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Research Article

Effectiveness of certain insecticides against the tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)

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ABSTRACT

Eight insecticides used in the present study were chloropyriphose, methomyl, lambada cyhalothrine, imidacolpyrid, abamectin, chlorfenapyr, chlorantraniliprole, and emamectin benzoate representing different insecticides with different modes of action were chosen to evaluate their toxicity against the tomato leaf miner, *T. absoluta* under laboratory and field condiations. Data clearly indicate that the order of efficiency of the tested insecticides was the same at both LC_{50} and LC_{90} levels. The tested insecticides could be descendingly arranged as follows: abamectin, chlorfenapyr, chlorantraniliprole, methomyl, emamectin benzoate, chlorpyrifos, lambada cyhalothrin, and imidacloprid. Also, the field results took the same trend of laboratory ones. The results indicated that all the tested insecticides had significantly affected the insect population and the average percentages reduction of infestation with *T. absoluta* in tomato field. The average percentages reduction of infestation had affected by tested insecticides and part of plant (leaves & fruits). It is recommended by using abamectin, chlorfenapyr, and chlorantraniliprole in controlling this insect according to their potency.

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a major pest of fresh tomatoes both in greenhouse and field. It was first described in Peru in 1917 and is now widespread in all the tomato-producing areas of South America (Desneux *et al.*, 2010). The tomato leafminer was first recorded in Europe in 2006 in Spain (Urbaneja *et al.*, 2007). However, after its introduction in Europe, *T. absoluta* rapidly became a threat to global tomato production (Desneux *et al.*, 2011), and then spread rapidly to all Mediterranean countries (Guenaoui, 2008; Viggiani *et al.,* 2009; Kilic, 2010), North Europe (United Kingdom, Germany, Lithuania) (EPPO 2010; Ostrauskas & Ivinskis, 2010; Đurić *et al.*, 2012), northern Africa (Algeria, Morocco, Tunisia, Egypt) (EPPO, 2009; Abbes *et al*., 2012) and Middle East (Syria, Saudi Arabia, Iraq, Iran) (Anonymous, 2011; Abdul Razzak *et al*.,2010). *T. absoluta* larvae can completely destroy the tomato canopy by mining leaves, stems and buds and burrowing tunnels in the fruits, causing the unmarketability of fresh tomatoes and yield losses up to 100% (Viggiani *et al.,* 2009).

Tuta absoluta can develop on cultivated and wild Solanaceae. However, its preferred host plant is tomato *Lycopersicon esculentum* (Mill). It can also occur on potato *Solanum tuberosum* (L.), eggplant *S. melongena* (L.), sweet pepper *S. muricatum* (L.), pepino *S. muricatum* (Aiton), and tobacco *Nicotiana tabacum* (L.). The pest appears to be adapting to new host plants, as it was recently recorded on Cape gooseberry *Physalis peruviana* (Tropea Garzia, 2009) and bean *Phaseolus vulgaris* in Italy (EPPO, 2009). In the absence of cultivated Solanaceae, this pest can attack a wide range of weeds of the same family or the genus Datura, such as *Datura stramonim* (L.) and *Datura ferox* (L.) (Pereyra & Sanchez, 2006; Desneux *et al.,* 2010).

Control of tomato leafminer infestations is difficult, because of the endophytic habit of larvae, which are protected in the leaf mesophyll or inside fruits. In South America, *T. absoluta* control relied on repeated insecticide treatments (Picanço *et al.,* 1995). Organophosphates and pyrethroids were used in control *T. absoluta* during the 1970's and 1980's until new products introduced in the 1990's (such as abamectin, spinosad, tebufonzide, and chlorfenpyr) became available (Lietti *et al.,* 2005). Also, abamectin, cartap, chlorfenapyr, phenthoate, methamidophos, spinosad, and indoxacarb, were recommended for controlling *T. absoluta* and use in the south, southeastern, and savannah tomato-growing regions, while chlorfenapyr, phenthoate, and spinosad were recommended for use in the northeastern region (IRAC, 2007). The objective of our study is evaluating the toxicity of the certain insecticides against the tomato leafminer, *T. absoluta* on tomato plants under open-field conditions.

Materials and Methods

The following insecticides were used to evaluate their toxicity against tomato borer, *T. absoluta* through laboratory and field assessments (Table 1).

Vegetable crop investigated

Tomato plants *Lycopersicon esculentum* Mill Varity Super strain B Hybrid was cultivated in university farm to use the tomato plants in the present expermients.

Insects

T. absoluta specimens were collected from tomato fields located in the farm of Agriculture Faculty of South Valley University, Qena Governorate; south of Egypt and transported in the laboratory to assay of certain insecticides.

