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Field evaluation and residues of insecticides against some sucking insects on tomato plants

Atef, T. El-Masry[1]; Dalia, E. El-Hefny[2]; and Ahmed, A. El-Ghanam[2]

[1]*Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*

[2]*Central Agricultural Pesticide Laboratory, Agricultural Research Center, Dokki, Giza, Egypt.*

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Abstract

The effectiveness of four neonicotinoids insecticides, Acetamiprid (Telfast 20% SP), Thiamethoxam (Pilote 25% WG), Imidacloprid (Vendex 30% wp), and Thiacloprid (Blanch 48% SC)] against sucking insects in tomato fruits, as well as the residual levels of thiacloprid under open field conditions using the recommended dose against whiteflies, were evaluated in field experiments and comparing the efficacy of three treatments. At 2, 5, and 7 days after the first, second, and third sprays, under field settings, the effects of all insecticidal treatments on the natural population of whitefly stages (Nymphs and adults) were calculated as a percent reduction of the whitefly population stage (Nymphs and adults). Overall, according to the data, all insecticidal treatments reduced the stage of the whitefly population (Nymphs and adults) in comparison to the control. A tomato can be harvested safely after 7 days of Thiacloprid treatment, and the RL_{50} was 5.62 days.

Introduction

In Egypt, one of the most significant solanaceous vegetable crops is the tomato (*Lycopersicon esculentum* Mill). There are numerous harmful bugs currently infesting the tomato plants. Whiteflies, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) are the bugs that cause the most damage. An insect pest on more than 600 distinct plant types, the whitefly is polyphagous (Jahel *et al.,* 2017). Whitefly, which feeds on phloem and injects toxins, damages vegetable, fiber, and ornamental crops directly and indirectly by injecting viruses into the host plant and by feeding on the phloem (Pereira *et al.,* 2004 and Brown, 2010).

The generation of carbohydrate-rich honeydew excretions, which bind the leaves together, hinder photosynthesis, and encourage the growth of sooty mould fungus on the surface of plants' leaves and fruits is another unpleasant side effect of whitefly infection (Stansly and Natwick, 2009). Neonicotinoid insecticides are substances that bind to and activate the nicontinic acetylcholine receptors in insects (nAChR). They are advised to manage numerous coleopterans and several lepidopteran pest species as well. They are particularly active on hemipteran pest species such as aphids, whiteflies, and plant hoppers (Nauen *et al.,* 2003).

In comparison to contact insecticides, systemic insecticides (Imidacloprid, Thiacloprid, Thiamethoxam, and Acetamiprid) typically offer continuous plant protection for the majority of the growing season without the need for additional applications. Moreover, systemic insecticides have a low danger of overexposure to applicators because they are not degraded by ultraviolet light or "wash off" during watering (Herbert *et al.,* 2008). For pesticide multiresidue analysis, the QuEChERS method was created as a new sample preparation methodology between 2000 and 2002 (Anastassiades *et al.,* 2003).

The objective of this study is to assess how well certain neonicotinoid compounds control different stages of tomato whitefly over the summer and fall of 2020 at the Etai Al-Baroud Agricultural Research Station.

Materials and methods

1. Experimental site:

In 2020, during the tomato planting season in El-Beheira Governorate, studies were conducted. (Summer and fall). The tomato plants were spaced 0.5 m apart in rows that were 1 m long. Five plots were created within the experimental area, one for control samples and the other four treatments. Two kilograms of tomato fruits were randomly taken from the control and treated plots after 1 hour, 1, 3, 7, 10, and 15 days, respectively, of application. Fruit samples were kept until extraction in a freezer at 20°C.

2. Tested insecticides:

Acetamiprid (Telfast 20% SP), Imidacloprid (Vendex 30% wp) were used at field rate of 25 g/100 liter water and 100 g/100 liter water, respectively. While Thiamethoxam (Pilote 25% WG) and thiacloprid (Blanch 48% SC) were used at field rate of g/100 liter and 120 c/ feddan, respectively.

