of each insect were put in each Petri dish with 10 replicates for each concentration including the control (distilled water). Thereafter, Petri-dishes were provided with filter paper to protect larvae from excessive humidity. Petri-dishes were maintained under laboratory conditions. Numbers of live and dead larvae of each treatment as well as the control treatment were observed and recorded at 1, 2, 3, 4 and 5 days intervals of treatment. During the experiment the old and consumed tomato leaves were daily removed and replaced with fresh and non-treated tomato leaves for control and treated leaves for treatments. Thereafter, the mortality percentages were calculated.

In case of treating *T. absoluta* larvae inside tunnels, another bioassay trial was carried out with tomatoes leaf, which *T. absoluta* larvae are feeding upon and living inside tunnels within the tomato leaf to mimic the natural conditions of the insect habitat and to measure the effect of emamectin-benzoate on the larvae with tomato leaf materials.

***Statistical analysis*:** The effect of emamectin-benzoate on the mortality of 2nd instar larvae of *T. absoluta* and *S. littoralis* were statistically analyzed. The experiments were arranged using the randomized complete blocks design with ten replications. Means were statistically analyzed and compared (RCBD) according to the least significant difference (LSD test) at the 5% level according to MSTACT SOFTWARE (1980). The percentage of the corrected mortality±Standard error (S.E.) for each of concentrations and periods was calculated according to Abbott (1925).

$$\textbf{Corrected mortality percentage} = \frac{Nc - Nt}{Nt} \times 100$$

Where, Nc = live individuals in the control after the treatment; Nt = live individuals in the treatment after the treatment.

RESULTS

***Emamectin-benzoate against the tomato leafminer, T. absoluta treatment of larvae inside the tomato leaf tunnels*:** Evaluation of four concentrations of emamectin-benzoate against 2nd larval instar of *T. absoluta* was carried out. Table 1 shows the insecticidal potency of emamectin-benzoate on 2nd larval instar of *T. absoluta* and the significant impact of all concentrations of emamectin-benzoate against 2nd instar larvae of *T. absoluta*. Though, the mortality varied for different concentrations tested. The highest initial mortalities (1st day after treatment) were also recorded. The average mortality percentage was observed 58.20 ± 4.32% after 1st day of application. Significant differences were observed among the concentrations within a treatment which LSD= 7.03** (Table 1).

On the 2nd day of treatment, the mortality percentage increased sharply over 50% for all concentrations (Table 1).

Table 1. Toxicity of emamectin-benzoate on 2nd instar larvae of *T. absoluta* inside the tomato leaves tunnels under laboratory conditions.

Conc. gm/L	Initial Mortality	Mortality % ± S.E.					LSD (within treatments) at 0.05	Residual Effect (%)	Total Activities (General Mortality %)
		1st Day	2nd Day	3rd Day	4th Day	5th Day			
0.5	0.0	35.60±0.67	60.40±0.67	88.00±0.57	100.0±0.00	100.0±0.00	1.59**	76.80±5.14	64.00±11.49
1	0.0	50.00±1.26	89.60±0.67	100.0±0.00	100.0±0.00	100.0±0.00	2.02**	87.92±3.97	73.27±8.85
2	0.0	61.60±3.60	89.60±1.19	100.0±0.00	100.0±0.00	100.0±0.00	5.62**	90.24±3.13	75.20±6.79
3	0.0	85.60±1.04	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	1.56**	97.12±1.19	80.93±2.63
Mortality % /day	0.0	58.20±4.32	84.90±3.41	97.00±1.20	100.0±0.00	100.0±0.00	---------	88.02±1.94	73.35±4.02
L.S.D. (within day) at 0.05	0.0	7.03**	2.35**	0.97**	N.S.	N.S.	1.35**	1.50	-------
L.S.D. (within treat.) at 0.05	3.01 **								

** = p < 0.05

LSD value between concentrations listed was 2.35**. The average mortality percentage was observed 84.90±3.41% after the 2nd day of application.

On the 3rd day of treatment, the mortality percentage reached 100% mortality at 1gm/L and beyond. In particular, the significant differences between the four treatments were observed at LSD value was 0.97** (Table 1). Clearly, all concentrations of emamectin-benzoate caused 100% mortality among *T. absoluta* 2nd instar larvae on the 4th and 5th days of treatment (Table 1) with no significant differences observed between the four concentrations on 4th and 5th day as the mortality percentages were 100% (Table 1).