Bioassey and toxicity studies

The 4^{th} instars larvae of *T. absoluta* were collected from infected tomato leaves. The residual film bioassay method was used to evaluate the toxicity of the tested insecticides. Toxicity was expressed as LC_{50} in mg/L or

Table 1. *Insecticides used in the study*

No	Common name	Trade name	Formulation type	Conc.	Rate (ml/ 100L water)	Chemical group
1	Chloropyriphose	Dursban H48	EC	48 %	500 ml	Organophosphate
2	Methomyl	Lannate	SP	90 %	100g	Carbamate
3	Lambada Cyhalothrine	Lambada touch	EC	5 %	100 ml	Pyrethroid
4	Imidacolpyrid	Imidor	EC	35 %	75 ml	Neonicotinoid
5	Abamectin	Vertimec	EC	1.8 %	40 ml	Evermectin
6	Chlorfenapyr	Challenger	SC	36 %	40 ml	Chlorinated pyrrole.
7	Chlorantraniliprole	Coragen	SC	20 %	20 ml	Ryanodine
8	Emamectin benzoate	Proclaim	SG	5 %	60 g	Emamectin

ppm. The serial concentrations of each insecticide tested were sufficient to cover almost a complete range of mortality. Three replicates per each concentration were used and each replicate contain 10 larvae. Mortality was recorded 24 h after treatment. Controls were sparyed with 0.5 ml water. Temperature was maintained at 30 ±1°C during bioassay time. The mortality recordss were corrected using Abbot's formula (1925). Concentration-mortality regression lines were analyzed using a computer program modified from the method of Finney (1971) to estimate the LC_{50}, the confidence limits and the slopes of LCp lines.

Field experiments

Field experiments were carried out in the farm of Agriculture Faculty, South Valley University, Qena Governorate, Egypt, during the two successive seasons (2011/ 2012), and (2012/ 2013) (starting on 18th November till the 23rd of May). The experimental area was divided into plots, each is $40m^2$ (1/ 100 fed.) and arranged in randomized complete blocks with three replicates. Three plots were left untreated to serve as control. The normal agricultural practices were done. Field experiments were conducted to evaluate the tested insecticides, i.e., chloropyriphose, methomyl, lambada-cyhalothrin, imidacolpyrid, abamectin, chlorfenapyr, chlorantraniliprole, and emamectin benzoate against *T. absoluta* in the tomato field during both 2012 and 2013 seasons. The tested insecticides were applied two times at two weeks intervals; on 10th and 25th October in two seasons. The insecticides were applied at the recommended rate (500 ml, 100 g, 100 ml, 75 ml, 40 ml, 40 ml, 20 ml, and 60 g of the aforementioned insecticides, respectively/ 100L water) using Knapsack hand spray fitted with one nozzle. The recommended amount was diluted with 200 litters of water per feddan. The control plots were sprayed only with water. Also, care was taken to avoid any drift among the treated plots.

Managemnet of T. absoluta in tomato leaves

Sample of 150 leaves were randomly collected from each treatment (representing three replicates; each replicate consist of ten plants) to determine the number of live larvae under the binucular. Infestation was assessed before spraying and after 3, 5, 7, 9, 12, and 15 days.

Managemnet of T. absoluta in tomato fruits

Also, sample of 300 fruits were randomly collected from each treatment (representing three replicates; each one consist of twenty plants) to determinate the fruit infestation ratio. The present of reduction in infestation in each case calculated using Handerson & Tilton equation (1955).

Statistical analysis

Data of the present study were statistically analyzed according to GLM in ANOVA. The comparisons among the means of different treatments were carried out using the revised LSD test using program MSTAT software version.

Results and Discussion

Bioassays for evaluation of the relative toxicity of certain insecticides against the 4th instar larvae of tomato leafminer, T. absoluta under laboratory conditions