3. Procedures of evaluation:

In this study, five treatments were used on the season in 2020 on tomatoes in summer and autumn plantations, all treatments were divided into five, including the control area of piece 182 m2. The random block design was completely used in the field experiment with four replicates per treatment (30 sheets / repetition) as the untreated piece. Each piece is separated from the other by a metering belt to reduce interference from another treatment drift. Observations were recorded before and after the treatment of whitefly on thirty leaves from the apical (Each of the upper, middle and lower canopy) of five plants with a random marker of each segment in each recurrence in one day before and after 1, 3, 7 and after 10 days of treatment or treatment. Population reduction using the Henderson and Tilton equation (1955).

4. Standards and reagents:

Thiacloprid reference standards of >99% purity was bought from Dr. Ehrenstorfer GmbH (Augsburg, Germany). All other HPLC-grade chemicals and solvents were bought from Sigma Aldrich. Thiacloprid was produced as a stock solution in acetonitrile at a concentration of 1 mg/ml, and it was stored there at 4°C. By serially diluting the stock solution, calibration standards and working solutions with concentrations ranging from 0.01 to 5.0 ug/ml were created. Agilent Technologies sold the QuEChERS salts: 4 g $MgSO_4$, 1 g NaCl, 1 g trisodium citrate dihydrate, 0.5 g disodium hydrogen citrate sesquihydrate, and d-SPE salts. (Wilmington, DE, USA).

5. Sample processing:

Extraction and cleanup were completed using the official technique described by Anastassiades *et al*. (2003), The steps of the analytical process were as follows: (A) placing 10 g of sample into a centrifuge tube; (B) adding 10 mL of acetonitrile, QuEChERS extraction salts in each tube; (C) centrifuging it at 3,500 rpm for 5 minutes; and (D) transferring 1 mL of the acetonitrile extract to a 15 mL centrifuge tube containing 25 mg PSA and 150 mg of anhydrous MgSO4. The tube was then vortexed for 1 minute and centrifuged at 3500 rpm for 5 minutes. Millipore, Billerica, Massachusetts, 0.2 m PTFE filter was used to filter the supernatants before placing them in auto-sampler vials for HPLC-DAD analysis.

By adding various standard solution concentrations to 10 g of tomato control samples in three levels of 0.1 to 1.0 mg/kg, fortified samples were created. Prior to extraction, the fortified samples were left at room temperature for 30 minutes to allow the pesticide to permeate the matrix. Five identical analyses of each fortification level were conducted using the same methods.

6. Instruments and apparatus:

The Agilent 1100 series HPLC system, a quaternary pump, a variable wavelength diode array detector (DAD), and an analytical column (Nucleosil C18) (30 mm4.6 mm id, 5 m) were used for the chromatographic investigations. For Thiacloprid, the mobile phase flow rate was 1 ml/min and the injection volume was 20 ul (Acetonitrile 60% + water 40%). A 210 nm detection wavelength was used. Thiacloprid had a retention time of 5.63 minutes.

7. Statistical analysis:

The findings were presented as mean ± S.D. The Statistical Package for Social Sciences was used to compile all data (SAS institute, 1988). One-way analysis of variance (ANOVA) was used to analyse the data, and Duncan's test was used to compare the effectiveness of the various treatment groups. The cutoff for statistical significance was $p \leq 0.05$.

Results and discussion

The effects of all insecticidal treatments on natural population of whitefly stages ((Nymphs and adults) were recorded as % of the percent reduction of whitefly population stage (Nymphs and adults) at 2, 5 and 7 days after one first, second and third spray under field conditions. In general, the obtained results indicated that all the insecticidal treatments decreased the whitefly population stage (Nymphs and adults) compared with the control.

1. First Spray

Data presented in Table (1) showed that, at 2 days, after one first spray Actra formulation caused the highest percent reduction of a natural population of nymphs and adults whitefly rates (95.56 and 88.03%) followed by Pestidor (88.18 and 75%), finally Mosiplan (87.13 and 81.19), respectively. On the contrary, calypso, treatment gave the lowest percent reduction which represents (64.34 and 82.05%), respectively.