Clearly, all four concentrations of emamectin-benzoate (0.5, 1, 2 and 3gm/L) were found to be effective against *T. absoluta* as the lowest concentration of 0.5gm/L showed less impact in the beginning but caused 100% mortality on the 4th day of treatment while the concentration 1.0gm/L and 2.0gm/L showed the 100% mortality on the 3rd day of treatment. The highest concentration of 3.0gm/L caused 100% mortality on the 2nd day of treatment. The effect of emamectin-benzoate, an active ingredient differed according to the rate of applications and the period of exposure to the insecticide (Figure 2 and 3). The percentage effects of emamectin-benzoate on the 1st, 2nd, 3rd, 4th and 5th day after the treatment (DAT) were calculated by Abbott's formula. The residual effects increased gradually by increasing the dose of the pesticide used, shown in (Figure 4).

Statistically, the results showed that there was a significant difference between four concentrations tested. LSD (within treatments) showed that the higher the dose concentration-used, the greater rate of mortality was obtained (Table 1). The duration of exposure to emamectin-benzoate (within DAT) showed significant differences between the1st, 2nd, and 3rd day of the treatment.

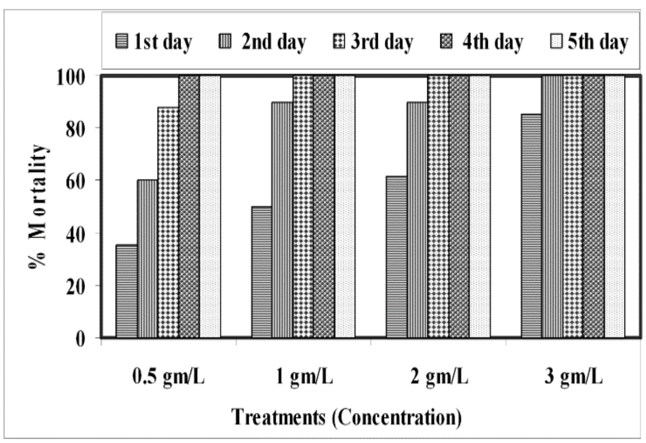

Figure 2. Effect of four different concentrations of emamectin-benzoate against 2nd instar larvae of *T. absoluta* mortalities treated inside the tunnels of tomato leaves under laboratory conditions.

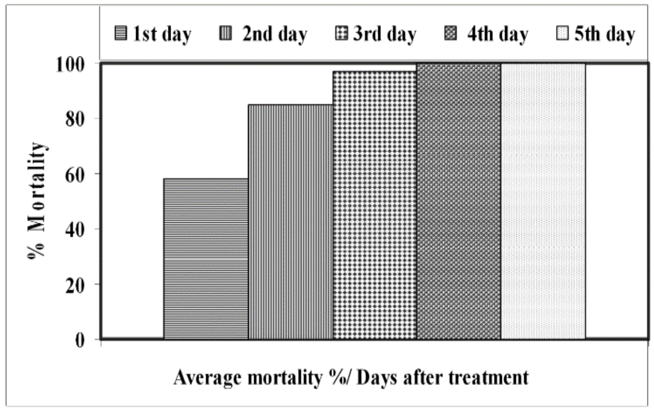

Figure 3. Duration effects of exposure to emamectin-benzoate on 2nd instar larvae of *T. absoluta* mortalities treated inside the tunnels of tomato leaves under laboratory conditions.

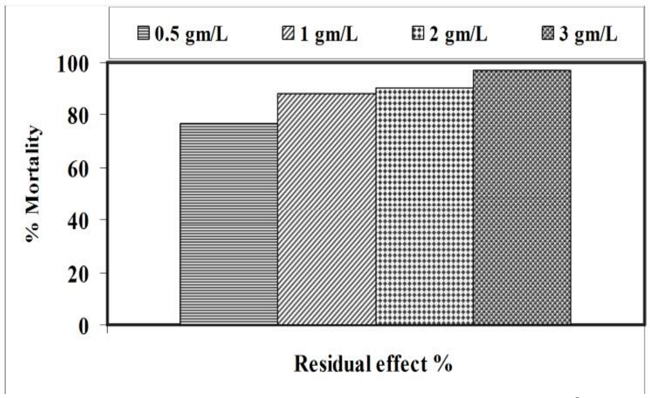

Figure 4. Emamectin-benzoate residuals against 2nd instar larvae of *T. absoluta* mortalities treated inside the tunnels of tomato leaves under laboratory conditions.

