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The Status of Tomato Leafminer; *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Egypt and Potential Effective Pesticides

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Abstract: A survey of the tomato leafminer, *Tuta absoluta* (Meyrick), infestation on tomato plants was carried out in twelve governorates across Egypt during flowering stage of summer plantation of 2010 and 2011 seasons. The pest causes severe damage to the foliage and fruit. The survey shows that the degree of infestation was 21%, 48% and 28% in Behara, Dommiette and Aswan governorates, respectively. The corresponding values in 2011 were 50% in Benisweef governorate to 100% in El-Gharbia, El-Monifia, El-Dakahleia, Domitt, El-Qalubia, El-Sharkia and El-Isamlia governorates. Also, the number of larvae per 10 plants in 2010 season ranged from 5 to 125 larvae in Banisweef and El-Monifia governorates. Whereas in 2011 season, the corresponding values in Banisweef and El-Monifia governorates ranged from 3 to 380 larvae. The pest was also found to infest newly cultivated area like Tushka at Aswan governorate during the harvesting period of winter planting in 2010 season. Analysis of chemical and biopesticide control methods shows that chemical pesticides such as Chlorantraniliprole 20% SC, Chlorfenapyr 36% SC, Indoxcarb 15%EC, Chlofenapyr 36% SC mixed with Indicarb 15%EC, Spinosad 24%SC, Spinosad 24% SC mixed with Abamectin 1.8%, Emamectin benzoate 50% SG and Imidacloprid 20% SC provide excellent control against *T. absoluta*, while a biopesticide *Bacillus thuringiensis* provides moderate control. These pesticides offer tomato growers the tools to control the pest and judicious use of these pesticides will prolong the efficacy and reduce resistance development in the pest.

Key words: Tomato Plants · *Tuta absoluta* Pest · Leafminer · Chemical Pesticides · Biopesticides

INTRODUCTION

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is the most destructive insect pest attacking tomato plant, *Lycopersicon esculentum* [1]. In early infestation, newly emerged neonates (First instar) penetrate the leaf into the mesophyll layer and feed between the lower and upper surfaces of the leaf to form small and transparent mines. As a result of continuous feeding by the larvae, the irregular mines combine together and eventually form galleries [2- 3]. Except for the roots, the larvae attack all other parts of the tomato plant *viz*, leaves, flowers, stems and both green and red fruits [4-7]. *T. absoluta* infestation may cause 50-100% losses in the tomato crop [8].

This pest was first discovered in South America attacking tomato crop [6- 9]. It has the capability to cross borders and devastate the crops either in open field or in protected greenhouse. Later on, infestation by this pest was reported in the western part of Spain at the end of 2006 [10]. Since then, it has spread very rapidly in various parts of the world. It has been reported for the first time in France, Malta, Greece, Switzerland, Portugal and Italy [11-14] and causes outbreak in United Kingdom as well [15]. In early 2009, various reports confirmed the reachability of this pest to the Mediterranean basin *viz*, Morocco, Algeria, Tunisia and Libya, that causes enormous damage to tomato crop [9, 11-13, 16, 17].

Egypt lies in the subtropical region and faces the Mediterranean Sea from the north and the Red Sea from

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the east and from the west and the south, it is bordered by Libya and Sudan. Egypt has an appropriate climate for tomato throughout the year in three different plantation seasons *viz*., winter, autumn and summer. Annually, it produces about 9,204,097 tons of tomato fruits from about 9,000 ha of cultivated area. Tomato crop is one of the most important vegetable crops in Egypt and is considered as the fifth largest tomato producer in the world [18]. Thus, it is very essential to control *T. absoluta* that attacks tomato plant starting from seedling till fruiting stages in order to prevent potential huge damage caused by such pest. In early 2010, *T. absoluta* was detected in Marsa Matrouh district, the western Egyptian border side to Libya through an informal report. In mid-2010, the insecticide panel of the Ministry of Agriculture in Egypt reported its presence in other parts of the Delta valley through the daily news and the national TV (http://www.apc.gov.eg). Later, the pest was discovered to have rapidly spread in the upper and lower regions of Egypt. Initially, farmers used several chemical insecticides with various modes of action in order to control this pest without any plan of control.

