Egypt. J. Chem. **Vol. 67**, No. 7 pp. 459 - 467 (2024)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Effect of Some Insecticides, Depletion and Risk Assessment against Whitefly Stages, *Bemisia tabaci* (Gennadius) on Cucumber Cultivation

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

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

[2] *Pesticides Residues and Environmental Pollution Department, Central Agricultural Pesticide Laboratory, Agricultural Research Center 12618, Giza, Egypt*

Abstract

The current study was carried out in the Etay El-Baroud Agricultural Research Station, El-Beheira Governorate -Egypt's during two seasons. The purpose was assessing the effectiveness of four pesticides: buprofezin (Primo® 10% SC), spirotetramat (Movento® 10% SC), sulfoxaflor (Closer® 24% SC), and pyriproxyfen (Antiflay® 10% EC) against cucumber whiteflies, and determine the residues of the most effective pesticide against insect's egg in cucumber samples. The findings demonstrated that the tested pesticides were effective against whitefly eggs, nymphs, and adults. After 10 days of treatment, the tested pesticides considerably decreased the amount of egg masses. The most effective pesticide was Antiflay® 10% EC, while the numbers of whitefly nymphs and adults were most reduced by Primo® 10% SC. According to the dissipation kinetics data, the half-life of pyriproxyfen was 1.69 days. The residues of pyriproxyfen on cucumber were sharply decreased until 5 days of treatments and below the determination limit on 5th day, risk quotient (RQ) was higher than 1 until 3 days which indicates risk may be imposed during long-term consumption, but can be harvested without risk at pre-harvest interval.

***Keywords*:** White fly; depletion; residues; efficacy; pyriproxyfen.

1. Introduction

The most significant vegetable's pests in the entire world are the whitefly, which also spreads viruses and causes direct damage **[1]**. Insecticides are one of the suggested control methods for whiteflies, because of their immediate and rapid results. They are frequently employed for this reason. Whiteflies became more resistant to these chemicals associated with their extensive use **[2].**

Using pesticides in agriculture is a common practice to increase productivity and control pests. One of the most typical routes that people are exposed to pesticides is the food consumption. Pesticide residues on fruits and vegetables can pose a risk to consumers and be a source of worry for human health. As stated in the literature, the optimum practice of pesticide mostly results in low residue levels on crops and cannot go above the maximum residue limits (MRLs) **[3]**.

Sulfoxaflor is the first member of a new chemical class of chemical known as sulfoximines, and it is characterized by broad-spectrum activity on sap-feeding agricultural insects like plant bugs (Lygusspp), aphids, wheal bugs, and wheal beetles. Over the past ten years, new insecticide chemicals have been introduced, providing with other targets to effective control of whiteflies. Sulfoxaflor has extended residual control and acts quickly **[4]**. The use of spirotetramat in place of neonicotinoid insecticides may help to limit the likelihood of mass multiplication and the development of resistance in *Myzuspersicae***[5]**. A broad-spectrum insect growth regulator is pyripraxyfen, or 2-[1-methyl-2-(4 phenoxyphenoxy) ethoxy] pyridine. It is an analog of the juvenile hormone that prevents larvae from maturing into adults and thus from reproducing.Pyriproxyfen impacts the physiology of an insect's morphogenesis, reproduction, and embryogenesis. At very low dose rates, it inhibits adult emergence from larvae with a high level of activity. It has little effect on the environment and is less hazardous to mammals **[6]**. The effectiveness of

*Corresponding author e-mail: dalia_elhafny@yahoo.com.; (Dalia El-Hefny).

EJCHEM use only: Received date 23 August 2023; revised date 26 December 2023; accepted date 01 January 2024

DOI: 10.21608/EJCHEM.2024.231222.8478

novel chemical pesticides against whitefly in field settings on cucumber plants has been studied for a variety of insects, including whiteflies **[7-9]**.

One of the most important vegetables, cucumber, *Cucumis sativus* L. (Cucurbitaceous), can be found all over the world. The cucumber plantation in Egypt is developing at a relatively rapid pace, particularly in the newly reclaimed open field and greenhouse, where fruit cucumber is grown for both domestic consumption and export to foreign markets.

Aim of this work is to evaluate the effect of some insecticides on a severe pest (white fly) andinvestigate depletionand risk assessment of the most effective pesticide on pest egg stage in cucumber.Also estimation of pre-harvest interval for ensuring human health safety.

2. Material and Methods

2.1. Experimental place

Etay-El-Baroud Agriculture Research station, Beheira Governorate, Egypt, during seasons 2021/2022.During the experiment the registered temperature ranged from 24 to 26 ºC and the humidity ranged from 55 - 60 %.

2.2. Insecticides

The examined insecticides were list in Table 1 obtaining their trade names, common names and field recommended rates.