***Treatment of Larvae without plant materials*:** Table 2 shows that the insecticidal potency of emamectin-benzoate on the 2nd larval instar of *T. absoluta*. It was noted that the mortality rates varied based on the concentrations tested. The highest initial mortality percentages (100%) (1st day after treatment) were obtained at 3gm/L. Average percent mortality per day on the 1st day of application was recorded 78.70±3.73%. Highly significant differences were observed among the concentrations within a treatment which LSD value was 4.70** (Table 2).

On the 2nd day of treatment, the mortality percentage increased significantly to achieve over 50% of mortality at all concentrations and reached 100% at 1gm/L (Table 2). LSD between concentrations listed 2.99**. The average percent mortality for the 2nd day of application was recorded as 97.40±1.12%

Table 2. Toxicity of the direct spray of emamectin-benzoate on 2nd instar larvae of *T. absoluta* without tomato leaves under laboratory conditions.

Conc. gm/L	Initial Mor-tality	Mortality % ± S.E.					LSD (Within treat.) at 0.05	Residual Effect (%)	Total Activities (General Mortality %)
		1st Day	2nd Day	3rd Day	4th Day	5th Day			
0.5	0.0	56.0 ± 1.26	89.6 ± 1.73	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	4.70**	89.12 ± 3.51	74.27 ± 7.78
1	0.0	74.0 ± 1.26	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	2.99 **	94.80 ± 2.14	79.00 ± 4.75
2	0.0	84.8 ± 1.66	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	N.S.	96.96 ± 1.29	80.80 ± 2.78
3	0.0	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	N.S.	100.0 ± 0.00	83.33 ± 0.00
Mortality % /Day	0.0	78.70 ± 3.73	97.4 ± 1.12	100.0 ± 0.00	100.0 ± 0.00	100.0 ± 0.00	---------	95.22 ± 1.13	79.35 ± 2.34
LSD (within Day) at 0.05	0.0	4.70**	2.99**	N.S.	N.S.	N.S.	1.06**	0.95**	-------
LSD (within treat.) at 0.05					2.11 **				

** = $p < 0.05$

On the 3rd day of the treatment, the mortality percentage among the 2nd instar larvae of *T. absoluta* increased to 100% at all four concentrations tested (Table 2). Therefore, all concentrations achieved 100% mortality among *T. absoluta* 2nd instar larvae with insignificant differences on the 3rd, 4thand 5th days of the treatment (Table 2).

The residual effects of emamectin-benzoate on *T. absoluta* were increased gradually by increasing the dose of the insecticide used and statistically there were significant differences between four concentrations tested compared with the control (distilled water) (Figure 7). LSD (within treatments) showed that the higher the dose concentration used, the greater the mortalities obtained (Table 2).

The duration of exposure to emamectin-benzoate (within DAT) showed significant difference between the1st, and 2ndday of treatment, while no alive larvae of *T. absoluta* were found on the 3rd, 4th and 5th day (Table 2).

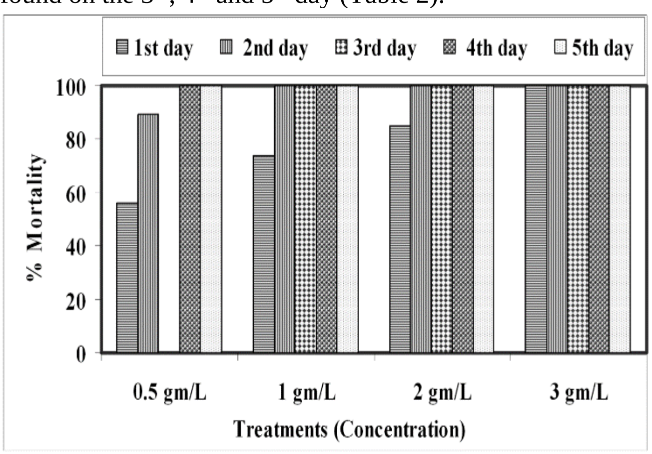

Figure 5. Effect of emamectin-benzoate concentrations on 2nd instar larvae of *T. absoluta* mortalities when treated without tomato leaves under laboratory conditions.