Table (2) shows the LC_{50}, lower and upper values of confidence limits, slopes of LCp-lines and the descending order of toxicity for the tested insecticides against the field strain. Data clearly indicate that the order of efficiency of the tested insecticides was the same at both LC_{50} and LC_{90} levels. The tested insecticides could be descendingly arranged as follows: abamectin, chlorfenapyr, chlorantraniliprole, methomyl, emamectin benzoate, chlorpyrifos, chlorantraniliprole, cyhalothrin, and imidacloprid. Based on the LC_{50} values the results indicated that the evermectin insecticide abamectin was the most toxic insecticide (LC_{50} =48.02 mg/L) followed by chlorfenapyr (154.64), chlorantraniliprole (314.73), methomyl (539.99), emamectin benzoate (566.36), chlorpyrifos (899.71), cyhalothrin (1663.90), and imidacloprid (2115.70). The difference in toxicity between the most toxic insecticide (Abamectin) and the least toxic one (imidacloprid) was up to 44.06 fold. The corresponding LC90values were 678.76, 1884.63, 3540.34, 4797.71, 6545.56, 12028.37, 34962.43, and 62008.05. It is obvious, as shown in Table (2), that abamectin had the steepest toxicity line and imidacloprid had the flattest, these reflect the superiority of abamectin and inferiority of imidacloprid. It is clear that abamectin the most toxic compound whereas imidacloprid imidacloprid was the least toxic one. These results were in agreement with those of Gontijo *et al.* (2012) stated that most populations of *T. absoluta* were susceptible to abamectin, chlorfenapyr and spinosad and not to bifenthrin, triflumuron and teflubenzuron. Roditakis *et al.* (2013) estimated the toxicity of certain insecticides registered for *T. absoluta* control in Greece. The results indicated that Low heterogeneity was detected in the populations tested with most insecticides. The LC_{50} ranged from 0.31 to 1.31 mg / L for flubendiamide, from 0.12 to 0.53 mg L−1 for chlorantraniliprole, from 0.03 to 0.12 mg / L for emamectin benzoate, from 0.08 to 0.26 mg / L for spinosad, from 31.8 to 159.5 mg / L for metaflumizone, from 1.73 to 17.5 mg / L for indoxacarb, from 530 to 2038 mg / L for chlorpyriphos and finally from 475 to 794 mg L−1 for cypermethrin. Radwan & Taha (2012) tested five insecticides on moths and 3rd instar larvae of *T. absoluta.* The results obtained that Imidacloprid was the superior toxicant against to moths and larvae of this insect. Phenthoate and thiocyclam H.O. had high toxic effect on two stages. Dinotefuran seemed to have moderate effect on moths and the same trend was observed with fenoxycarb on larvae.

Shalaby *et al.* (2012) revealed that profenofos, cyfluthrin, lufenuron, chlorpyriphos-methyl and indoxacarb were the most toxic insecticides as compared to other chemicals against tomato leaf miner, *T. absoluta* under the laboratory condations. Hafsi *et al*. (2012) showed a medium to low efficacy of bio-insecticides on all instars of *T. absoluta* except for *Bacillus thuringiensis* Berliner var. kurstaki which was distinguished by an average mortality of 72.5%. Spinosad and Spinetoram

Table 2. *Toxicity of insecticides against the 4th instar larvae of field strain of T. absoluta under field condations*

Treatment	LC_{50} ppm	LC_{90} ppm	Slope	Toxicity index at LC_{50}	Confidence limits at LC_{50}	
					Lower	Upper
Abamectin	48.02	678.76	1.114	100	33.01	63.53
Chlorfenapyr	154.64	1884.63	1.180	31.05	117.11	194.59
Chlorantraniliprole	314.73	3540.34	1.219	15.26	253.01	399.85
Methomyl	539.99	4797.71	1.351	8.89	431.99	721.78
Emamectin benzoate	566.36	6545.56	1.206	8.48	442.03	787.97
Chlorpyrifos	899.71	12028.37	1.138	5.33	655.16	1450.97
Cyhalothrin	1663.90	34962.43	0.969	2.89	1004.41	5121.45
Imidaclopride	2115.70	62008.05	0.862	2.27	1378.49	4469.98

Table 3. *Mean number of infested leaves with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application on tomato (2011/ 2012)*

Treatment	Before spray	First spray					Second spray					General mean
		1	3	7	15	mean	1	3	7	15	mean	
Abamectin	35.00	13.33	9.33	7.33	9.67	9.91	5.00	4.33	3.67	6.67	4.92	7.42
Chlorfenapyr	34.00	13.00	9.67	9.33	13.67	11.42	6.67	5.33	5.00	7.33	6.08	8.75
Chlorantraniliprole	33.33	13.33	9.33	8.33	10.00	10.25	6.67	5.00	4.33	5.67	5.42	7.84
Methomyl	34.67	10.67	11.67	12.33	16.33	12.75	8.00	7.33	10.67	15.33	10.32	11.54
Emamectin benzoate	35.33	16.00	13.67	13.33	18.00	15.25	10.00	8.33	9.00	14.00	10.33	12.79
Chlorpyrifos	34.67	18.67	16.33	17.33	23.00	18.83	14.67	13.67	18.00	22.00	17.08	17.96
Imidaclopride	33.67	18.00	16.67	17.67	22.33	18.67	15.33	14.67	17.67	18.67	16.58	17.63
Cyhalothrin	35.67	19.00	14.00	13.67	18.33	16.25	11.33	10.33	10.33	14.00	11.50	13.88
Control	33.33	39.67	43.00	48.33	61.00	48.00	52.00	51.33	57.33	49.67	52.58	50.29

Table 4. *The percentages reduction in infestation of infested leaves with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application (2011/ 2012)*

