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Biological Activity of some Natural Plant Extracts and Bio-Pesticides against Tomato Leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and their Residues on Tomato Fruits

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ABSTRACT

Five new pesticides were evaluated for their effectiveness in the control of *Tuta absoluta* (Meyrick), (Lepidoptera : Gelechiidae) on tomato plant. The effect of pesticides against egg and larvae were estimated after 2, 5 and 7 days from application. The highest reduction percentage of eggs of *Tuta absoluta* during two successive seasons achieved by Emacit® (81.25 and 74.5) % respectively after 7 days from application. However, during the first season, the lowest reduction percentage of eggs occurred by Challenger® (10.77 %) whereas, during the second season, the lowest reduction percentage of eggs achieved by Tracer ® (28.62 %) after 7 days from application. On the other hand, the highest reduction percentage of larvae occurred by Tracer® and Challenger® after 7 days from application. The residual behavior of azadirachtin (Nimbecidine 0.03 % EC), spinosad(Tracer® 24% SC), chlorfenapyr (Challenger® 36% SC) and emamectin benzoate (Emacit® 5% SG), in tomato fruits under the environmental conditions of Egypt was studied. The rate of recovery for azadirachtin, spinosad, chlorfenapyr and emamectin benzoate residues from spiked samples of tomato fruits were averaged ranged from 83.07 % to 93.31 % The pre – harvest interval (PHI) was determined to be 0, 1.87, 6.45, and 6.33 days for tomato with azadirachtin, spinosad, chlorfenapyr and emamectin benzoate under prevailed local field conditions respectively. Results showed that waiting for the recommended pre - harvest intervals, indicated on the prospectuses of both pesticides, lowered the residue levels to within acceptable limits.

Key words: Bio-pesticides, natural plant extracts, *Tuta absoluta*, Tomato, dissipation rate, half-life values and (PHI).

Introduction

Tomato, *Lycopersicon esculentum* Mill is an important vegetable crop grown throughout the world. It is the first horticultural crop in Egypt. Tomatoes are grown both under plastic covered greenhouses and in open field. Tomato leaf miner moth, *Tuta absoluta* (Meyrick) (*Lepidoptera*: *Gelechiidae*) has become one of the dangerous pests in tomato greenhouse production in recent years. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) commonly known as tomato leaf miner is an important pest that also feeds on other host plants from the Solanaceae family (Vargas, 1970). It was first recorded in Western Egypt in late 2009 (Temerak, 2011). Young larvae can mine leaves, stems, shoots, flowers and developing fruits.

Later instars can attack mature fruits (Vargas, 1970). Since the time of its initial detection, the pest has caused serious damages to tomato in invaded areas and it is currently considered a key agricultural threat to European and North African tomato production (Desneux *et al*., 2010, Garcia and Vercher, 2010).

Chemical pesticides continue to be an important component of insect pest management even with the development of other control methods (mass-trapping, plant resistance...). Pesticides play an important role in boosting agricultural production, but their haphazard use causes harmful effects on human health (Soomro *et al*., 2008) and the non-target organisms (Akobundu, 1987) and ultimately pollute the environment. Ninety nine percent of all poisoning cases occur in developing countries. The farm workers in the fields are at high risk of being poisoned (UNDP, 2001)

Conventional pesticides have not only distressed the agro-ecosystem but also cause the chronic pesticide poisoning like disorder of immune functions, peripheral neuropathies and allergic reactions, principally of skin, which ultimately led to cancer risk (UNEP, 1993). Scientists and environmental toxicologists have investigated different groups of pesticides, so far, for their toxic end points including endosulfan which involved different health related problems such as cardiovascular disorders and hypertension, (Chandra *et al*., 1992).

Governments and international organizations are regulating the use of pesticides and are setting the acceptable MRL When these compounds are applied according to good agricultural practices, MRL are not

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exceeded, but there in correct application may leave harmful residues, which involve possible health risk and environmental pollution Teratogenic, carcinogenic and toxic properties of these compounds have been reported by Bernard and Gordon (2000)

The use of pesticides based on different chemistries and with varying modes of action is an important component of an integrated pest management strategy. Hence, pesticides will continue to be an integral component of pest management programs due mainly to their effectiveness and simple use (Braham and Hajji, 2011).The internal living and feeding habits of the larvae and its ability to produce several broods each year make it necessary for farmers to apply insecticide every 4 – 5 days / season with minimum and maximum numbers of sprays 8 to 25 sprays respectively (Temerak, 2011).