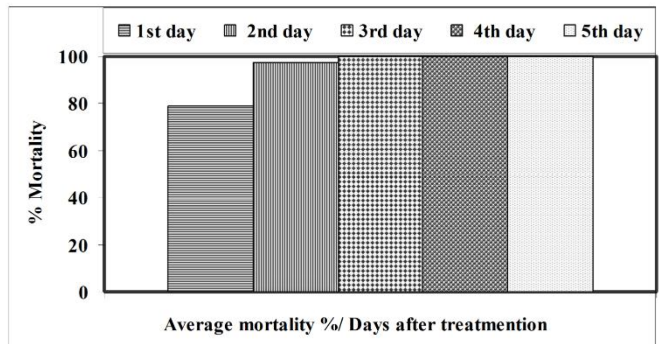

Figure 6. Duration effects of exposure on 2nd instar larvae of *T. absoluta* mortalities treated without tomato leaves under laboratory condition.

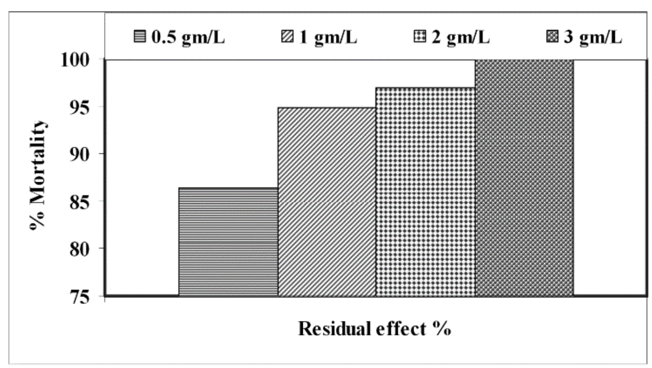

Figure 7. Emamectin-benzoate residuals on 2nd instar larvae of *T. absoluta* mortalities treated without tomato leaves under laboratory conditions.

Emamectin-benzoate against 2nd instar larvae of *S. littoralis*: Efficacy of four concentrations of emamectin-benzoate against *S. littoralis* 2nd instar larvae was evaluated under laboratory conditions. Table (3) represents the effectiveness of emamectin-benzoate on *S. littoralis* larvae. All concentrations were found to be highly effective against

Table 3. Toxicity of emamectin-benzoate on 2nd instar larvae of *S. littoralis* under laboratory conditions.

Conc. gm/L	Initial Mor-tality	Mortality % ± S.E.					LSD (within treat.) at 0.05	Residual Effect (%)	Total Activities (General Mortality %)
		1st Day	2nd Day	3rd Day	4th Day	5th Day			
0.5	0.0	66.80±1.66	92.00±1.26	100.0±0.00	100.0±0.00	100.0±0.00	3.16**	91.76±2.66	76.47±5.87
1	0.0	70.80±0.91	92.00±1.26	100.0±0.00	100.0±0.00	100.0±0.00	2.52**	92.56±2.33	77.13±5.16
2	0.0	73.60±1.04	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	1.56**	94.72±2.17	78.93±4.82
3	0.0	88.40±1.31	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	1.97**	97.68±0.98	81.40±2.12
Mortality % /Day	0.0	74.90±1.98	96.00±1.03	100.0±0.00	100.0±0.00	100.0±0.00	---------	94.18±1.07	78.48±2.21
LSD (within Date) at 0.05	0.0	4.73**	2.92**	N.S.	N.S.	N.S.	0.98**	1.09**	-------
LSD (within treat.) at 0.05					2.19 **				

** = $p < 0.05$

S. littoralis 2nd instar larvae (Table 3). The highest initial mortality (1st day after treatment) were obtained at 3gm/L, respectively. The average mortality percentage/day listed as 74.90±1.98% on the 1st day of application. Significant differences were observed among the different concentrations within a treatment of which LSD value was 4.73** (Table 3). Two days after the treatment, the mortality percentage increased significantly to achieve over 95% of mortality at 1gm/L (Table 3). LSD between concentrations listed 2.92**. Meanwhile, the average mortality percentage/day recorded 96.0 ± 1.03%.