Also, the results tabulated in Table (1) clear the effect of the tested insecticidal on individual whitefly population stage (Nymphs and adults) at 5 days after One first spray recorded the highest percent reduction of Blanch 48% SC, Telfast 20% SP, Pilote 25% WG and Vendex 30% wp rates 90.40, 86.14, 82.08 and 77.17% of nymph stage, respectively, while Vendex 30% wp formulation gave the lowest controlling rates 62.05 % of adults stage. The corresponding adult stage of whitefly population, Telfast 20% SP and Pilote 25%WG gave intermediate controlling rates 78.82 and 75.50%, respectively. Compared with Blanch 48% SC treatment, gave the highest controlling rates 81.13%, respectively (Table 1).

After the seventh day during one first spray, Pilote 25% WG was found superior to all insecticidal treatments for a percent reduction in individual whitefly population stage (Nymph) but, Blanch 48% SC gave superior to all insecticidal treatments to a percent reduction in individual whitefly population stage (Adults) compared to control. On the contrary, Vendex 30% WP, treatment gave the lowest percent reduction which represents (75%) of a nymph, and Pilote 25% WG gave the lowest percent reduction which represents (62.16%) of adults, respectively.

Table (1): Effect of some insecticides against whitefly, *Bemisia tabaci* population on tomato after 1st spray under field.

Treatments	Reduction over control in % (Days)							
	2		5		7		Mean	
	Nu	%	Nu	%	Nu	%	Nu	%
Nymphs								
Vendex30% WG	56.00 c	88.18	107.00 b	77.18	118.00 b	75.00	93.66	80.12
Blanch 48% SC	169.00 b	64.34	48.33 e	90.40	89.00 cd	81.14	101	78.62
Telfast 20% SP	61.00 c	87.13	65.00 d	86.14	94.00 c	80.08	73.33	84.45
Pilote 25% WG	21.00 d	95.56	84.00 c	82.08	84.00 d	82.20	63.00	86.61
Control	474.00 a	-	469.00 a	-	472.00 a	-	-	-
LSD 0.05	**21.34**		**8.41**		**5.02**			
Adults								
Vendex30% WG	117.00 b	75.00	181.00 b	62.05	197.00 b	59.04	165	65.36
Blanch 48% SC	84.00 c	82.05	90.00 d	81.13	105.00 e	78.17	93.00	80.45
Telfast 20% SP	88.00 c	81.19	101.00 d	78.82	139.00 d	71.10	109.33	77.03
Pilote 25% WG	56.00 d	88.03	119.00 c	75.50	182.00 c	62.16	119.00	75.23
Control	468.00 a	-	477.00 a	-	481.00 a	-	-	-
LSD 0.05	**8.32**		**13.54**		**13.94**			

Nu=Mean number of White fly Nymph and Adult / 30 leaves%= %Reduction

2. Second spray:

Data presented in Table (2) clarified those differences between the effects of Blanch 48% SC, Telfast 20% SP, Pilote 25% WG and Vendex 30% wp against these whitefly population stages (Nymphs and Adults) at 2, 5 and 7 days after the second spray. Blanch 48% SC formulation decreased whitefly population Nymph compared to other treatments at 2, 5 and 7 days after the second spray. It gave the highest percent reduction rates (95.58,86.04 and 81.13%) followed by Telfast 20% SP (95.37 ,85.20 and 78.19%), Pilote 25% WG (95.16,80.12 and 76.10%), and finally Vendex 30% WP (85.08,81.18 and 79.24%), respectively.

Also, Vendex 30% WP treatment gave the lowest percent reduction in whitefly population adults at 2 and 5 days after the second spray, but it gave the highest percent reduction at 7days after the second spray followed by all insecticidal treatments to percent reduction on individual whitefly population stage (Adults). All insecticidal treatments recorded the highest percentage of reduction in whitefly population (Nymphs and Adults) at 2, 5 and 7 days after second spray compared un treatment.

Table (2): Effect of some insecticides against whitefly, *Bemisia tabaci* population on tomato after 2nd spray under field.