Table 1: Insecticides trade name, active ingredient and rate of application

Trade Name	Common Name	Rate
buprofezin	Primo®10%SC	468.8 cm^3/ha
spirotetramat	Movento® 10 %SC	600 cm^3/ha
sulfoxaflor	Closer® 24% SC	30 cm^3/100 L water
pyriproxyfen	Antiflay® 10% EC	75 cm^3/100 L water

2.3. Experimental Layout

Four pesticides were tested against the cucumber whitefly at the authorized dosages, together with untreated plants (the control). With five treatments, including the control, and three replications, the experiment was set up using a randomized complete block design. Water was sprayed on the control plot. Under standard agronomic procedures, the crop was cultivated in experimental plot (4×3 m) with a row spacing of 75 cm by 60 cm (R x P). With a fifteen-day interval between applications, knapsack sprayers employing 20 Liters of spray solution/ha were used.

2.4. Observations taken

On five randomly chosen tagged plants from each plot in each replication, pre and post treatment observations of whitefly were made on thirty apical leaves (each from the top, middle, and bottom canopy) at 1 day before and 1, 3, 7 and 10 days after treatment. The Henderson and Tilton equation **[10]** was used to estimate the population reduction percentage.

2.5. Standard and reagents

Standards for pyriproxyfen with purity greater than 99% were purchased from Dr. Ehrenstorfer GmbH (Augsburg, Germany). All other HPLC chemicals and solvents were purchased from Sigma Aldrich. Pyriproxyfen was produced as a stock solution in acetonitrile at a concentration of 1 mg/mL, and stored there at 4 °C until used. Through serial dilution of the stock solution, calibration standards and working solutions were established with concentrations ranged from 0.1 to 10.0 µg/mL. Agilent Technologies sold QuEChERS salts: 4 g $MgSO_4$, 1 g sodium chloride. (Wilmington, DE, USA) was used.

2.6. Sample processing

The official method outlined by Anastassiades et al. **[11]**was used for extraction and cleaning, and the steps of the analytical process were as follows: A 10-g sample is placed into a 50 ml falcon tube, followed by the addition of 10 mL of acetonitrile and the salts of the QuEChERS extract, centrifugation at 3,500 rpm for 5 min, and the transfer of 1 mL of the acetonitrile extract to a 15-mL centrifuge tube containing 25 mg of primary secondary amine (PSA) and 150 mg of anhydrous $MgSO_4$. After one min of rotation, the tube underwent 5 min of centrifugation at 3,500 rpm. The supernatants were filtered through a Millipore, Billerica, Massachusetts, 0.2 µm PTFE filter, before being put into autosampling vials for HPLC-DAD quantity.

2.7. Validation

Fortified samples were created by adding three different standard solution concentrations, ranged from 0.1 to 1.0 mg/kg, to 10 g of cucumber control samples. Inoculated samples were kept at room temperature for 30 min, before extraction. So, the pesticide could permeate the matrix. Each fortified level was subjected to 5 identical analyses using the same techniques. Also 5 standard levels prepared in solvent as calibration levels.

Limit of detection (LOD) and limit of quantification (LOQ) were calculated by multiplying 3*standard deviation, then divided by slope of calibration standard levels for LOD and multiplying by 10 for LOQ.

2.8. Depletion and risk evaluation

First order equations were used to evaluate pyriproxifen depletion manner and half time span in cucumber, equation 1and 2:-

$$C_t = C_{oe}^{-kt} \quad (1)$$

$$t_{1/2} = ln2/k \quad (2)$$

Where, C_t (mg/kg) is the residue of pyriproxifen at time t (days), C_0 (mg/kg) is the initial and k is the decomposition rate (day).

The long-term uptake for pyriproxifen in cucumber can conduct health risk for consumers, as estimated through the following equations[12]:

$$NEDI = \sum (STMR \ x \ Fi/body \ weight \ (bw) \quad (3)$$

$$RQ = NEDI / ADI \quad (4)$$

Where, NEDI is the national estimated daily intake (mg/kg b. w) and STMR is the median residue. Fi is food consumption, bw is body weight and ADI is acceptable daily intake. The average body weight is 60 kg and the risk quotient was calculated by dividing NEDI by ADI. The risk must be less than 1 to be reasonable for human health.

2.8. Measurement

The chromatographic quantity was conducted using an Agilent 1100 series HPLC system, quadruple pump, variable wavelength diode array detector (DAD), and analytical column (Nucleosil C_{18}) (30 mm by 4.6 mm ID, 5 mm). For pyriproxyfen, the injection volume was 20 µl (acetonitrile 60% + water 40%) and the mobile phase flow rate was 1 mL/min. The detection wavelength was 210 nm. The retention time for pyriproxyfen was 5.63 min.

