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Rational Insecticides Against *Tuta Absoluta* in Relation to Pesticides Residue on Tomatoes

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ABSTRACT

An Evaluation for certain Agricultural candidates against *Tuta absoluta* on Tomatoes was carried out during two seasons. The determination of the pesticide residues was, also carried out during the course of the study. The obtained results indicated that the traditional insecticides rating in the following order; Voliam flexi (Thiamethoxam + Chlorantraniliprole), Avaunt (Indoxacarb) and Coragen (Chlorantraniliprole), are more effective than Bio-insecticides; Proclaim (Emamectin benzoate) followed by Dipel (*Bacillus thuringensis* var korstaki) and then Achook (Azadirachtin), respectively.

Under open field conditions, the investigation on residual limits and dissipation behavior of some tested insecticides was conducted after the last application. Extraction was carried out using a quick, easy, cheap, effective, rugged, and safe (QuEChERS) method for multiclass, multiresidue analysis of pesticides in a variety of matrices. Meanwhile residue determination was performed using Liquid chromatography tandem mass spectrometry (LC.MS.MS). Recoveries were within acceptable levels. Dissipation rates followed the first order kinetics and half-life values for tested insecticides were ranged from 2.3 to 4.53 days and one day for bio- insecticides. According to the Maximum Residue Limits (MRLs) of European Union, the calculated Pre Harvest Intervals (PHIs) of ranged between 2.9 and 8 days for traditional insecticides and between 2.09 and 4.3 days for bio-insecticides.

Keywords: Tuta absoluta, Residue, Analysis, PHI.

INTRODUCTION

The tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), has been recognized as one of the most serious tomato pests (Shalaby *et al*., 2012; Ramadan *et al*., 2016). The caterpillar feeds on several parts of tomato plants such as leaves, stems and fruits causing direct and indirect damages that could result in 100% yield loss (Desneux *et al*., 2010; Saad et al., 2020).

The widespread use of pesticides has emerged as dominate feature. However, reliance on pesticides is difficult to sustain because of unintended long term adverse effect on human health and the environment. Pesticide residues are present in all agro-ecosystems, but the real risk to human health is practulary through exposers to residues in primary and derived agricultural products (Gad Allah et al., 2015; Abd EL-Rahman, 2020).

To determine effective pesticides to control *Tuta absoluta* with a modest endeavor studies have focused on the behavior and dissipation of these chemicals which created a huge pesticide residues problems in agricultural productions. Rational rotating use of pesticides and integrated pesticide residues management programs are urgently needed take into consideration consecutive monitoring of pesticide residues and to determine precisely the pre harvest intervals, to ensure access to safely tomato production for local consumers and suitable for marketing so that it meets requirements of pesticide residues limits (*Gacemi* and *Guenaoui, 2012;* Taha *et al*., 2017; Abd El-Maksoud *et al.,* 2020).

The present study focused on *Tuta absoluta* infestation to tomato under open field and determination the level of pesticide residues compared to MRLs during the course of study. Looking for low-risk pesticides to be potential control agents that can be adopted within integrated pest management programs.

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MATERIALS AND METHODS

Tested rational pesticides*:*

Two different experiments were carried out to evaluate the efficacy and dissipation rate of some insecticides under open field conditions and natural infestation against *Tuta absoluta* (Table. 1). Each Pesticides were applied at recommend doses, 4 times during the first experiment and 5 times at the second ones.

Experimental design and Treatments:

The study was conducted in one of the most important area of cultivating and producing Tomato crop in Egypt (the region of Abo - Homas, Behaira governorate). Two field experiments were carried out at a commercial field during two successive growing seasons for Tomato in 2021. The first experiment was cultivated on March and second ones on September 2021.