Treatments	Reduction over control in % (Days)							
	2		5		7		Mean	
	Nu	%	Nu	%	Nu	%	Nu	%
Nymph								
Vendex30% WG	71.00 b	85.08	89.00 c	81.18	99.00 d	79.24	86.33	81.83
Blanch 48% SC	21.00 c	95.58	66.00 d	86.04	90.00 e	81.13	59.00	87.58
Telfast 20% SP	22.00 c	95.37	66.67 d	85.20	104.33 c	78.19	76.66	86.25
Pilote 25% WG	23.00 c	95.16	94.00 b	80.12	114.00 b	76.10	77.00	83.79
Control	476.00 a	-	473.00 a	-	477.00 a	-	-	-
LSD 0.05	**8.17**		**4.89**		**3.35**			
Adults								
Vendex30% WG	118.00 b	75.05	129.00 b	73.18	82.00 e	83.09	109.00	77.10
Blanch 48% SC	104.00 c	78.01	105.00 e	78.17	116.00 d	76.08	108.33	77.42
Telfast 20% SP	85.00 d	82.02	115.00 d	76.09	135.00 c	72.16	111.66	76.75
Pilote 25% WG	85.00 d	82.02	125.00 c	74.01	145.00 b	70.10	118.33	75.37
Control	473.33 a	-	481.00 a	-	485.00 a	-	-	-
LSD 0.05	**5.35**		**3.58**		**9.25**			

Nu=Mean number of White fly Nymph and Adult / 30 leaves%= %Reduction

3. Third spray:

By 2, 5 and 7 days after the third spray, the results in Table (3) clarified that all the tested insecticidal treatments reduced the whitefly population stage (Nymphs and Adults) compared to control. Moreover, all the chemical treatments gave the highest percent reduction of the whitefly population stage. Pilote 25% WG gave the highest percent reduction of mean whitefly population stage (Nymphs and Adults) with rates (89.85 and 79.07%) followed by all insecticidal treatments, however, Vendex 30% WP, gave the lowest percent reduction of mean whitefly population stage (Nymphs and adults) with rates (80.37 and 74.53%), respectively.

Table (3): Effect of some insecticides against whitefly, *Bemisia tabaci* population on tomato after 3rd spray under field.

Treatments	Reduction over control in % (Days)							
	2		5		7		Mean	
	Nu	%	Nu	%	Nu	%	Nu	%
Nymph								
Vendex30% WG	81.00 b	83.01	90.00 b	81.09	110.00c	77.03	93.66	80.37
Blanch 48% SC	33.00 c	93.08	71.00 d	85.08	111.00c	76.82	71.66	84.99
Telfast 20% SP	27.00 c	94.12	80.00 c	83.19	86.00d	82.04	64.66	86.45
Pilote 25% WG	31.00 c	93.50	81.67 c	80.04	119.00b	96.03	81.66	89.85
Control	477.00a	-	476.00a	-	479.00a	-	477.33	-
LSD 0.05	**8.49**		**2.60**		110.00c			
Adults								
Vendex30% WG	120.00 b	75.05	120.00 c	75.50	132.00 c	73.06	124.33	74.53
Blanch 48% SC	62.00 d	87.11	111.00 d	77.11	161.00 b	67.14	111.33	77.12
Telfast 20% SP	61.00 d	87.31	126.00 b	74.02	117.00 d	76.12	101.33	79.15
Pilote 25% WG	77.33 c	81.08	87.00 e	82.06	126.00 c	74.08	101.66	79.07
Control	481.00 a	-	485.00 a	-	490.00 a	-	485.33	-
LSD 0.05	**9.21**		**5.72**		**6.34**			

Nu=Mean number of White fly Nymph and Adult / 30 leaves%= %Reduction

After two, five, and seven days of spraying for each insecticidal treatment, the population of whiteflies gradually declined, and the percent reduction over control increased. The current findings are somewhat in agreement with other studies like Al-Kherb (2011) which found that thiamethoxam had the maximum efficacy against whiteflies in cucumbers and tomatoes.

According to Zhang *et al.* (2011), Actara's great efficacy is a result of its long-term impact on the population of whiteflies and the fact that it dissolves gradually within plant tissues. For their effectiveness against the cotton leafhopper, Ramalakshmi *et al.* (2012) investigated the bioefficacy of several novel insecticides, including fipronil 5% SC @ 50 g a.i. ha-1, fipronil 80% WG @ 50 g a.i. ha-1, Diafenthiuron 50% WP @ 375 g a.i. ha-1, Buprofezin 25% SC @ 150 g a.i. The next two most effective therapies after fipronil were Buprofezin and Diafenthiuron, then Acephate and Imidacloprid.