Treatment	First spray					Second spray					General mean
	1	3	7	15	mean	1	3	7	15	mean	
Abamectin	68.0	79.0	85.5	89.5	80.3	90.0	92.0	93.0	87.0	90.5	85.37
Chlorfenapyr	67.0	77.9	81.0	78.0	75.3	87.0	89.0	91.0	85.0	88.0	81.87
Chlorantraniliprole	66.0	78.0	82.0	83.6	77.3	87.0	90.0	92.0	88.0	89.3	83.25
Methomyl	74.0	73.9	75.0	74.0	74.0	85.0	86.0	82.0	70.0	80.8	77.37
Emamectin benzoate	61.9	61.0	73.0	72.0	66.9	81.0	84.0	85.0	73.0	80.8	73.83
Chlorpyrifos	54.7	63.0	65.0	63.7	61.6	72.0	74.0	69.0	57.0	68.0	64.80
Cyhalothrin	55.0	69.0	73.0	76.0	68.25	79.0	81.0	83.0	73.0	79.0	73.62
Imidaclopride	55.0	61.0	63.0	63.0	60.5	70.0	71.0	69.0	62.0	68.0	64.25

based insecticides showed high efficiency in controlling all instars of larvae with respectively an average mortality of 66.5% and 85.6%. However, this study revealed a unique ovicide effect of azadirachtinneem oil based insecticide with 43.8% egg mortality.

Effect of the tested insecticides against T. absoluta infested tomato leaves in tomato field during two seasons

Data in Tables (3& 4) show the larvicidal action of the eight tested insecticides. It is abvious that number of living larvae/ 100 leaflets was greatly decreased after insecticide application. Counting the surviving larvae may be more accurate than counting the mines which do contain dead larvae empty mines as well as the living ones. Also, data indicated that all the tested insecticides had significantly affected the insect population (larval instar) from infested leaves. Abamectin was the more effective than other tested insecticides. The insecticides are arranged according to their potency as follow; abamectin, chlorantraniliprole, chlorfenapyr, methomyl, emamectin benzoate, cyhalothrin, imidaclopride, and chlorpyrifos. General mean of infested leaves with tomato borer, *T. absoluta* larval stage post spraying on tomato plants in the first season were 7.42, 7.84, 8.75, 11.54, 12.79, 13.88, 17.63, and 17.96, while the average percentages reduction of infestation were 85.37, 83.25, 81.87, 77.37, 73.83, 73.62, 64.25, and 64.80 % in the first season. While, in the second season were 84.90, 86.39, 78.55, 75.00, 81.00, 70.40, 36.30, and 36.50 % as shown in Tables (5& 6). In the firest season it's obvious that from data abamectin was the most effective insecticides and chlorpyrifos was the least effective, while in the second season were chlorantraniliprole was the most effective insecticides and imidaclopride was the least effective. Chlorfenapyr, methomyl, emamectin benzoate, and cyhalothrin were intermediate position. The tested insecticides showed a variable adverse effect on *T. absoluta,* this may be due to the differences between the chemical structure, mode of action of the used compound, and the prevailing environmental conditions during individual studies. All these factors played an important role on the pesticide disappearance from plants and influencing in efficacy of tested insecticides. The uptake of insecticide by the outmost layers of the plant surface and the following criteria which depend on the uptake amounts of the used insecticide, e. g., the permeability, the binding with the plant tissues and the metabolism, greatly differ depending on the chemical structure of this compound, the plant species and even the target of the same species, the climatic conditions, and the used spraying equipment as reported by Nigg & Stamper (1980).

Abamectin is a highly toxic compound, however most formulated products containing abamectin are of low toxicity to mammals as stated by Hayes & Laws (1990), and used to control insect and mite pests of a range of agronomic, fruit, vegetable and ornamental crops as confirmed by Lankas *et al*. (1989). Imidacloprid is a neonicotinoid insecticide in the chloronicotinyl nitroguanidine chemical family (Tomlin, 2006). Neonicotinoid insecticides are synthetic derivatives of nicotine, an alkaloid compound found in the leaves of many plants in addition to tobacco (Copping, 2001). These results were agreement with those of Braham *et al.* (2012), who reported that good efficacy of the following products: Tracer (spinosad), Nimbecidine (azadirachtin), Biocatch (Verticillium lecanii), Voliam Targo (chlorantraniliprole + abamectin), Tutafort (plant extracts), and Vydate (oxamyl) for the control of T. absoluta on tomatoes grown in greenhouses. However, laboratory trials demonstrate good performance of Challenger (chlorfenapyr), Ampligo (chlorantraniliprole + lambda-cyhalothrin), Movento (spirotetramat), Armorex (plant extracts), Deffort (plant extracts), and Konflic (plant extracts). Similar results were recorded by Gontijo *et al.* (2012), who found that most populations of *T. absoluta* were susceptible to abamectin, chlorfenapyr and spinosad and not to bifenthrin, triflumuron and teflubenzuron. Hanafy & El-Sayed (2013) evaluated three bio-insecticides and four chemical insecticides for their efficacy in the control of *T. absoluta*. Results obtained that Spinetoram exhibited the highest toxic effect in reducing infestation of T.