The aim of this research is to evaluate the efficiency of some pesticides on egg and larvae of tomato leaf miner, *T. absoluta* and determine the dissipation rate, half-life values (RL_{50}) and pre-harvest interval (PHI) for the each insecticide.

Materials and Methods

To evaluate the effect of the tested pesticides on the incidence of *T. absoluta* population, plants were sprayed with the pesticides to show what extent they might be included in an IPM program of tomato. Treatments included the five pesticides plus untreated check controls were evaluated for their efficiency in the control of *Tuta absoluta* on tomato plant and determination of the residues of the pesticides in tomato fruits.

A. Field treatments and samples preparation

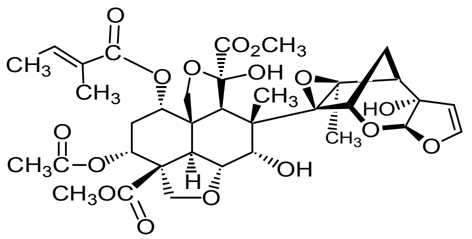
Pesticides used: -

i. Botanical extracts:

1- Trade name :(Nimbecidine®0.03 % EC)

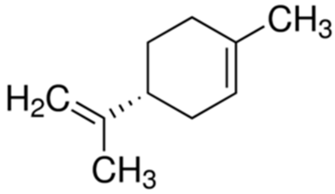
Common nameAzadirachtin

Chemical structure:



2- Trade name (Toutafort® 1 % Liquid)

Common name: limonene

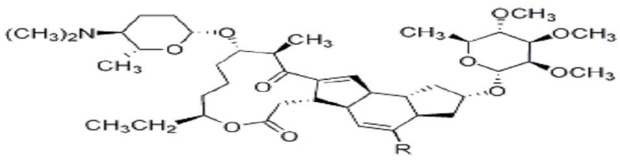


Chemical structure:

ii. Bio- pesticides:

1-Tracer® (24% SC):

Common name: Spinosad



spinosyn A, R = H-

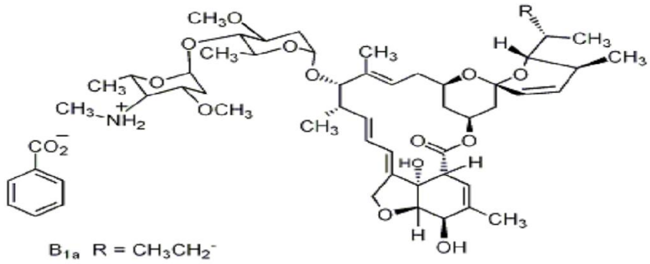
spinosyn D, R = CH_3-

Chemical structure:

2-Trade name *(*Emacit®5 *% SG):*

Common name: *Emamectin benzoate*

Chemical structure:



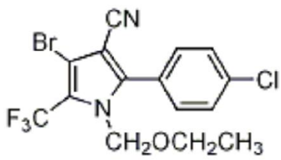
B_{1a} R = $CH_3CH_2^-$

B_{1b} R = CH_3^-

iii. Chemicals pesticides

1- Trade name (Challenger® 36 % SC):

Common name: Chlorfenapyr



Chemical structure:

Table 1: List of pesticides and their rates of application.

Compounds			Recommended Rate/ 1 L water	Source
Trade name	Formulation type	Common name		
Toutafort®	9% L 1 % L	Plant extract limonene	6.25 ml	Altinco Agro Co.
Emacit®	5% SG	emamectin benzoate	0.40 gm	Sulphur Mills Co.
Nimbecidine®	0.03 EC	azadirachtine	5.00 ml	T. Stanes Co.
Challenger®	36% SC	chlorfenapyr	0.5 ml	BASF Co.
Tracer®	24% SC	spinosad	0.25 ml	Dow Agro sciences Co.

L=Liquid, SG = Soluble Granule, EC = Emulsifiable Concentration and SC= Suspension Concentrate

B. Field experiment and sampling:

The experimental area was divided into plots, each of one 100 m^2. Seedling were grown along distance of 20 cm apart and in rows of 120 cm width were planted with tomato, *Lycopersicon esculentum* variety Fayroz during the two successive seasons; 2012 and 2013 at Nubaria region, Beheria governorate, Egypt. Seedlings were grown on 1st March in both 2012 and 2013seasons.One insecticidal application was conducted for the control of *T. absoluta*, larvae and eggs stages after fruit setting. Treatments were applied using a Hydraulic Back Pack sprayer (20 L) at the rate of 200 Liters / Feddan, to give a complete coverage of all plants. The pesticides were used according to their recommended field rates: Agric. Ministry, Egypt. Two rows were used as a barrier between the each treatment and others. Treatments were arranged in a complete randomized block design (RCBD) with three replicates for each. Ten plants were randomly collected from each plot, 3 leaves from each plant were inspected under binocular microscope to count the numbers of eggs and living larvae. Samples were inspected out at periods of 0, 2, 5, and 7 days post treatment. The percentages of infestation reduction were calculated according to Henderson and Tilton's equation (1955) as follows:

Reduction % = $(1- (A/b \times c/d) \times 100)$

Whereas:
a = Population in treatment after spraying
b = Population in treatment before spraying
c = Population in check untreated (control) before spraying
d = Population in check untreated after spraying
Reduction percentages were calculated after 2, 5 and 7 days after treatment for egg and the larvae.

C. Determination of insecticide residues in tomato fruits during the second growing season, 2013:

The residues of the pesticides (Emacit®, Nimbecidine® Challenger®,and Tracer®)were determined at the Central of Pesticides laboratory (CAPL), Agricultural Research Center, Ministry of Agriculture.

Sampling:

Samples of tomato fruits with similar ripening stage, size, and shape were located and tagged. Samples about 1.0 kg were taken 1 h after the pesticides application. Subsequent samples were taken 2, 5, 7 and 10 days after treatment. During the experiment, a control sample was taken in each sampling time. Immediately after collecting the samples, all the samples were packed in polyethylene bags and transported to the laboratory in an ice box. The samples were homogenized using a food processor (Thermomix Vorwerk). The homogenate of each sample was done where three representative samples of 15 g were taken. Samples were then placed into polyethylene 50-ml centrifuge tube and frozen at -20 °C until the time of analysis.

Extraction and Clean up of Pesticides Residues:

Analyses of tested pesticides were carried out in the Central Agricultural Pesticides Laboratory, Agricultural Research Center ARC.

Chemical and reagents:

All organic solvents were of HPLC grade and supplied by Merck, USA. Primary and secondary amines (PSA, 40 ml Bondesil) were purchased from Supelco (Supelco, Bellefonte, USA). Anhydrous magnesium sulphate was of analytical grade, purchased from Merck, USA, and was activated by heating at 250°C for 4 h in the oven before use and kept in desiccators.

Samples were extracted and cleaned up immediately after sampling using QuEChERS methodology (Anastassiades *et al.*, 2003). About 15 g of the homogenized samples were weighted in a 50-mL centrifuge tube and 10 ml of acetonitrile (1% acetic acid) were added, then the screw cap was closed and the tube vigorously shaken for 1 min using a vortex mixer at a maximum speed. Next 1 g sodium chloride and 4 g anhydrous magnesium sulfate were added. The sample was vortexed for 30 s. The extracts were centrifuged for 5 min at 3800 rpm and 40 °C. An aliquot of 4 ml was transferred from the supernatant to new clean 15 ml centrifuge tube and cleaned up by dispersive solid-phase extraction with 100 mg PSA, 20 mg GCB and 600 mg $MgSo_4$. The sample was again vortexed for 1 min and then centrifugation was carried out as mention above. Then, 1ml of the supernatant was taken, mixed with 2ml toluene and evaporated to dryness. The residues were redissolved in 1ml of toluene, filtered through 0.22 um PTFE filter (Millipore, USA) and transferred into a 1.5 ml glass vial for HPLC analysis.

Instrumental determination:

All the insecticides residues were determined by employing High Performance Liquid Chromatography (HPLC). HPLC analysis was performed with an Agilent 1100 HPLC system (USA), with diode array detector (DAD) and fluorescence detector (FLD) The chromatographic column was C_{18} Zorbax SB (250 X 4.6 mmX 5 lm film thickness). HPLC grade solvents used as mobile phase were purchased from Fisher Scientific. All solvents were properly degassed using sonicator and filtered through 0.45 Lnylon filter medium before use. Twenty µL., of the filtered sample was injected. The HPLC conditions like mobile phase, flow rate and detection wave length are shown in Table 2. Recovery studies were carried out by spiking 3 replicates of untreated date samples (control) with 50, 100, and 50 mg/kg of pesticides. Samples were analyzed using their prescribed procedure and mean values of the three replicates were calculated Recovery percentages were satisfactory for pesticides and ranged from 83.07 % to 93.31 % .The minimum detection limit of pesticides was 0.005mg/kg.