El-Naggar and Zidan (2013) studied the combined effects of imidacloprid and thiamethoxam against pest sucking insects such as aphids, jassids, and whiteflies and found that the largest percentage of the decrease occurred after 40 days. Zewain *et al.* (2013) tested three pesticides for their effectiveness against cucumber whiteflies (*B. tabaci*) using the following three doses: 100, 200, and 300 ml/ha.

Significant whitefly mortality was caused by Proteus at its field recommended dose and Sulfoxaflor at 200 and 300 ml/ha up to three days after the initial application. When used in the spraying method with a concentration of 2 g / L water, Actara gave a high mortality rate of 87% against the whiteflies (Biotype B) on the cucumber, according to AbdElhady *et al*. (2014).

Imidacloprid, Fipronil, and Buprofezin all demonstrated high efficacy against white flies and jassids, according to Das and Islam (2014), while Thiamethoxam + Emamectin benzoate demonstrated moderate efficacy. Surwase (2017) evaluated seven insecticides including Acetamiprid 20 SP @ 150 g/acre, Imidacloprid 200 SL @ 250 ml/acre, Bifenthrin 10 EC @ 250 ml/acre, Carbosulfan 25 EC @ 500 ml/acre, Thiamethoxam 25 WG @ 24 g/acre, Diafenthiuron 50 WP @ 200 ml/acre and Methamidophos 60 SL @ 500 ml/acre for their efficacy against jassid, whitefly and thrips in cotton and found that Imidacloprid and Acetamiprid were most effective against jassid, Acetamiprid and Thiamethoxam were most effective against whiteflies, and Acetamiprid, Imidacloprid, and Methamidophos were most successful against thrips.

The high efficacy of the Neocontinoids, Acatra, and Calypso, which provided the best mortality after one day of application, was demonstrated in a study by Mohammadali *et al.* (2019). The high efficacy is related to the destructive effect of these insecticides on Nicotinic acetylcholine receptor (NAchR) receptors in the neurotransmitter fibers of the central and peripheral nervous systems of the insects. Lasheen (2020) demonstrated that residual control of the white fly, *B. tabaci*, on spring cantaloupes was given by the Spiromesifen spray treatment.

In conclusion, it could be recommended to use four Neonicotinoids [Thiamethoxam (Actara 25% WG), Imidacloprid (Pestidor 25% WP), Acetamiprid (Mosiplan 20% SP) and Thiacloprid (Calypso SC 480)] in commercial formulation size using recommended dose against whitefly stage on tomato.

4. Recovery:

For assessment of the method precision, blank samples were fortified with thiacloprid standard at three levels: 0.1 to 1.0 mg kg^{-1} for tomato samples. The fortified samples were analyzed in five replicates (n= 5). Calculating the recovery average at the measured levels allowed for an evaluation of the method's accuracy. Precision has been determined as the relative standard deviation (% RSD), which is the ratio between the standard deviation and average concentration found. Accuracy has been computed as the percentage ratio between the found and the known concentrations. According to the validation criteria set forth by Filho *et al.* (2006), the precision and accuracy were deemed sufficient for validating the approach. The recovery results for Thiacloprid ranged from 95.24-99.86% and RSD 1.01-1.59%.

5. Determination of thiacloprid in tomato fruits using HPLC-DAD analysis:

The devised approach was used to investigate Thiacloprid's dissipation in tomato fruits under field circumstances. The initial deposit of thiacloprid in tomato was 2.32 ± 1.95 mg/kg, after application for an hour. Then regularly declined to 2.04 ± 1.11mg/kg within one day following application, this value declined to 1.45 ± 0.97, 0.50 ± 1.20 and 0.21±0.89 mg/kg, after 3,7 and 10 days after treatment, respectively. The residues of thiacloprid were below detection limits after 15 days of application.

Residue amounts, RL_{50}, MRL and estimated PHI in tomato fruits were shown in (Table 4 and Figure 1). Estimated PHI values according to Codex (2007) MRL was 7 days for recommended dose. The half-life of Thiacloprid was 5.62 days.