On the 3rd day of the treatment, the mortality percentage among *S. littoralis* 2nd instar larvae increased to achieve 100% with all four concentrations used (Table 3) and no significant differences were observed (Table 3). Therefore, all concentrations caused 100% mortality among *S. littoralis* 2nd instar larvae on the 4th and 5thdays of treatment (Table 3). Statistically, no significant differences were observed among different concentrations (Table 3). Effects of emamectin-benzoate on *S. littoralis* 2nd instar larvae started from the 1st day of treatment and continued up to the 5th day (Table 3; Figure 7). The active ingredient of insecticide has a varied impact over pest larvae according to different used-concentrations and the duration of exposure (Figure 9 and 10). The residual effects of emamectin-benzoate were shown in Figure (10), where it shows that the residual effects increased gradually by increasing the dose of the pesticide used.

Statistically, the results showed significant differences between the four concentrations used. LSD (within treatments) showed that the higher the dose concentration tested, the greater mortalities obtained between *S. littoralis* 2nd instar larvae populations (Table 3).The duration of exposure to emamectin-benzoate (within DAT) showed significant differences between the mortality percentage on the 1st, 2nd, and 3rd day of treatment, while no significant differences were recorded on the 4th and 5th day, this is due to the death of all *S. littoralis* 2nd instar larvae populations used in the experiment (Table 3).

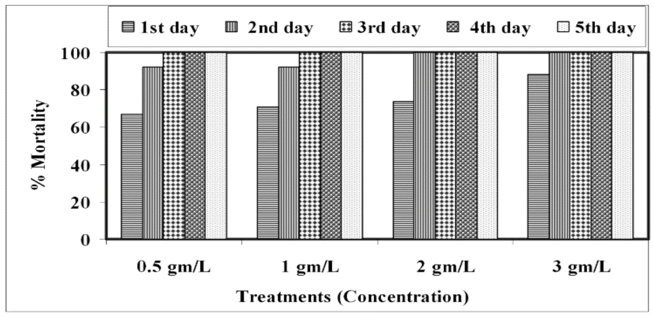

Figure 8. Effect of emamectin-benzoate concentrations on 2nd instar larvae of *S. littoralis* mortalities under laboratory conditions.

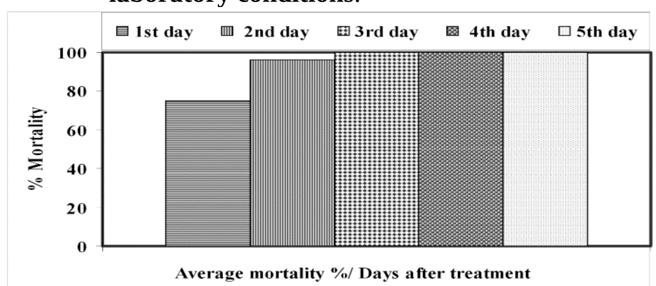

Figure 9. Duration effects of exposure on 2nd instar larvae of *S. littoralis* mortalities under laboratory conditions.

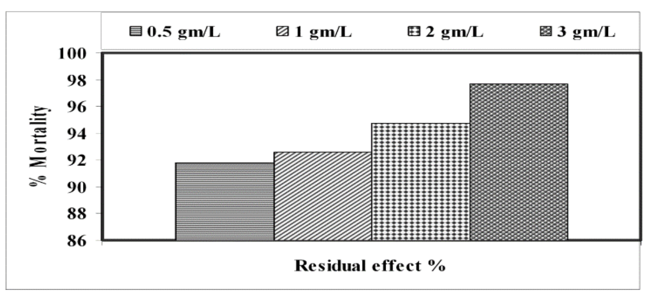

Figure 10. Emamectin-benzoate residuals on 2nd instar larvae of *S. littoralis* mortalities under laboratory conditions.

DISCUSSION

The practical insect control requires the strategy that can keep the pest population under economic threshold level to protect crop losses to increase crop production. The loss caused by an insect pest can be estimated according to the insect species, their numbers and densities, most infective stage of insect pest and the stage of the crop that is most susceptible for pest attack. (Sharma *et al*., 2001). Without the use of chemical insecticides, an estimated two-thirds of crop production will be lost; millions of people will be denied to get their daily essential food (Aktar *et al*., 2009). Also, due to the heavy reliance on chemical pesticides, there are a number of environmental problems including the development of insect resistance against the majority of commercial insecticides.