The study was aimed to locate and determine the degree of infestation of the tomato leafminer throughout Egypt and to determine effective pesticides to control the pest.

MATERIALS AND METHODS

In order to achieve the goal of the current study, two different experiments were carried out to measure the infestation distribution of tomato plants by *T. absluta* in Egypt. The first experiment was to measure the incidence of tomato leafminer over to subsequent seasons on tomato plant. The second experiment was a small scale experiment carried out to evaluate the effect of different chemicals and biopestisides on *T. abslouta*.

Incidence of T. Absoluta: In order to estimate the percentage infestation of tomato leafminer, samples were collected from thirteen governorates representing four different regions, covering whole cultivated area, during the flowering stage of summer plantation from early March 2010 till the end of June 2011 in Egypt *viz*, North, South, East and West regions (Fig.1).

An area of one feddan (0.42 hectare) was divided into four replicates. In order to determine the degree of infestation, one hundred plants were randomly chosen per replicate and the percentage of infested plant were calculated and recorded. Further from each infested area,

Fig. 1: Egypt map shows the sites from which the samples were collected (dots).

forty more plants were randomly chosen and were inspected carefully for infested parts. The infested parts of each plant were cut and kept in paper bags which were sealed tightly and were brought directly to the lab. The total number of larvae was counted and the average number per 10 plants was calculated.

Effect of Different Insecticide Compounds Against *T. Absoluta*: An area of one hectare was chosen at Abo-Zahra village, Sugar Beet area, Borg El-Arab district, Alexandria governorate. The area was cultivated in late summer plantation with tomato variety 1077 on 15th of May 2011 and was divided into seventy two plots of 100 square meters each. In this area, seventeen chemical and biopesticide compounds were tested. Four plots were sprayed with clean water and served as negative controls. Potential pesticide compounds for the current study were selected based on their high effectiveness against potato tuber moth *Phothremyia oberculella*, a similar pest belonging to the same order as *T. absoluta.*

Seventeen pesticides (Table 1) were sprayed fully on tomato foliage using motorised knapsack sprayer according to a completely randomized block design where each of them was replicated four times. All tested compounds were applied on the tomato foliage on 15 June 2011. Twenty plants in each treatment were randomly chosen (5 plants per replicate) and inspected carefully.

Table 1: Tested compounds sprayed to control *T. absoluta* in experimental field with their various rates/100 liters.

Serial No.	Trade name	Active ingredient	Dose/100 liters
1	Coragen 20%Sc	Chlorantraniliprole	20 ml
2	Challenger 36% SC	Chlorfenapyr	50 ml
3	Avaunt 15% EC	Indoxcarb	50 ml
4	Challenger 36% SC + avaunt 15%EC	Chlorfenapyr + Indoxcarb	25 ml each
5	Tracer 24%SC at	Spinosad	50 ml
6	Tracer 24% SC + Vertimec 1.8%.	Spinosad + abamectin	25 ml and 50 ml
7	Proclaim 5% SG	Emamectin benzoate	30 g
8	Admir 20% SC	Imidacloprid	150 ml
9	Radical 0.15% EC	Emamectin benzoate	150 ml
10	Tracer 24%SC	Spinosade	30 ml
11	Selecron 72%EC	Profenofos	250 ml
12	Ashock 0.15%EC	Azdrachtin	250 ml
13	Dipel 2x	*Bacillus thuringiensis* var.*Kurstaki*	100 g
14	Vertimic 1.8% EC	Abamectin	75 ml
15	Lannate 90% SP + Runner 24% SC	Methomyl + Methoxyfenozide	75 g + 40 ml
16	Lannate 90%SP + Match 5% EC at	Methomyl + Lufenuron	75 g + 40 ml
17	Galben copper 46%WP	11% Benalaxyl + 35% Copper Oxychloride	250 g
18	Positive Control (Untreated area)	water	100%

The larval infested parts of the plants were cut, kept in paper bags and immediately transferred to the laboratory. In order to determine mortality percentage of each compound; surviving larvae were counted before and after 5, 7 and 10 days of treatment.