The area of approximately 3000 m² were cultivated with seedlings of tomato *Lycopersicon esculentum* (MILL.) variety Dessera. Then divided following Randomized Complete Block Design with seven treatments and four replicates. each plot was separated from the adjacent one by a half meter (barrier) to minimize interference of spray drift between plots. Each plot had 6 rows, approximately 20 - 25 plants in a row. Tested pesticides were applied individually 4 times on 28 Mach, 18 April, 9 and 23 May for the first experiment, while applied 5 times on 25 June, 9 July, 23 July, 6 and 20 August for the second experiment. During both seasons Good agricultural practices (GAP) were applied, according to Egyptian Ministry of Agriculture recommendation.

Biological performance of tested rational pesticides against *T. absoluta* on tomato:

The natural infestation of *T. absoluta* appears during the vegetative growth and confirmed by observing the current symptoms on morphological changes from the adopted treatments in the field. To achieve the main strategy for this study that to keep pest population below economic threshold level (ETL) 2.23 larvae/leaf as according to ETL value of 40 - 49 larvae/20 leaves reported by (Ammar et al., 2018) and ETL value of 2.25 larvae/leaf reported by (Shiberu and Getu, 2018). Applications were carried out on natural developing of *T. absoluta* population as foliar spray using motor- operated knapsack sprayer.

However, four sprays were needed to keep the *T. absoluta* population below ETL levels. Meanwhile, five applications were applied for the second experiment. The infestation levels were recorded weekly by collecting randomly 16 Leaves of 8 plants (2 leaves/8 plant, young and old once). Collected leave samples were transferred in paper bags to the laboratory for count. Samples were taken before and after treatment one time a week during whole seasons. The reduction percentage of larvae were determined at each collection interval, and calculated according to Hinderson-Tilton formula (Albeltagy, 2021).

Determination of the pesticide residues:Sample collection:

Tomato fruits were collected from both untreated and treated plots for recovery and pesticide residue analysis, before and after 1 hour (initial deposit), 1, 3 ,7 and 14 days of application. Immediately after collecting, tomato fruits were packed in well ventilated, airtight polyethylene modified containers (boxes) and transported under air conditional environment to the laboratory for residue analysis.

Reagents and chemicals used in the extraction:

All organic solvents were HPLC grade and purchased from Merck (Darmstadt, Germany). Millipore – Q System was used for water purification. Primary Secondary Amin (PSA, 40 µm Bondesil) sorbents was purchased from Supelco (USA). Anhydrous magnesium sulfate was analytical grade purchased from Merck ltd., Sodium chloride and Tri Ethyl Amin (TEA) was analytical grade purchased from El-Naser Pharmaceutical Chemical Co., Egypt. Anhydrous magnesium sulfate and sodium chloride were activated by heating at 400 ^{0}C for 4 hours in the oven before use and kept in the desiccators.

Table 1. Pesticide treatments used during the course of study

Trade name	Common name	Mode of action	*IRAC MOA Group	Rate/fed
Voliam flexi SC 30% SC	Chlorantraniliprole	Ryanodine receptors modulators	28	80 gm/fed
	Thiamethoxam	Nicotinic acetylcholine receptors modulators	4 A	80 gm/fed
Coragen 20% SC.	Chlorantraniliprole	Ryanodine receptors modulators	28	60 gm/fed
Avaunt 15% EC.	Indoxacarb	Sodium channel blockers	22 A	60 ml/fed
Proclaim 5% SG.	Emamectin benzoate	Glutamate chloride Channel modulators	6	120 gm/fed
Achook 0.15% EC.	Azadirachtin	Uncertain mode of action	UN	750 ml/fed
Dipel 54% WP	*Bacillus thuringensis*	Microbial disruptors of insect mid gut	11 A	400 g/fed

*IRAC., (2022)

Analytical methods:

Sample preparation and extraction:

The extraction, cleaning and persistence analysis was carried out by triplicate. For residue analysis, tomato samples were homogenized for 5 min. at high speed in laboratory homogenizer and extracted. The homogenate of each sample was done by using a quick, easy, cheap, effective, rugged, and safe (QuEChERS) method according to European Union method, namely EN 15662:2018 (EFSA, 2021).