2.9. Statistical analysis

All data were statistically analyzed using the COSTAT computer program's design, and analysis of variance was performed to test all of the results. According to Gomez and Gomez [12], the differences between the means of the various treatment combinations were compared using the least significant difference test at 0.05 level of probability.

3. RESULTS AND DISCUSSION

The findings of a study conducted to evaluate efficacy of the examined insecticides against whiteflies, *B. tabaci* (Gennadius), on cucumber over the two seasons.

3.1. The efficiency percentages of the tested insecticides against the egg's whitefly Bemisiatabaci Genn on cucumber during 1st season

The present finding showed that after 1, 2, 5, 7, and 10 days in the field, the tested pesticides were still effective against whitefly eggs (Table 2). Additionally, statistically significant differences can be seen among all insecticides examined. At 1, 2, 5, 7, and 10 days after treatment, there has been a noticeable reduction in the number of whitefly egg fatalities, respect to the control group. The average numbers of whiteflies per 30 leaves were reduced by each treatment clearly varied from one another. Antiflay® 10% EC exhibited the highest reduction (30.22 Egg/30 leaves), followed by Closer® 24% (41.726 egg/30 leaves), Primo® 10% SC (49.89 Egg/30 leaves), and Movento® (51.13 egg/30 leaves). The current findings and those of other studies are somewhat consistent. Seni and Sahoo (2015) [13] stated that IGR, buprofezin induced notable papaya mealy bug mortality, which is nearly comparable to carbaryl's efficacy.

Additionally, there weren't many offspring found in the buprofezin-treated plants. Although early mortality was minimal, considerable mortality was reached after 7 and 14 days of the initial spraying as post-treatment time progressed. According to this research, buprofezin needs a considerably longer period of time to kill papaya mealy bug. Whereas pyriproxyfen was reported to have a 57.8–78.4% yield in cotton fields and to be efficient against thrips aphid, jassid, and whiteflies [14, 15]. In order to increase insecticidal activity against *B. tabaci*, we advised using Movento® 10% SC.

Table 2: The effect of different treatments against eggs stage of whiteflies infesting cucumber plants during 1st season field conditions

Treatments	Mean number of whitefly eggs/30 leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay 10% EC)	10.95^{c}	7.98^{b}	24.06^{b}	10.11^{b}	98.00^{b}	30.22
sulfoxaflor (Closer® 24% SC)	39.46^{b}	7.11^{b}	23.05^{b}	12.95^{b}	126.06^{b}	41.726
spirotetramat (Movento® 10 %SC)	24.66^{bc}	10.65^{b}	23.35^{b}	18.31^{b}	178.5^{a}	51.13
buprofezin (Primo®10% SC)	22.87^{bc}	13.31^{b}	16.65^{b}	26.33 a	170.30^{a}	49.89
Control	179.54^{a}	239.39^{a}	241.65^{a}	49.66 a	209.45^{a}	183.93
LSD $_{(0.05)}$	20.09	7.90	20.41	8.03	23.03	15.89

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.2. The efficiency percentages of tested insecticides against the eggs of whitefly on cucumber during 2nd season

The effect of the examined insecticides on the egg stage of whiteflies that infested cucumber plants during 2021 is shown in Table 3 under field settings. After 1, 2, 5, 7 and 10 days, it is shown that the insecticides are still effective against treating whitefly eggs in the field. Additionally, they display statistically significant variations. After 1, 2, 5, 7, and 10 days of treatment, there was a noticeable decrease in the number of whitefly egg fatalities compared to the control. The average number of whiteflies per 30 leaves decreased in each treatment, and the data revealed differences across the treatments. In comparison to the control (170.73 egg/30 leaves), Antiflay® 10% EC exhibited the greatest reduction (27.85 egg/30 leaves), followed by Closer® 24% SC (38.47 egg/30 leaves), Primo® 10% SC (53.912 egg/30 leaves), and Movento® 10%SC (55.49 egg/30 leaves). These findings are in agreement with those made public by Hilton et al. (2014) [16]. They stated that pyriproxyfen had a lower harmful effect on young whiteflies in the field than in the laboratory, where it had a higher activity. Pyriproxyfen degraded more quickly outdoors than it did in a laboratory. However, buprofezin's field efficacy was demonstrated to have considerable mortality (100%) with long-term monitoring (up to 10 days) **[13]**, which is consistent with the current findings. Additionally, buprofezin is a safer option for coccinellids and a less toxic alternative to harmful broad-spectrum insecticides like carbaryl **[17]**. Results of the two-year studies conducted to determine spirotetramat's effectiveness against *M. persicae* populations are comparable. They very effectively demonstrate the spirotetramat's high activity and protracted persistence, which have already been noted by other writers at different times and under different circumstances **[18]**.