Table 5. *Mean number of infested leaves with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application (2012/ 2013)*

Treatment	Before spray	First spray 1	3	7	15	mean	Second spray 1	3	7	15	mean	General mean
Abamectin	13.33	6.00	5.33	4.67	6.33	5.58	4.00	3.67	3.33	4.67	3.92	4.75
Chlorfenapyr	15.33	6.00	4.67	4.67	5.33	5.17	3.00	3.00	3.67	6.33	4.00	4.58
Chlorantraniliprole	14.67	6.33	4.33	3.67	4.67	4.75	3.67	3.33	2.67	4.67	3.58	4.16
Methomyl	13.33	5.67	6.33	6.33	10.33	7.16	7.00	6.33	9.67	11.00	8.50	7.83
Emamectin benzoate	14.0	6.67	6.33	7.00	9.00	7.25	5.67	4.67	7.00	9.67	6.75	7.00
Chlorpyrifos	14.0	8.00	8.00	9.67	14.00	9.92	9.67	9.33	13.33	16.33	12.16	11.04
Cyhalothrin	14.67	10.33	10.33	13.00	17.33	12.75	12.33	11.67	14.33	18.67	14.25	13.50
Imidaclopride	13.0	9.00	8.33	10.00	13.33	10.17	8.67	8.00	9.67	15.00	10.33	10.25
Control	14.33	21.00	25.67	33.00	41.67	30.33	45.33	45.00	49.00	45.67	46.25	38.25

Table 6. *The percentages reduction in infestation of infested leaves with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application (2012/ 2013)*

Treatment	First spray 1	3	7	15	mean	Second spray 1	3	7	15	mean	General mean
Abamectin	69.2	77.6	80.4	83.6	77.5	90.5	91.4	92.6	95.0	92.3	84.90
Chlorfenapyr	73.2	82.9	82.9	88.0	63.25	93.0	93.8	92.9	94.5	93.5	78.55
Chlorantraniliprole	70.5	70.4	86.0	89.0	78.97	92.0	92.9	94.6	95.8	93.8	86.39
Methomyl	70.9	52.5	72.0	73.0	66.89	83.0	85.0	75.8	89.0	83.2	75.00
Emamectin benzoate	67.4	74.7	72.0	77.9	73.0	87.0	89.0	85.3	98.0	89.8	81.00
Chlorpyrifos	60.9	68.0	73.4	65.6	66.7	78.0	79.0	75.0	84.0	79.0	36.50
Cyhalothrin	51.8	60.6	46.8	62.6	65.1	73.4	75.0	72.0	83.0	75.8	70.40
Imidaclopride	52.0	64.2	78.9	65.6	65.17	78.9	80.0	78.0	84.0	80.22	36.30

Table 7. *Mean number of infested fruits with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application (2011/ 2012)*

Treatment	Before spray	First spray 1	3	7	15	mean	Second spray 1	3	7	15	mean	General mean
Abamectin	32.00	31.00	28.67	27.00	24.67	27.83	23.67	22.00	20.33	18.33	21.08	24.45
Chlorfenapyr	33.00	32.00	30.33	28.67	26.67	29.42	26.00	24.33	23.33	22.00	23.91	26.67
Chlorantraniliprole	34.67	33.33	30.67	31.33	25.00	30.08	24.00	22.33	20.33	18.00	21.16	25.62
Methomyl	34.00	33.33	31.67	32.67	35.33	33.25	34.33	33.00	34.33	37.67	39.83	34.04
Emamectin benzoate	35.67	35.00	33.67	34.67	37.00	35.08	36.00	34.33	35.33	38.00	35.91	35.49
Chlorpyrifos	33.33	32.67	31.67	33.33	37.67	33.86	37.33	35.00	37.67	42.33	38.33	36.09
Cyhalothrin	33.33	32.67	31.33	33.33	38.33	33.91	38.00	37.00	40.33	45.67	40.25	37.08
Imidaclopride	31.33	30.67	29.33	30.00	33.33	30.83	32.67	32.33	39.00	38.00	34.25	32.54
Control	34.67	36.67	39.67	45.67	59.33	45.33	62.67	68.67	82.33	92.33	76.50	60.91

absoluta followed by Spinosad then Emamectin. These effects were concentration dependanton the tested considered chemical isecticides, Pyridalyl was the most effective in reducing infestation of *T. absoluta* followed by Chlorantraniliprole, then Indoxcarb and least by Chlorfenapyr.