Where three representative extracted samples of 10 gm were taken and placed into polyethylene 50 ml centrifuge tube and analyzed immediately; 10 ml acetonitrile with 1 % trifluoro acetic acid (TFA) was added, and the mixture was vortices for 2 min. After that, 4 gm of anhydrous magnesium sulfate, 1 gm of sodium chloride were added, then extract by shaking vigorously on vortex for 2 min and centrifuged for 10 min at 5000 rpm.

An aliquot of 1 ml of the MeCN phase from second extraction step was transferred into a new centrifuge tube already contain 50 mg of PSA and 300 mg of magnesium sulfate. Afterwards, centrifugation was carried out at 5000 rpm for 5 min. Aliquot of 2 ml of the supernatant were filtered through a 0.2 μm PTEE filter.

The sample were then ready for the final analysis. The HPLC analysis was performed with an Agilent 1260 HPLC system (USA), with auto sampler injector, quaternary pump, thermostat compartment for the column and detector. The chromatographic column was Zorbax C18 XDB (150 mm x 4.6 mm, 5 mm film thickness). The column was kept at room temperature. Flow rate of mobile phase (acetonitrile / methanol / ammonium acetate = 45+45+10; V/V/V) was 0.8 ml / min and the injection volume was 20 ml. The residues in treated samples were identified by comparing the retention times (RTs) of the sample peaks with the (RTs) of the injected standards. The recovery experiments were carried out on fresh untreated tomato fruits by fortifying the sample (10 gm) in five replicates with pesticide standard at three fortified levels (0.1, 0.5 and 1.0 mg kg^{-1}). The half-life time ($t_{½}$) of tested pesticides were calculated according to (Moye et al., 1987).

Statistical analysis:

All obtained data were statistically subjected to analysis of variance (ANOVA) using F test and means were compared by Tukey's Standardized Range Test at 0. 05 probability level were determined according to computer program (COSTAT software, 1988).

The first experiment:

Data in (Table. 2) shows the percent reduction on *T. absoluta* population after using four spray regimes of different insecticides. Three weeks after transplanting the first spray was applied. The Performance of Traditional insecticides; Voliam flexi, Coragen and Avaunt were noticeable higher than bio insecticides, causing reduction rates (100, 91.1 and 75.5%) for

Voliam flexi, (41.2, 88.9 and 84.2) for Coragen and (52.8, 66.7 and 64.2%) for Avaunt, after the first, second third week, respectively. While bio insecticides caused reduction rats; (0.0, 8.3 and 37.7%) for

Proclaim, (25.0, 25,0 and 36.6 %) for Achook and (25.0, 61.5 and 54.9%) for Dipel, after the first, second and third week, respectively. The second spray came three weeks followed the first one. All treatments were effective brought reduction rats; (80.5, 75.2 and 71.0%) for voliam flexi, Coragen and Avaunt, respectively. Meanwhile biological insecticides brought percent reductions at; (72.3, 70.2 and 65.8%) for Proclaim, Achook and Dipel, respectively. Until this period both traditional and biological insecticides maintained *T. absoluta* infestation limits three times below the ETL, whereas, it was exceeding ETL for untreated plants. After three weeks of second spray, the third one was done. Traditional insecticides provided the major impact reducing infestation by; (59.7 and 43.4 %) for voliam flexi, (58.8 and 35.2%) for Coragen and (45.1 and 19.3%) for Avaunt. However, Biological insecticides caused; (48.9 and 19.3%) for Proclaim, (35.1 and 18.9%) for Achook and (39.2 and 18.1%) for Dipel. During this period, infestation levels were recorded below ETL, while, it was twice ETL for untreated plants and the fourth spray were applied (Fig. 2). As were expected, traditional pesticides achieved the highest reduction rats

At; (46.7, 46.5 and 50.2%) for Voliam flexi, Coragen and Avaunt, respectively. Meanwhile, biological insecticides brought percent reductions at; (43.5, 38.3 and 35.4%), for Proclaim, Achook and Dipel, respectively. In contrast, untreated plants recorded high infestation at mean number exceed the ETL by three times.