Our results agreed with Li *et al.* (2022) who investigated the levels of residue and dissipation of thiacloprid in cowpeas under field conditions. The QuEChERS method and (HPLC–MS/MS) were used to detect thiacloprid residues content in cowpeas. Relative standard deviations (RSDs) ranged from 2.1 to 9.5%, and recoveries ranged from 81.3 to 95.1%. According to the dissipation kinetics data, the half-lives of thiacloprid in cowpeas were 1.14–1.54 days. The pre-harvest interval (PHI) was 3 days, and the terminal residues of thiacloprid were 0.0255–0.4570 mg kg1 after two applications.

Pesticide residues in crops are affected by climatic variations, dosage, and the intervals between application and harvest. Yet, high temperatures are the main element in reducing the residual pesticides on the plant surface. Light also has a significant impact on how pesticides behave in the environment. Climatic conditions like sunlight and temperature influence how quickly sprayed pesticides dissipate. Moreover, the degradation of insecticides may be brought on by biological, chemical, or physical processes, or, if they are still present in the field, by reduction by crop growth (Waghulde *et al.*, 2011 and Christensen, 2004).

Table (4): Dissipation behavior and Residue levels of thiacloprid in tomato under open field conditions.

Intervals after application (days)	Residues (ppm)±SD	% Loss	% Persistence
initial*	2.32 ± 1.95	0.00	100.0
1	2.04 ± 1.11	12.06	87.94
3	1.45 ± 0.97	37.50	62.50
7	0.50 ± 1.20	78.44	21.56
10	0.21±0.89	90.94	9.06
15	ND	---	---
RL_{50}	5.62 days		
MRL	0.5 mg/kg (Codex2007)		
PHI (days)	7 days		

RL 50: Half lifeperiod.MRL:Maximum residue level. PHI:Pre-harvest interval

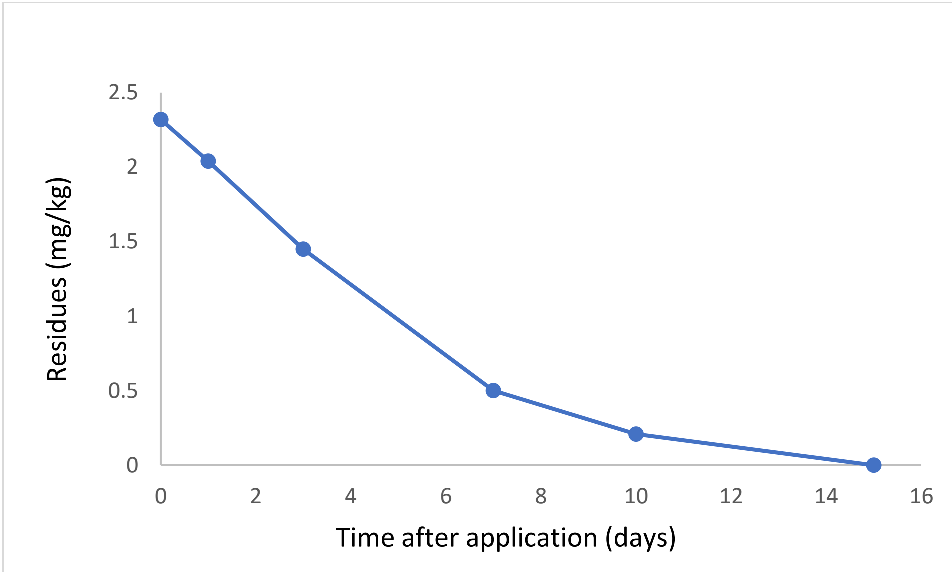

Figure (1): Residue levels and dissipation behavior of thiacloprid in tomato fruits under open field conditions.

The aim of the research is to evaluate the effectiveness of some neonicotinoid compounds [Thiamethoxam (Pilote 25% WG), Imidacloprid (Vendex 30% WP), Acetamiprid (Telfast 20% SP) and Thiacloprid (Blanch 48% SC)] on some stages of whitefly (Nymphs and Adults) on tomatoes at the Etai Al-Baroud Agricultural Research Station during the fall and summer season 2020. In general, the obtained results indicated that all insecticidal treatments decreased the whitefly population stage (Nymphs and adults) compared to the control on tomato. Tomato can be harvested safely after 7 days of Thiacloprid treatment.

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