Effect of the tested insecticides against T. absoluta infested tomato fruits in tomato field during two seasons

Data in Tables (7& 8) showed that the insecticidal treatments decreased the mean number of the infested fruits/ 25 fruits on tomato plants, and percentage of infestation. In both seasons, the percentage reduction of infestation increased in the 1st week, while decreased in

Table 8. *The infestation percentages reduction in infested fruits with T. absoluta larval stage post treaments after 1, 3, 7 and 15 days of application (2011/ 2012)*

	First spray					Second spray					General
Treatment	**1**	**3**	**7**	**15**	**mean**	**1**	**3**	**7**	**15**	**mean**	**mean**
Abamectin	8.40	21.69	35.94	54.94	30.24	59.00	65.28	73.24	78.49	69.00	49.62
Chlorfenapyr	8.31	19.67	34.04	52.77	28.70	56.00	62.77	70.22	74.96	65.99	47.34
Chlorantraniliprole	9.10	22.68	31.39	57.86	30.26	61.76	67.48	75.30	80.50	71.26	50.76
Methomyl	7.31	18.59	27.05	39.27	23.06	44.14	50.99	57.48	85.39	59.50	41.28
Emamectin benzoate	7.22	17.50	26.21	39.38	22.58	44.16	51.40	58.29	59.99	53.46	38.02
Chlorpyrifos	7.32	16.95	24.08	33.95	20.58	38.00	46.98	52.40	52.31	47.42	34.00
Cyhalothrin	7.32	17.85	24.08	32.79	20.51	36.92	43.95	49.04	48.54	44.61	32.56
Imidaclopride	7.44	18.18	27.30	37.83	22.69	42.32	47.9	47.57	54.45	48.06	35.37
Control											

Table 9. *Mean number of infested fruits with T. absoluta larval stage post spraying with the tested insecticides after 1, 3, 7 and 15 days of application (2012/ 2013)*

	Before	First spray					Second spray					General
Treatment	**spray**	**1**	**3**	**7**	**15**	**mean**	**1**	**3**	**7**	**15**	**mean**	**mean**
Abamectin	11.67	11.33	10.33	9.33	8.33	9.83	7.67	7.00	6.33	5.33	6.38	8.20
Chlorfenapyr	11.33	11.00	10.33	9.67	8.67	9.92	8.33	7.67	7.00	6.00	7.25	8.58
Chlorantraniliprole	13.33	12.67	11.32	10.00	8.67	10.67	8.33	7.67	6.67	5.33	7.00	8.83
Methomyl	12.00	11.67	11.00	11.67	12.67	11.75	12.33	11.67	12.33	14.33	12.67	12.21
Emamectin benzoate	13.33	13.00	12.33	13.00	13.67	13.00	13.33	12.67	13.00	14.00	13.25	13.13
Chlorpyrifos	12.00	11.67	11.67	13.00	14.00	12.58	13.67	13.33	14.67	18.00	14.92	13.75
Cyhalothrin	12.67	12.33	12.33	13.67	16.00	13.58	15.67	15.00	16.67	20.67	17.00	15.29
Imidaclopride	11.67	11.33	11.33	12.00	13.00	11.91	12.67	12.00	12.67	14.33	21.25	16.58
Control	13.33	14.67	17.33	22.00	29.00	20.75	33.67	40.67	51.00	61.67	46.75	33.75

Table 10. *The infestation percentages reduction in infested fruits with T. absoluta larval post treaments after 1, 3, 7 and 15 days of application (2012/ 2013)*

	First spray					Second spray					General
Treatment	**1**	**3**	**7**	**15**	**mean**	**1**	**3**	**7**	**15**	**mean**	**mean**
Abamectin	11.78	31.91	51.55	67.18	40.61	45.88	80.34	85.82	90.12	75.54	58.07
Chlorfenapyr	11.78	29.87	48.28	64.8	38.68	43.75	77.81	83.85	88.55	73.49	56.09
Chlorantraniliprole	13.63	34.67	54.54	70.10	43.24	48.57	81.14	86.92	91.35	76.99	60.11
Methomyl	11.63	29.49	41.07	51.46	33.41	37.09	68.12	73.14	74.18	63.13	48.27
Emamectin benzoate	11.38	28.85	40.96	52.86	33.51	37.34	68.84	74.50	77.24	64.48	49.00
Chlorpyrifos	11.63	25.19	34.35	46.37	29.39	32.65	63.56	68.04	67.57	57.96	43.67
Cyhalothrin	11.57	25.14	34.62	41.95	28.32	31.14	61.19	65.61	64.73	55.67	42.00
Imidaclopride	11.78	25.32	37.69	52.73	31.88	34.43	66.29	71.62	73.45	61.45	46.66