The general means of reduction percentages indicated that, the traditional insecticides were more effective than biological insecticides. And significant difference recorded between intervals, treatments and both intervals and treatments (Table.1). The insecticide Voliam flexi provided the highest effectiveness against

T. absoluta larvae, followed by Avaunt and Coragen. Biological insecticides, Dipel gave the highest effect against *T. absoluta* larvae, followed by Proclaim and Achook.

During the experiment intervals traditional suppressed infestation below ETL. While, biological insecticides kept also population of the pest in levels below ETL except the last week of the experiment. The similar results were obtained by (El-Sayed *et al*., 2015; Azzam *et al*., 2017; Taha *et al*., 2017; Bastola *et al*., 2020). Who found that voliam flexi caused the highest reduction rates, followed by chlorantraniliprole and Indoxacarb. Also, were more effective than biological insecticides: emamectin benzoate, Dipel and Achook.

The second Experiment:

Efficacy data for the frequently spraying of tested traditional and biological pesticides against *T. Absoluta* infesting tomato plants under open field conditions are presented in the (Table. 3). The tested insecticides gave a remarkable reduction on the pest population density with different levels. Significant differences were recorded between Treatments, Intervals, and between Intervals with Treatments.

The first treatment was applied against infestation levels ranged between 6 and 8.75 larvae/8 leaves. All pesticides caused relative comparable effect reducing infestation by 80.9,75.0 and 86.1% for Traditional insecticides Voliam flexi, Coragen and Indoxacarb, respectively, and 65.9, 69.8 and 71.3% for biological insecticides; Proclaim, Achook and Dipel, respectively. Two weeks after, infestation levels of all treatments increased to levels below ETL, whilst infestation rats of untreated plants reached ETL. The second application was applied after two weeks of the first one. The weekly assessment of infestation rates showed that all Pesticides performed effectively, causing reduction rates at 84.7, 84.7 and 88.08% for traditional pesticides, while recorded rats of 79.5, 75 and 72.67 for biological insecticides; Proclaim, Achook and Dipel, respectively. Two weeks followed the second spray, reduction percentages were fallen nearly by half; the applied third spray resulted as almost as second one. Until this time all treatments kept *T. absoluta* infestation at levels far below ETL, while infestation in untreated plants were exceeded ETL. The fourth and fifth applications performed similarly to previous applications and maintained infestation at below ETL during experiment period. obtained results made clear that the traditional insecticides Voliam flexi was the most effective against Tuta absoluta followed by Avaunt and Coragen, similar to findings by Hanafy and El-Sayed (2013); Moussa *et al.* (2013) and Abd El-Maksoud *et al*. (2020) who obtained approximately the same results showing that the most effective chemical pesticides were voliam flexi followed by Avaunt and then Coragen, similar to findings of Nazarpour *et al*. (2016). On the other hand, the efficacy of biological insecticides against Tuta absoluta indicated that Dipel were the most effective biological insecticides followed by proclaim and then Achook. These results are in line with findings of El- Sayed *et al*. (2015) who delineated that Diple caused highest reduction rates among tested biopesticides, also, in comparison with findings of Azzam *et al*. (2017)

Table 2. Percent Reduction of treatments on *T. absoluta* larvae infesting tomato plants (Experiment. 1)