Table 2: HPLC conditions and % Recovers for Pesticides Residues Determination.

Pesticides	Mobile Phase	Flow Rate (ml/min)	Detectors Wave length (nm)	Recovery%
Emamectin benzoate	ACN 95 % + H2O 5%	1.0	365 FLD	93.31 ± 2.83
Chlorfenapyr	MeOH 80 % + H2O 20%	1.0	260 DAD	84.00 ± 4.34
Spinosad	MeOH 35% containing 0.5% Ammonium Acetate + 65% ACN	2.0	250 DAD	91.69 ± 2.06
Azadirachtine	MeOH 35 % + ACN 15 % + H2O 50%	1.2	220 DAD	83.07 ± 1.62

- FLD= fluorescence detector and DAD =Diode-Array Detection

Residue half-life estimation (t0.5):

The half-life time ($t_{0.5}$) for each investigated pesticides were calculated using the following equation of (Moye *et al*., 1987).

Whereas:
$t_{0.5}$ = Ln 2/K = 0.6932/K
k′ = 1/Tx x Ln(a/bx)
k′ = rate of decomposition Tx = time in days
A = initial residue Bx = residue at x time

Data were subjected to the analysis of variance test (ANOVA) via Randomized Complete Block Design (RCBD) (F. test). The least significant differences (LSD) at the 5% probability level were calculated according to computer program CoStat by Steel and Torrie (1981) to compare the average numbers of inspected pest infestations.

Results and Discussion

Bio-efficacy of pesticides on eggs of Tuta absoluta:

Season 2012:

The results in table (3) showed that the effect of pesticides against the mean number of eggs after interval days. Nimbecidine® demonstrated good effectiveness towards the reduction percentage of eggs of *T. absoluta*after 2 and 5 days from the first application (65.92 and 64.27 %). Whereas, the highest value of reduction percentage of eggs occurred by Emacit® after 7 days from application (81.25%) followed by Nimbecidine® and Tutafort® (73.3 and 38.72%). The lowest mean number of reduction percentage of eggs achieved by Challenger® (10.77%) after 7 days from application.

Table 3: Effectiveness of certain pesticides against egg of tomato leaf miner (*Tuta absoluta* Meyrick) during season 2012.

Treatments	Pre- spray	Average no. of egg (Days)			Reduction percentages (Days)		
		2	5	7	2	5	7
Tutafort®	21	19	22	9	16.76 d	22.27 d	38.72 c
Emacit®	23	16	11	3	36 c	64.51 a	81.25 a
Nimbecidine®	27	10	13	5	65.92 a	64.27 a	73.37 b
Challenger®	29	13	25	18	58.75 b	36.04 c	10.77 e
Tracer ®	11	8	7	5	33.09 c	52.78 b	34.65 d
Control	23	25	31	16	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

Season 2013:

During the second season 2013, the same pesticides were applied towards the eggs of *T. absoluta*. The obtained results in table (4) showed the highest reduction percentage of eggs occurred by Nimbecidine® after 2 and 5 days from application (55.25 and 61.57%) but, after 7 days the highest reduction of eggs achieved by Emacit®(74.5 %).

Table 4: Effectiveness of certain pesticides against egg of tomato leaf miner (*Tuta absoluta* Meyrick) during season 2013.

Treatments	Pre- spray	Average no. of egg (Days)			Reduction percentages (Days)		
		2	5	7	2	5	7
Tutafort®	22	18	20	7	7.5 d	18.49 c	50.99 c
Emacit®	24	17	10	4	19.92 c	62.64 a	74.5 a
Nimbecidine®	28	11	12	6	55.25 a	61.57 a	67.22 b
Challenger®	30	15	23	14	43.47 b	31.26 b	69.41 b
Tracer ®	15	7	6	3	47.24 b	64.13 a	28.62 d
Control	26	23	29	17	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

Bio-efficacy of pesticides against larvae of Tuta absoluta:

Season 2012:

Reduction percentage of *T. absoluta* infestation on tomato leaves with the different tested pesticides ranged between 34.66 to 100 % after 7 days from application (Table5). Generally, the considered bio-pesticides were more effective in the control of *T.absoluta* than the conventional chemical pesticides. Tracer ® exhibited the highest effect on *T. absoluta* after 7 days following the first application, followed by Challenger® then by Nimbecidine®(100, 99.33 and 95.8 ,respectively) .Whereas, after 2 days from the first application the highest mean reduction percentage achieved by Challenger® (99.27%) followed by Tracer ® and Emacit® (86.47%). But, after 5 days from application Challenger® has the first ranked of reduction percentage (98.27 %) while, Emacit® has the lowest reduction percentage (67.81 %) as shown in Table (5).