Nowadays, new chemical insecticides are needed to regulate or suppress pest populations or activities in order to produce the highest crop yield: quantity as well as value (Abdel-Baky and Al-Soqeer, 2017). Consequently, certain chemical insecticides may be applied directly against a wide range of insect pests with higher mortality rates (Abdel-Baky and Al-Soqeer, 2017).

The obtained results confirmed that the efficacy of emamectin-benzoate can eradicate the larvae of *T. absoluta* even inside the tunnels of tomato leaves, although, it was reported in several studies that many effective chemical compounds failed to suppress the infestation of *T. absoluta* inside the tunnels (Cocco *et al*., 2013). Furthermore, it was justified that the endophytic habit of its larvae can protect it inside the leaves. In this study, emamectin-benzoate was found to be highly effective in controlling the larvae of *T. absoluta* even inside the tunnels of tomato leaves as it can cause 100% mortality after 3 days of exposure to the lowest concentration tested (0.5gm/L). Results also proved that emamectin-benzoate requires prolonged exposure to be highly effective especially with a low concentration. Its effects on 2^{nd} instar larvae of *T. absoluta* were visible from the 1^{st} day of treatment and continued increasingly with time (Table 2; Figure 5). These findings were consistent with findings of several studies done in evaluating the toxicity of emamectin-benzoate against *T. absoluta*. For example, Hanafy and El-Sayed (2013) found that the efficacy of the following insecticides; spinetoram, spinosad, emamectin-benzoate, indoxacarb, caragen and chorfenaper were concentration and time dependent. Thus, the above statement can conclude that an immediate mortality *T. absoluta* larvae cannot be obtained after the application of certain chemical insecticides. It would be very convenient to evaluate the efficacy of emamectin-benzoate against the larvae of *T. abslouata* inside the fruits of tomato plants, but the residual effects must be taken into consideration. Furthermore, the impact of insecticide's active ingredient differed according to the concentration dose and the exposure periods (Table 2 and 4). Therefore, the above-mentioned results revealed that the all tested insecticides had a toxic effect on *T. absoluta* and caused biochemical disturbance in their bodies. So that a small amount from the effective chemical insecticides could be used in rotation with Insect Growth Regulator (IGRs) and bio-insecticides in the IPM program of *T. absoluta*. Abdel-Baky and Al-Soqeer (2017) reported that Simmondsin in extractions had a great impact on controlling the 2^{nd} instar larvae of *T. absoluta*. They concluded that the use of Simmondsin extracts was a good alternative to the effective chemical insecticides only particularly with fresh vegetables and could be implemented within IPM programs. In another study, Zeolites caused higher mortality rates in eggs and larvae of *T. abslouata*, when the particle film was residually applied. Significant differences in mortality rates from exposure to zeolites compared to other products, such as kaolin, its formulated product Surround, and the insecticide spinosad, were discerned (De Smedt *et al.*, 2016).

On the other hand, much concerns of the damage of *S. littoralis* on the fruits, significantly reduced the percentage of infested barriers in comparison with the non-infested. The Obtained results showed that the efficacy of emamectin-benzoate against *S. littoralis* larvae was observed at all concentrations tested with no statistically significant difference between the four different treatments. Furthermore, maximum mortality was seen at the lowest concentration tested (0.5gm/L) after 3 days of treatment. That means emamectin-benzoate can persist as its effect is increasing with time. These findings were consistent with the results of Abduallah (2011) as he recorded that emamectin-benzoate was effective in controlling *S. littoralis* larvae and persistent under field conditions.

***Conclusion*:** The tested insecticide was found effective against the tomato leaf miner, *T. absoluta* and *S. littoralis* 2^{nd} instar larvae. This insecticide proved highly toxic to both insect pests tested. Finally, emamectin-benzoate is a tested insecticide which has toxic effect on the tomato leaf miner and the Egyptian cotton leaf worm. Consequently, we can use small amount of this insecticide and it can be implemented in the successful IPM program against lepdiopterous insect pests. The application of emamectin-benzoate at various concentrations (0.5, 1.0, 2.0, and 3.0 gm/L) caused mortalities among *T. absoluta* and *S. littoralis* 2^{nd} instar larvae and reached 100% from the 3^{rd} day of treatment. It is recommended that emamectin-benzoate may be used as one of the best chemical control against certain lepidopterous insects and further evaluation is needed to analyze its effects against beneficial insects and other pests.

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