Treatment	Percent Reduction / week											
	1 *	**2**	**3**	**4 ***	**5**	**6**	**7 ***	**8**	**9 ***	**10**	**Mean**	**SY**
Voliam flexi	100	91.1	75.6	80.5	44.4	9.76	59.7	43.4	46.7	0.0	55.1	a
Coragen	41.2	88.9	84.2	75.2	19.9	0.0	58.8	35.2	46.5	7.5	45.7	b
Avaunt	52.8	66.7	64.2	71.0	51.4	35.9	45.1	19.3	50.2	2.2	45.9	b
Proclaim	0.0	8.3	37.7	72.3	58.2	23.3	48.9	19.5	43.5	1.7	31.3	c
Achook	25.0	25.0	36.6	70.2	46.5	22.0	35.1	18.9	38.3	0.0	31.8	c
Dipel	25.0	61.5	54.9	65.8	40.6	20.5	39.2	18.1	36.4	0.1	36.2	c
Untreated	50.0	18.8	10.9	8.9	10.0	0.0	7.2	4.5	4.1	8.1	12.3	

LSD 0.05 (Intervals) = 10.85, LSD (Treatments) = 5.54, LSD (Intervals and Treatments) = 17.4. * After spry round.

Table 3. Percent Reduction of treatments on *T. absoluta* larvae infesting tomato plants (Experiment. 2)

Treatment	Percent Reduction / week											
	1 *	**2**	**3 ***	**4**	**5 ***	**6**	**7 ***	**8**	**9 ***	**10**	**Mean**	**SY**
Voliam flexi	80.9	33.6	84.7	54.6	85.7	37.1	89.1	28.0	87	1.9	58.2	A
Coragen	75.0	14.5	84.7	37.9	84.3	37.3	78.0	22.4	71.2	17.2	52.2	B
Avaunt	86.1	27.7	88.0	58.1	88.4	28.9	86.2	24.7	75.6	7.0	57.1	a
Proclaim	65.9	18.3	79.5	32.4	79.9	30.3	69.1	24.2	72.6	8.4	48.1	cd
Achook	69.8	16.4	75	40.7	73.3	31.7	66.1	14.8	65.0	9.6	46.2	d
Dipel	71.3	25.5	72.6	35.1	73.1	41.7	61.5	13.4	80.5	30.6	50.5	Bc
Untreated	9.4	13.2	6.7	13.2	10.4	10.2	10.1	14.4	11.1	9.5	10.8	e

LSD 0.05= (Intervals) = 5.05 LSD 0.05= (Treatments) =2.96 LSD 0.05= (Intervals and Treatments) = 9.3 * After spray round

Recovery and detection limits:

To ensure quality of the pesticide residue results, the method performance characteristics were generated and evaluated before tomato samples were analyzed. The average recovery (REC) and relative standard deviation (RSD) data of insecticides from spiked samples are detailed in (Table .4). The obtained recovery (REC) percentages for the following concentrations 0.1, 0.5 and 1mg/kg ranged between; (78 and 98%) for Thiamethoxam, between (89 and 100%) for Chlorantraniliprole, between (90 and 95%) for Indoxacarb, between (85 and 94%) for Emamectin benzoate. While, at the same concentrations, the obtained relative standard deviation (RSD) percentages averaged between (4 and 5%) for Thiamethoxam, between (4 and 9%) for Chlorantraniliprole, between (4 and 13%) for Indoxacarb and between (3 and 7%) for Emamectin benzoate.

These results are considered to be highly satisfactory for the purpose of pesticide residue analysis and they are compliant with the European Union criteria which stipulate the average recoveries in the range 70- 120% with corresponding RSD less or equal 20% (SANTE, 2021).

The limit of quantification (LOQ) of the method was defined as the lowest spiking level for which the validation criteria were satisfied and it was equal 0.005 mg/kg. Excellent linearity with the coefficient of determination (R2) > 0.99 was achieved for the studied insecticides when using standard in the extract of tomato matrix (matrix-matched standard).

Residues of tested pesticides on tomato fruits:

The pesticide residues and dissipation behavior of pesticides: Voliam flexi (Chlorantraniliprole + Thiamethoxam), Coragen (Chlorantraniliprole, Avaunt (Indoxacarb) and Proclaim (Emamectin benzoate) were Investigated on tomato fruits sprayed according to designed pesticide applications regime of experiments (Table. 5 and 6).