Table 5: Effectiveness of certain pesticides against larvae of tomato leaf miner (*Tuta absoluta* Meyrick) during season 2012.

Treatments	Pre- spray	Average no. of larvae (Days)			Reduction percentages (Days)		
		2	5	7	2	5	7
Tutafort®	14	16	6	5	76.81 c	89.65 b	90 b
Emacit®	6	4	8	14	86.47 b	67.81 d	34.66 c
Nimbecidine®	20	17	12	3	82.75 b	85.51 c	95.8 ab
Challenger®	28	1	2	1	99.27 a	98.27 a	99.33 a
Tracer ®	15	10	5	0	86.47 b	91.95 b	100 a
Control	14	55	58	50	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

Season 2013:

During the second season, the evaluated pesticides were repeated towards the larvae of *T. absolutafor* evaluating the mean number of reduction percentage (Table 6). The highest toxic of pesticides against larvae of *T. absoluta* achieved by Challenger® (100%) followed by Tracer ® (94.97 %).These values were estimated after 7 days from application . But, after 2 days from the first application the highest reduction percentage values were recorded by Challenger® (98.17 %) . Also, Challenger® repeat the first ranked of reduction percentage after 5 days from application (98.93%). Generally, Challenger® was the best application between all tested pesticides whereas, the lowest reduction percentage after 7 days of application occurred by Emacit® (39.35%).

Table 6: Effectiveness of certain pesticides against larvae of tomato leaf miner (*Tuta absoluta* Meyrick) during season 2013.

Treatments	Pre- spray	Average no. of larvae (Days)			Reduction percentages (Days)		
		2	5	7	2	5	7
Tutafort®	15	17	8	4	74.09 c	85.77 c	90.95 b
Emacit®	7	5	9	13	83.67 b	65.71 d	39.35 c
Nimbecidine®	19	15	10	5	81.95 b	85.96 c	91.4 b
Challenger®	25	2	1	0	98.17 a	98.93 a	100 a
Tracer ®	13	8	4	2	85.93 b	91.79 b	94.97 b
Control	16	70	60	49	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

Finally, results demonstrate significant differences in infestation percentages of larvae of *T. absolutaas* affected by the different tested pesticides. The differences can be attributed to different modes of action of the products. Also, the obtained results cleared excellent efficacy of bio-pesticides, Tracer ®, Nimbecidine®, Tutafort® and Emacit® against *T. absoluta*. Where, spinosad activate the nicotinic acetylcholine receptors, but at a site distinct from that of nicotine or the neonicotinoids. Whereas, emamectin is a nonsystemic insecticide which penetrates leaf tissues by translaminar movement, following its treatment, larvae stop feeding within hours and die after 2-4 days.

(Challenger®)chlorfénapyr is an acaricide, but gave the highest reduction percentage larvae of *T .absoluta* infestation (99.33 and 100) % during two seasons treatment respectively). Spinosad as insecticide showed high efficacy in controlling all instar larvae of *T. absoluta* giving reduction percentage of 100% and 94.97% during two successive seasons respectively . Hafsi*et al*., (2012) and Braham *et al*., (2012) investigated the efficacy of 7 different pesticides against *T. absoluta*in a laboratory bioassays. Spinosad, chlorantraniliprole + abamectin or indoxacarb treatment resulted in 100% mortality at their recommended doses of 120, 50.4 and 60 mg respectively.

The efficacies of abamectin, metaflumizone and azadirachtin were found to be moderate to low at the recommended doses of 4.5, 240 and 50 mg respectively. Nannini *et al*., (2011) found that in all tests, spinosad proved to be highly effective against tomato larvae. Indoxacarb, metaflumizone, azadirachtin and abamectin appeared to be less active. Gacemi and Guenaoui (2012) evaluated the efficacy of emamectinbenzoate against larvae of the tomato leaf miner in tomato greenhouse. Three foliar applications were made at 7 days interval in a tomato greenhouse. The results showed a good activity on *Tuta absoluta* larvae with a mortality reaching 87%.