Statistical Analysis: Data were statistically analyzed using [19] formula and Chi-square test [20].

RESULTS AND DISCUSSION

Incidence of *T. Absoluta*: Percentage of infestation and average number of larvae per 10 plants were determined during normal agriculture practice in the targeted areas during the flowering stage of summer plantation in 2010 and 2011.

Season 2010: The percentage of infested plants with *T. absoluta* ranged from 21 to 48% (Table 2). Domitta and Marsa Matruh governorates represented the highest infestation amounting to 48 and 44%, respectively. On the Other Hand, El-Behaira and El-Dakahlia governorates represented the lowest infestation amounting to 21 and 24%, respectively. In Aswan governorate, the percentage of infested plants was 28% during the harvesting period of winter planting on 15 March 2010. This result was in agreement with those reported by [21].

The degree of infestation ranged between 5 and 125 larvae per 10 plants. The highest infestation was recorded in El-Monifia and El-Gharbia governorates with 125 and 120 larvae per 10 plants, respectively. On the other hand, the lowest number was recorded in Beni Swief and El-Behaira governorates with 5 and 8 larvae per 10 plants, respectively. This data is in accordance with the previous results obtained by [22] who mentioned that the climate change had a significant impact on the ecological parameters and the duration of the life cycle of *T. absoluta* pest. While, Aswan governorate harbored 12 larvae per 10 plants during winter planting season [11].

Season 2011: The percentage of infested plants ranged between 50 and 100%. The highest (100%) infestation was recorded in El-Gharbia, El-Monfia, El-Dakahlia, Damietta, Qalubyia, El-Sharkia and El-Ismailia governorates (Table 2). However, the lowest infestation (50% and 70%) was recorded in Beni Sweef and El-Behaira governorates respectively [11, 12, 13, 14 and 15].

The degree of infestation ranged between 3 and 380 larvae per 10 plants. The highest infestation was recorded in El-Monfia, El-gharbia and Qulubia governorates with 380, 320 and 280 larvae per 10 plants, respectively. Interestingly, Beni Swief, El-Behaira and Marsa Matrouh governorates harbored the lowest number with 3, 9 and 15 larvae per 10 plants, respectively [6 and 9].

Table 2: The incidence of tomato leafminer *T. absoluta* at various governorates during flowering stage of summer plantation in 2010 and 2011 season in Egypt.

NO.	Governorate	District	% Infested plants 2010	% Infested plants 2011	Larvae/10plants 2010	Larvae/10plants 2011
1	Marsa Matruh	El-Hamam	44^{a}	90^{b}	10^{e}	15^{f}
2	Alexandria	Borg El-arab (Sugar beet region)	35^{b}	90^{b}	11^{e}	16^{f}
3	El-behera	Kom Hamada	21^{d}	70^{c}	8^{e}	9^{g}
4	El-Gharbia	El-Mahala El-koubry	25^{c}	100^{a}	120^{a}	320^{b}
5	El-Monifia	Quasni	32^{b}	100^{a}	125^{a}	380^{a}
6	El-Dakahlia	Aga	24^{c}	100^{a}	13	60^{e}
7	Dommiette	Kafr saad	48^{a}	100^{a}	65^{b}	176^{d}
8	Qalubyia	Kaha	35^{b}	100^{a}	27^{c}	280^{c}
9	El-Sharkyia	New Salhai	38^{b}	100^{a}	18^{c}	29^{f}
10	El-Ismailia	El-Salhai	39^{b}	100^{a}	22^{c}	150^{d}
11	El-Giza	Abo El-Numrous	35^{b}	70^{c}	24^{c}	20^{f}
12	Beni Sweef	Ceeds	32^{b}	50^{d}	5^{e}	3^{g}
13	Aswan*	Aswan	28^{c}	-	12^{c}	-
Q square probability <		0.001	0.001	0.001	0.001	

* Winter planting (during harvesting period on 15 March 2010).

a, b, c, d, e, f, g mean there is significant differences using Fischer Exact Probability test at P< 0.05

Table 3: Effect of different compounds against tomato leafminer *T. absoluta* infesting tomato plants, sugar beet region, Alexandria Governorate in 2011 summer planting. No.: Represent number, C.M.: Represent corrected mortality percentage.