the 2nd week, this may be due to rate of decomposition of pesticides from plants. General mean of infested fruits with tomato borer, *T. absoluta* larval stage post spraying on tomato plants in the first season were 24.45, 26.67,25.62, 34.04, 35.49, 36.09, 37.08, and 32.5 and for abamectin, chlorfenapyr, chlorantraniliprole, methomyl, emamectin benzoate, chlorpyrifos, cyhalothrin, and imidaclopride, respectively. The corosponding Tables (9& 10) in 2nd season were 8.20, 8.58, 8.83, 12.21, 13.13, 13.75, 15.29, and 16.58. According to the recommendation of the Egyptian ministry of agriculture for using the insecticides and their alternative in controlling pests, effective materials should give initial effect not less than 70% reduction and residuals effect not less than 40% reduction. According to this recommendation, result in Tables (7 &8) show that the average percentages reduction of infestation for abamectin, chlorfenapyr, chlorantraniliprole, methomyl, emamectin benzoate, chlorpyrifos, cyhalothrin, and imidaclopride on the tomato fruits were 49.62, 47.34, 50.76, 41.28, 38.02, 34.00, 32.56, and 35.37 %, respectively in the first season. In the second season, the corresponding values were 58.07, 56.06, 60.12, 48.27, 49.00, 43.67, 42.00, and 46.67%. It's obvious that from data chlorantraniliprole was the most effective insecticides and cyhalothrin was the least effective. This study obtained that there is a slight difference in the efficiency of pesticides tested between leaves and fruits due to the amount of pesticides that are located on the surface plant. The present study confirms the findings of Alsayeda *et al.* (2008) reported that more than 85% of the imidacloprid taken up by the tomato plants was translocated to the shoots, and only small quantities were found in the roots. Shoot concentrations declined towards the top of the plant. The tomato fruits also contained imidacloprid, although tissue concentrations were not related to the position of the fruits on the plant. Chlorpyrifos is an organophosphat is moderately toxic to humans, for acute effects, the EPA classifies chlorpyrifos as Class II, and non-systemic insecticide with contact, stomach, and respiratory act (Annoymous, 1989). There are very few studies of insecticide resistance in *T. absoluta*. Salazar & Araya (1997) recorded resistance to deltamethrin, metamidophos, esfenvalerate, lambdacyhalothrin and mevinphos in Chilean populations of *T. absoluta.*

References

1. Abbes K, Harbi A & Chermiti B. (2012). Comparative study of 2 protection strategies against *Tuta absoluta* (Meyrick) in late open field tomato crops in Tunisia. Bulletin OEPP/EPPO Bulletin, 42: 297–304.
2. Abbott WA. (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18: 265-267.
3. Abdul Razzak AS, Al-Yasiri II & Fadhil HQ. (2010). First record of tomato borer (tomato moth) *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato crop in Iraq. Arab Near East Plant Protection Newsletter 51, 34.
4. Alsayeda H, Pascal-Lorber S, Nallanthigal C, Debrauwer L & Laurent F. (2008). Transfer of the insecticide [14C] imidacloprid from soil to tomato plants. Environmental Chemistry Letters 6: 229-234.
5. Anonymous (1989). U.S. Environmental Protection Agency. Registration Standard (Second Round Review) for Re-registration of Pesticide Products Containing Chlorpyrifos. Washington, DC, 5-44
6. Anonymous (2011). *Tuta absoluta* News. http://www.tutaabsoluta.com/ news/ [accessed on 1 December 2011].
7. Braham M, Glida-Gnidez H & Hajji L. (2012). Management of the tomato borer, *Tuta absoluta* in Tunisia with novel insecticides and plant extracts. Bulletin OEPP/EPPO Bulletin 42: 291–296.