Determintion of the pesticides residues in tomato fruits during season 2013:

Data in Table (7) represent the amounts of emamectin benzoate, chlorfenapyr, spinosad and azadirachtin in tomato fruits under field conditions, after different intervals. It is obvious that, the amounts of emamectin benzoate, chlorfenapyr, spinosad and azadirachtin initially detected in tomato fruits were 1.060, 0.705, 1.815 and 0.245mg/kg, respectively. Pesticides dissipated rapidly after application. The concentrations of emamectin benzoate, chlorfenapyr, spinosad and azadirachtin 2 days after treatment were 0.483, 0.200, 0.940 and 0.100mg/kg, respectively.

These amounts decreased gradually till reached undetectable amounts after 5 days of azadirachtin, while in the case of both of emamectin benzoate, Chlorfenapyr were reached undetectable amounts after 10 days. on the other hand spinosad recoded 0.007 mg/kg after 10 days.

The dissipation rate of tomato fruits exhibited a first order kinetics. The half-life of emamectin benzoate, chlorfenapyr, spinosad and azadirachtin calculated in tomato fruits treated at recommended dose were 1.65, 1.29, 2.19 and 1.52 days, respectively. European Union MRL for emamectin benzoate, chlorfenapyr, spinosad and azadirachtin were 0.02, 0.01,1 and 1 mg/kg, respectively.

It can thus be concluded that the preharvest interval (PHI) of emamectin benzoate, chlorfenapyr, spinosad and azadirachtin were 6.33, 6.45, 1.87 and zero days respectively (Table 7) after the last treatment.

Also, the obtained results cleared that spinosad achieved the highest means of pesticides residues (0.622 mg/kg) followed by emamectin benzoate, chlorfenapyr and azadirachtin (0.333, 0.194 and 0.069., respectively). But, the highest mean of time occurred after 0 initial time for all treatment (0.956 mg/kg) whereas the lowest mean of time achieved after 7 and 10 days from application (0.008 and 0.02 mg/kg).

These results harmonize with other investigators working on residues of pesticides in tomato fruits and other Gambacorta *et al*., (2005), Fenoll *et al*., (2009), Akbar *et al*., (2010), Tahany *et al*., (2011) and Giovanni Galietta *et al*., (2011).

Table 7: Initial residue deposit and residue decline of emamectin benzoate, chlorfenapyrspinosad and azadirachtin in tomato fruits under field conditions.

Time(days) / Pesticides	0 Initial time	2	5	7	10	Average of pesticides	MRL* mg/kg	$T_{0.5}$ (days)	PHI (days)
Emamectin benzoate	1.060	0.483	0.116	0.008	0.000	0.333 b	0.02	1.65	6.33
Chlorfenapyr	0.705	0.200	0.060	0.005	0.000	0.194 c	0.01	1.29	6.45
Spinosad	1.815	0.940	0.330	0.020	0.007	0.622 a	1.00	2.19	1.87
Azadirachtin	0.245	0.100	0.000	0.000	0.000	0.069 d	1.00	1.52	0.00
Means of time	0.956 a	0.431 b	0.126 c	0.008 d	0.02 d				

- *MRL= Maximum Residue Limits according to (European Union MRL, 2014).*
- *PHI= Pre Harvest Interval.*
- *Means followed by the same letter(s) in each column are not significantly different at $P \leq 0.05$ level.*

Conclusion:

Tomato, *Lycopersicon esculentum* Mill is an important vegetable crop grown throughout the world. Tomato leaf miner moth, *Tuta absoluta* (Meyrick) (*Lepidoptera*: *Gelechiidae*) has become one of the dangerous pests in tomato greenhouse production in recent years. Chemical pesticides continue to be an important component of insect pest management even with the development of other control methods. Governments and international organizations are regulating the use of pesticides and are setting the acceptable MRL When these compounds are applied according to good agricultural practices, MRL are not exceeded, but there in correct application may leave harmful residues, which involve possible health risk and environmental pollution. So, the results showed that, the highest reduction percentage of eggs of *Tuta absoluta* during two successive seasons achieved by Emacit® (81.25 and 74.5) % respectively after 7 days from application. Whereas, the highest reduction percentage of larvae occurred by Tracer® and Challenger® after 7 days from application. Also, The rate of recovery for azadirachtin, spinosad, chlorfenapyr and emamectin benzoate residues from spiked samples of tomato fruits were averaged ranged from 83.07 % to 93.31 % The pre – harvest interval (PHI) was determined to be 0, 1.87, 6.45, and 6.33 days for tomato with azadirachtin, spinosad, chlorfenapyr and emamectin benzoate under prevailed local field conditions respectively. Results showed that waiting for the recommended pre - harvest intervals, indicated on the prospectuses of both pesticides, lowered the residue levels to within acceptable limits.

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