			Mean number of larvae/5 plants								
				Post treatment observations						Total mortality mean number	
				5 days		7 days		10 days			
Trade name	Active ingredient	Dose/100 liter	Pre-treatment	No.	C.M	No.	C.M	No.	C.M	No.	C.M
Coragen 20%SG	Chlorantraniliprole	20 ml	21.0	0.0	100	0.0	100	1.0	97.7	0.33	99.2a
Challenger 36%SC	Chlorfenapyr	50 ml	18.5	0.0	100	0.0	100	1.5	96.0	0.5	98.7a
Avaunt 15%EC	Indoxacarb	50 ml	19.0	0.0	100	0.5	98.3	2.5	93.6	1.0	97.3a
Challenger 36%+Avaunt15%	Chlorfenapyr + Indoxacarb	25+ 25 ml	17.0	0.0	100	0.5	98.1	2.5	92.9	1.0	97.0a
Tracer 24%SC	Spinosad	50 ml	18.5	0.0	100	1.5	94.6	2.5	93.4	1.3	96.0a
Tracer 24% +Vertimec18%	Spinosad + Abamectin	25+ 50 ml	14.5	0.0	100	2.0	90.9	2.5	91.6	1.5	94.2a
Proclaim 5%SG	Emamectin benzoate	30 g	16.0	0.5	97.5	2.5	89.7	3.5	89.4	2.2	92.2ab
Admir20%SC	Imidacloprid	150 ml	17.0	1.0	95.3	2.5	90.3	3.0	91.4	2.2	92.3ab
Radical 0.5%EC	Emamectin benzoate	150 ml	16.5	1.0	95.2	2.5	90.0	3.5	89.7	2.3	91.6ab
Tracer 24%SC	Spinosad	30 ml	19.0	3.0	87.4	4.5	84.4	6.0	84.6	4.5	85.5b
Selecron 72%EC	Profenofos	250 ml	14.0	2.5	85.8	4.5	78.8	5.5	80.9	4.2	81.8b
Ashock 0.15%EC	Azadiractin	250 ml	17.0	3.5	83.6	5.5	78.6	9.0	74.3	6.0	78.8b
Dipel2x 6.4%	*Bacillus thuringiensis* var. *kurstaki*	100 g	18.5	4.0	82.8	7.0	75.0	11.5	69.8	7.5	75.9b
Vertimic 1.8%EC	Abamectin	75 ml	17.0	4.0	81.3	8.0	68.9	11.5	67.1	7.8	72.4c
Methomyl 90%SP+ Runner 24 5 SC	Methomyl + Methoxyfenozide	75 g +50 ml	18.0	4.5	80.1	8.5	68.8	15.5	58.1	9.5	69.0c
Methomyl90 %SP+ Match 5% EC	Methomyl + Lufenuron	75 g + 40 ml	16.0	6.0	70.2	11.0	54.6	18.0	45.3	11.7	56.7d
Gallbeen Copper	Benalaxyl 11% + Copper Oxychloride 35%	250 g	14.5	22.5		31.0	-	41.5	0	31.7	0e
Positive control	Water	-	17.5	22.0	-	26.5	-	36.0	0	28.2	0e

a, b, c mean there is significant difference using Fischer Exact Probability test at P< 0.05.