Tomato fruits were collected periodically on before, after 1h, 1, 3, 5, 7, 10, and 14 days after final application of the spraying regime. Under open field the weekly average means of high and low temperature were recorded at (27 ^{0}C and 19 ^{0}C) for (Experiment. 1), while it was (27 ^{0}C and 25 ^{0}C) for (Expermint.2).

The obtained results indicated that pesticides residue of certain pesticides on tomato fruits were significantly decreasing with time elapsing, and dissipation rates followed the first order kinetics.

Persistence and dissipation kinetics of tested pesticides on tomato fruits of the 1st and 2nd experiment:

Experimental obtained data revealed the Persistence and dissipation kinetics of tested pesticides; Coragen (Chlorantraniliprole), Proclaim (Emamectin benzoate), Avaunt (Indoxacarb) and Voliam flexi (Chlorantraniliprole and Thiamethoxam) Tables (5 and 6).

Table. 4. Percent recovery of applied pesticides on tomato fruits at various fortification levels

Spiked level mg/ kg	0.1mg/kg		0.5mg/kg		1mg/kg	
Pesticides	**REC%**	**RSD%**	**REC%**	**RSD%**	**REC%**	**RSD%**
Thiamethoxam	94%	4%	98%	4%	78%	5%
Chlorantraniliprole	100%	6%	98%	9%	89%	4%
Indoxacarb	90%	4%	92%	13%	95%	9%
Emamectin benzoate	87%	7%	85%	5%	94%	3%

Table 5. Residue levels of tested pesticides on tomato fruits (Experiment. 1)

Insecticides	Intervals (days)	pre	1 h	1 d	3 d	7 d	14 d	MRLS (PPM)	T ½	PHI day
Chlorantraniliprole	Residue mg/kg	0.01	0.85	0.69	0.463	0.108	0.036	0.3	2.97	4.24
(Coragen. 20% SC)	loss %	- -	0.00	18.82	45.53	87.29	95.76			
Emamectin benzoate	Residue mg/kg	ND	0.267	0.087	0.033	LOQ	ND	0.02	0.76	4.3
(Proclaim. 5% SG)	loss %	- -	0.00	67.42	87.64					
Indoxacarb	Residue mg/kg	LOQ	0.96	0.83	0.63	0.448	0.046	0.5	4.53	5.28
(Avaunt. 15% SC)	loss %		0.00	13.54	34.38	53.33	95.21			
Chlorantraniliprol*	Residue mg/kg	LOQ	0.370	0.31	0.2	0.081	0.007	0.3	3.15	2.5
Voliam flexi. 30% SC)	loss %	- -	0.00	16.21	45.94	78.10	98.10			
Thiamethoxam	Residue mg/kg	ND	0.268	0.155	0.127	0.061	0.02	0.05	2.48	8.34
Voliam flexi. 30% SC)	loss %	- -	0.00	42.16	52.61	77.24	92.54			

Table 6. Residue levels of tested pesticides on tomato fruits (Experiment. 2)

Insecticides	Intervals (days)	pre	1 h	1 d	3 d	7 d	14 d	MRLS (PPM)	T ½	PHI day
Chlorantraniliprole	Residue mg/kg	0.005	0.98	0.82	0.41	0.08	0.006	0.3	2.33	3.68
(Coragen. 20% SC)	Loss %	- -	0.00	16.32	58.16	91.83	99.38			
Emamectin benzoate	Residue mg/kg	ND	0.17	0.07	0.007	ND	ND	0.02	0.711	2.09
(Proclaim. 5% SG)	Loss %	- -	0.00	58.82	95.88	-- --	-- --			
Indoxacarb	Residue mg/kg	0.01	0.81	0.71	0.51	0.198	0.001	0.5	2.87	3.96
(Avaunt. 15% SC)	Loss%	- -	0.00	12.34	37.03	75.55	98.76			
Chlorantraniliprol*	Residue mg/kg	LOQ	0.306	0.165	0.104	0.045	0.01	0.3	3.13	0.6
Voliam flexi. 30% SC)	Loss%	- -	0.00	19.90	49.51	78.16	95.15			
Thiamethoxam	Residue mg/kg	ND	0.271	0.238	0.077	0.042	0.004	0.05	2.3	5.65
Voliam flexi. 30% SC)	Loss%	- -	0.00	12.17	71.58	84.50	98.52			