8. Copping LG. (2001). The Biopesticide Manual, 2nd ed.; British Crop Protection Council: Surrey, England, pp 202-203.
9. Desneux N, Luna MG, Guillemaud T & Urbaneja A. (2011). The invasive South American tomato pinworm, *Tuta absoluta*, continues to spread in Afro-Eurasia and beyond: the new threat to tomato world production. Journal of Pest Science 84: 403–408.
10. Desneux N, Wajnberg E, Wyckhuys KAG, Burgio G, Arpaia S, Narváez-Vasquez CA, González-Cabrera J et al. (2010). Biological invasion of European tomato crops by *Tuta absoluta*: ecology, geographic expansion and prospect for biological control. Journal of Pest Science 83: 197–215.
11. Đurić Z, Hrnčić S, Vujanović M, Đurić B & Mitrić S. (2012). *Tuta absoluta* (Meyrick) (Lepidoptera, Gelechiidae) in the Republic of Srpska (Bosnia and Herzegovina). OEPP/EPPO, EPPO Bulletin 42: 337–340.
12. EPPO (2010). First record of *Tuta absoluta* in Germany. EPPO Reporting Service 1, 3.
13. EPPO (2009*). Tuta absoluta* found on *Phaseolus vulgaris* in Sicilia (IT). EPPO Reporting Service 8, 3.
14. Finney DJ. (1971). Probit Analysis. (3rd Edition ed.), Cambridge Uni Press, Cambridge.
15. Gontijo PC, Picanço MC, Pereira EJG, Martins JC, Chediak M & Guedes RNC. (2012). Spatial and temporal variation in the control failure likelihood of the tomato leaf miner, *Tuta absoluta*. Annals of Applied Biology 162: 50–59.
16. Guenaoui Y. (2008). Nouveau ravageur de la tomate en Algérie. Premiére observation de *Tuta absoluta*, mineuse de la tomate invasive, dans la région de Mostaganem, au printemps 2008. Phytoma – La Défense des Végétaux 617: 18–19.
17. Hafsi A, Abbes K, Chermiti B & Nasraoui B. (2012). Response of the tomato miner *Tuta absoluta* (Lepidoptera:Gelechiidae) to thirteen insecticides in semi-natural conditions in Tunisia. Bulletin OEPP/EPPO Bulletin 42: 312–316.
18. Hanafy HEM & El-Sayed W. (2013). Efficacy of Bio-And Chemical Insecticides in the Control of *Tuta absoluta* (Meyrick) and *Helicoverpa armigera* (Hübner) Infesting Tomato Plants. Australian Journal of Basic and Applied Sciences 7: 943-948.
19. Hayes WJ & Laws ER (eds.)(1990). Handbook of Pesticide Toxicology, Classes of Pesticides, Vol. 3. Academic Press, Inc., NY.
20. Henderson GF & Tilton EW. (1955). Test with acaricides against the brown wheat mites. Journal of Economic Entomology 48: 157-161.
21. Kilic T. (2010). First record of *Tuta absoluta* in Turkey. Phytoparasitica 38: 243–244.
22. IRAC (2007). Tomato leafworm resistance managment practice in Brazil. IRAC (Insecticide Resistance Action Comittee) News-Resistance Managment News, Conferences, and Symposia (15):3. www.iraconline.org/documents/index15.pdf
23. Lankas GR & Gordon LR. (1989). Toxicology in W.C. Campbell (ed.). Ivermectin and Abamectin. Springer-Verlag, NY.
24. Lietti MM, Botto E & Alzogaray RA. (2005). Insecticide Resistance in Argentine populations of *Tuta absoluta* (Lepidoptera; Gelechiidae). Neotropical Entomolgy 34: 113-119
25. Nigg HN & Stamper JH. (1980). Persistence of phenthoate (Cidial) and phenthoate oxon on fruits, leaf, and soil surface and in air in Florida citrus. Chemosphere, 9: 343-350.
26. Ostrauskas H & Ivinskis P. (2010). Records of the tomato pinworm (*Tuta absoluta* Lepidoptera: Gelechiidae in Lithuania. Acta Zoologica Lituanica 20: 151– 155.
27. Pereyra PC & Sanchez NE. (2006). Effect of two Solanaceous plants on developmental and population parameters of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology 35: 671–676.
28. Picanço MC, Guedes RNC. Leite GLD. Fontes PCR & Silva EA. (1995). Incidência de Scrobipalpuloides absoluta (Meyrick) (Lepidoptera: Gelechiidae) em tomateiro sob diferentes sistemas de tutoramento e controle quı´mico de

pragas. Horticultura Brasileira 13: 180–183.

29. Radwan EMM & Taha HS. (2012).Toxic and biochemical effects of different insecticides on the tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Egyptian Acadamic Journal of Biologlogical Science 4: 1-10.
30. Roditakis E, Skarmoutsou C & Staurakaki M. (2013). Toxicity of insecticides to populations of tomato borer *Tuta absoluta* (Meyrick) from Greece. Pest Managemnet Science 69: 834-840
31. Salazar ER & Araya JE. (1997). Detección de resistencia a insecticidas en la polilla del tomate. Simiente 67: 8-22.
32. Shalaby SEM, Soliman MMM & Abd El-Mageed AEM. (2012). Evaluation of some insecticides against tomato leaf minor (*Tuta absoluta*) and determination of their residues in tomato fruits. Applied Biological Research 14: 113-119.
33. Tomlin CDS. (2006). The Pesticide Manual, A World Compendium, 14th ed.; British Crop Protection Council: Surry, England, pp 598-599.
34. Tropea Garzia G. (2009). Physalis peruviana L. (Solanaceae), a host plant of *Tuta absoluta* in Italy. IOBC/WPRS Bull. 49: 231–232.
35. Urbaneja A, Vercher R, Navarro V, Garcia Mari F & Porcuna JL. (2007). La polilla del tomate, *Tuta absoluta*. Phytoma España 194: 16–23.
36. Viggiani G, Filella F, Delrio G, Ramassini W & Foxi C. (2009). *Tuta absoluta*, nuovo lepidottero segnalato anche in Italia. L'Informatore Agrario 65: 66–68.