The percentage of infested plants and number of larvae per 10 plants varied from one governorate to another; with some governorates (viz., El-Monfia, El-gharbia and Qulubia) showed rapid increase in infestation 2011 as compared with the 2010 season; whereas, other governorates *viz*., Beni Swief, El-Behaira and Marsa Matrouh; the level of infestation remained considerably low. Since, no specific pesticide was recommended for *T. absoluta* by the Egyptian government; farmers sprayed random pesticides. Indiscriminate spray of pesticides brought little success, as proposed by the increased infestation of the pest in the successive year.

Effect of Different Commercial Pesticide Compounds Against *T. Absoluta*: Seventeen pesticide compounds were tested for their efficacy against *T. absoluta* in field to explore their potential to control the pest population. Table (3) shows the effect of the tested pesticide compounds on *T. absoluta*. One day before the treatment, the mean number of the total survived larvae per 5 plants varied from 14.0 to 21.0.

Five days following the first application, all the compounds performed well except Benalaxyl 11% mixed with Copper oxychloride 35% (Galben copper 46% WP). The first six compounds *viz*., Chlorantraniliprole 20% SC, Chlorfenapyr 36% SC, Indoxcarb 15% EC, Chlorfenapyr 36% mixed with Indoxcarb 15%, Spinosad 24% SC and Spinosad 24% mixed with Abamectin 1.8% caused 100 percent mortality (corrected mortality) of *T. absoluta*. These results in agreement with [23] who found that spinosad proved to be highly effective against tomato borer larvae *T. absoluta*. Chlorantraniliprole 20% SC and Chlorfenapyr 36% SC were able to overwhelm the pest population completely until the 7th day after treatment. On the 10th day after treatment, the degree of effectiveness of these six compounds decreased. The mortality percentage reduced and ranged from 97.7 to 91.6%. It has been reported that indoxacarb and chlorfenapyr were numerically the best treatments reaching 96.1% and 91.4% mortality, respectively three days after application and 93.6% and 93.3% mortality respectively seven days after application [24].

Moreover, Emamectin benzoate 5% SG, Imidacloprid 20% SC and Emamectin benzoate 0.5% EC gave satisfactory results (97.5, 95.3 and 95.2%, respectively) five days after treatment. Gacemi and Guenaoui [25] reported that, Emamectin benzoate showed a good activity on *T. absoluta* larvae with 87% mortality. the Spinosad 24% SC, Profenofos 72% EC, Azdrachtin 0.5% EC, *Bacillus thuringiensis* var.*kurstaki* 6.4%, Abamectin 1.8% and Methomyl 90% SP mixed with Methoxyfenozide 24% SC provided 87.4 to 80.1 mortality percentage respectively five days after treatment. On the other hand, Methomyl 90% SP mixed with Lufenuron 5% delivered the lowest percent mortality amounting to 70.2 % five days after treatment. All tested insecticides significantly reduced *T. absoluta* larvae when compared with control. Interestingly, treatment with a fungicide, Galben Copper 46% WP (containing Benalaxyl 11% mixed with Copper oxychloride 35%) shows no significant difference compared with the control.

Regarding to the corrected mortality according to Abbott formula, there were no significant differences between the first nine compounds, the corrected mortality percentage ranged from 91.6% for Emamectin benzoate to 99.2% for Chloraniliprole. However,Spinosad (30 ml./100 L.W.), Profenofos, Azadiractin and *Bacillus thuringiensis* var.*kurstaki* provide satisfactory results (85.5, 81.8, 78.8 and 75.9%, respectively). Abamectin (72.4%) and Methomyl + Methoxyfenozide (69.0%) showed mild efficacy. Though, Methomyl + Lufenuron performed well till 5 days following the application (70.2%). In this study, the data suggested the possibility of grouping the insecticides into three categories according to their efficacy on tomato leafminer as follows: Excellent (94.2-99.2% average mortality); Good (78.8-92.3% average mortality); and Moderate (56.7-75.9% average mortality). Since there are multiple insecticides with different modes of action that can provide good-to-excellent control, tomato growers have the advantage of rotating these insecticides to reduce the probability of resistance developing in the pest.

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