Persistence of Coragen (a.i. Chlorantraniliprole):

In the first experiment, the initial deposit of Chlorantraniliprole after 1 hour of spraying was 0.85 mg/kg dissipated to 0.69, 0.463, 0.108 and 0.036 mg/kg after 1, 3, 7 and 14 days' post spraying, respectively. Meanwhile at the second experiment, the initial deposit was 0.98 mg/kg dissipated to 0.82, 0.41, 0.08 and 0.006 mg/kg after 1, 3 ,7 and 14 days from treatment, respectively.

The calculated half-life (T ½) values for Chlorantraniliprole on tomato fruit were 2.97 and 2.33 days. whereas the calculated PHI values based on (MRLs)EU were 4.24 and 3.68 days for the first and second experiments, respectively. Similar findings of half-life and PHI were calculated at 3.3 and 7 days respectively by Malhat *et al*. (2012).

Persistence of Proclaim (a.i. Emamecti benzoate):

At the first experiment. After 1 hour of application.The initial residue was 0.267 mg/kg. this deposite decrased to 0.087 and 0.033 mg/kg in 1 and 3 days after application, respectively. While, at the second experiment the Intial residue of 0.17 mg/kg dissipated to 0.07 and 0.007 mg/kg, and no residues were detected on the 7th day. The impoted Hal-life values were r 0.76 and 0.711 days. And based on EU.MRLs PHI values calculted at 4.03 and 2.09 for the first and second experiments, respectively. This findings are in agreement with Nasr *et al.* (2009) who stated that the emamamectin benzoate half-life and PHI on tomate were 0.6 and 3 days.

Persistence of Avaunt (a.i. Indoxacarb):

In the first experiment, the initial residue of Indoxacarb after 1 hour after spraying was 0.96 mg/kg decreased to 0.83, 0.63, 0.448 and 0.046 mg/kg along 1, 3, 7 and 14 days after application, respectively. While in the second experiment, the initial deposit of 0.81 mg/kg declined to 0.71, 0.51, 0.198 and 0.001 mg/kg after 1, 3, 7, 14 days from spraying respectively.

The calculated Half-life values (T ½) of Indoxacarb were 4.53 and 2.87 days. And calculated PHI values based on EU. MRLs were 4.28 and 3.96 days for the first and second experiments, respectively. Similar results were obtained by Shams EL Din *et al.* (2015) and Madan *et al.* (2018) they found that the half-life values of Indoxacarb on tomato fruits ranged between 2 and 4 days. Meanwhile, the PHI values recorded at 4 - 5 days.

Persistence of Voliam flexi (a.i. Chlorantraniliprole)

At the first experiment, the prime residue after 1 hour was 0.370 mg/kg ddissipated to 0.31, 0.2, 0.081 and 0.007 mg/kg in 1, 3, 7 and 14 days post spraying, respectively.while, In the second experiment intial deposite of 0.306 declined to 0.165, 0.104, 0.045 and 0.01 mg/kg in 1, 3, 7 and 14 days post spraying, consecutively . The acounted half-lives were 3.14 and 1.85 days. And According to EU.MRLs, PHI values were 1.6 days and 0.4 days for the first and second experiments, respectively.

Persistence of Voliam flexi (a.i. Thiamethoxam).

In the first experiment, the basic deposit of 0.268 mg/kg of Thiamethoxam, 1 hour followed the impelemention, dissibated to 0.155, 0.127, 0.061 and 0.02 mg/kg after 1, 3, 7 and 14 days from sprayin, respectevily .while, the first deposit of 0.271 mg/kg, declined to 0.238, 0.077, 0.042 and 0.004 mg/kg, after 1, 3, 7 and 14 days, respectively. The calculated half- life values were 2.3 and 2.48 days. And based on EU MRLs PHI values were 8.34 and 5.65 days for the first and second experiments, successively. The obtained results are in agreement with Karmakar and Kulshrestha (2009). Who decleared that 82-87% of Thiamethoxam dissipated in 10 days; half life and PHI calculated at 4 and 8 days, conscutively.

In fact it was concluded that, the use of both traditional and biological insecticides for control *Tuta absoluta* on tomato according to study program could be accepted from the efficacy point of view. Since the pesticide residues were less than the MRLs. For the used insecticides.

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الملخص العربي

مبيدات الآفات الرشيدة لمكافحة التوتا ابسليوتا التي تصيب الطماطم ومتبقياتها

عبد الفتاح سيد عبد الكريم سعد، مجدي عبد الظاهر حسين، أشرف محمود المرصفي، عبد الناصر توفيق حسن وفريد عياد الميتشو

خلال موسميين زراعيين لمحصول الطماطم. تم تقييم فعالية بعض المبيدات الزراعية في مكافحة حشرة التوتا ابسليوتا *Tuta absoluta* التي تصيب الطماطم، وقدرت متبقياتها.

بينت النتائج المتحصل عليها، أن مبيدات الآفات الكيماوية اعلى فاعلية من المبيدات الحيوية. واظهر مبيد الفوليام فلكسي Voliam flexi (الثايميتوكسام Thiamethoxam + الكلورانترانيليبرول Chlorantraniliprole) اعلى فاعلية، تبعه مبيد الافانت Avaunt (الاندوكساكارب Indoxacarb) ثم مبيد الكوراجين Coragen (الكلورانترانيليبرول Chlorantraniliprole).

اظهر مبيد البروكليم Proclaim (الايمامكتين Emamectin benzoate) اعلى فاعلية بين المبيدات الحيوية تبعه مبيد الدايبل Diple باسلس تورينجينسزز تحت النوع كورستاكي (Bacillus thuringiensis var korstaki) ثم مبيد الاشوك Achook (الازاديراشتين Azadirachtin).

تحت ظروف التطبيق الحقلي خلال موسمين زراعيين تم تتبع مستويات مخلفات المبدات المستخدمة وأزمنة تبددها الحيوي بعد أخر تطبيق حقلي. تقدير متبقيات المبيدات. تم بمرحلتين الاستخلاص وكان وفق الطريقة المعتمدة (الكيتشرز QuEChERS methods) والتقدير الكمي تم باستخدام جهاز الكروماتوجرافي السائل ة مع جهاز الطيف الكتلي (LC.MS.MS). اثبث نتائج كفاءة الاسترجاع أن قيم كفاه الاسترجاع ضمن النطاق المقبول وان طرق الاستخلاص المتبعة مناسبة للمبيدات المستخدمة. كم تبين أن تكسير بقايا مبيدات المستخدمة أخدت منحنى من الدرجة الأولى وان فترة نصف العمر المقدرة للمبيدات كانت بين ٢-٤ أيام للمبيدات الكيماوية، واقل من يوم في المبيدات الحيوية. كما تبين أن فترة ما قبل الحصاد تراوحت بين ٢-٧ أيام للمبيدات الكيماوية و2 -٤ أيام للمبيدات الحيوية وفق معايير الاتحاد الأوربي لمتبقيات المبيدات المسموح بها في الأغدية (EU MRLs).

الكلمات المفتاحية : توتا ابسليوتا, متبقيات, تحليل, بي اتش أي