Table 3: The effect of different treatments against eggs stage of whiteflies infesting cucumber plants during 2nd season under field conditions

Treatments	Mean number of whitefly eggs/30 leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay® 10% EC)	10.06^{d}	4.97^{c}	16.93^{b}	10.03^{d}	97.29^{e}	27.85
sulfoxaflor (Closer® 24% SC)	34.43^{b}	6.16^{c}	19.11^{b}	12.06^{d}	120.63^{d}	38.47
spirotetramat (Movento® 10 % SC)	19.33^{c}	13.00^{b}	16.33^{b}	16.00^{c}	168.33^{b}	55.49
buprofezin (Primo®10% SC)	20.33^{c}	13.33^{b}	15.66^{b}	24.66^{b}	153.00^{c}	53.912
Control	159.00^{a}	238.33^{a}	222.33^{a}	44.33^{a}	189.66^{a}	170.73
LSD $_{(0.05)}$	3.38	3.48	6.96	3.18	5.47	4.49

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.3. The effect of different treatments against the nymph of whitefly on cucumber during 1st season

The findings in Table 4 showed that, after 2, 5, 7, and 10 days of treatment, the tested insecticides were effective against whitefly eggs underneath the field. Significant variations can also be seen among all tested insecticides. After 1, 2, 5, 7, and 10 days of treatment, there has been a noticeable drop in the quantity of whitefly nymphs in comparison to the control. The findings of the mean decrease in the number of whitefly nymphs per 30 leaves in the various treatments show the differences between the treatments. The collected data showed that, when compared to the control (223.71 nymph/30 leaves), Antiflay® 10% EC exhibited the greatest reduction (50.26 nymph/30 leaves), followed by Movento® 10% SC (60.48 nymph/30 leaves), Primo® 10% SC (72.73 nymph/30 leaves), and Closer® 24% SC (49.18 egg/30 leaves).

According to reports, IGRs have a distinct activity range and a unique insecticidal mechanism that is not reliant on a neurotoxic effect. They are appropriate for use in conjunction with biological management and also to get around pesticide resistance, because they interfere with the physiology and development of the target insects and exhibit no or low toxicity towards non-target organisms **[19]**. So for the IPM programme of *Aphis ipsilon*, pyriproxyfen could be suggested as an environmentally suitable substitute for other insecticides **[20]**.

Table 4: Efficacy of different treatments against nymph stage of whiteflies infesting cucumber plants during 1st season under field conditions

Treatments	Mean number of whitefly nymph/30 leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay® 10% EC)	29.93^{b}	8.29^{b}	57.00^{cd}	17.03^{b}	139.05^{d}	50.26
sulfoxaflor (Closer® 24% SC)	23.05^{b}	19.34^{b}	79.05^{bc}	17.17^{b}	107.30^{d}	49.18
spirotetramat (Movento® 10 %SC)	45.22^{b}	21.36^{b}	53.22^{d}	23.06^{a}	159.55^{c}	60.48
buprofezin (Primo® 10% SC)	33.06^{b}	13.88^{b}	80.04^{b}	15.44^{b}	221.23^{b}	72.73
Control	252.60^{a}	299.65^{a}	271.60^{a}	55.70^{a}	239.01^{a}	223.71
LSD $_{(0.05)}$	13.57	19.95	16.43	10.98	17.06	15.49

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.4. The efficiency percentages of tested compounds against the nymph of whitefly on cucumber during 2nd season

Results showed the effectiveness of several pesticides against whiteflies in their nymphal stage that were infesting cucumber plants in 2022 under field conditions (Table 5). At 1, 2, 5, 7 and 10 days after treatment, it appeared that the insecticides were effective against insect eggs when used in the field, but there were also noticeable variances between them. When compared to the control, the quantity of whitefly nymphs at 1, 2, 5, 7, and 10 days after treatments has significantly decreased.

Compared to the control (212.57 nymph/30 leaves), Closer® 24% SC exhibited the greatest reduction (43.86 nymph/30 leaves), followed by Antiflay® 10% EC (46.15 / nymph/30 leaves), Movento® 10% SC (55.88 nymph/30 leaves), and Primo® 10% SC (69.99 egg/30 leaves). These findings are consistent with those of Abdel-Razek et al. [21], who stated that the administration of sulfoxaflor and azadirachtin may lead to the development of resistance in the population of whiteflies. On the other hand, Al-kazafy et al. (2015) [22] assessed the bio-efficacy of spirotetramat 15% OD as a foliar spray against whiteflies. It was obtained that spirotetramat at 75 g a. i/ha significantly decreased the whitefly population compared to control by 89.7%. Spirotetramat's LC_{50} for whiteflies was 1.671 g/ml. When spirotetramat was applied topically to control whiteflies, it lasted for up to 25 days at a concentration of 75 g a. i/ha. According to numerous studies, sulfoxaflor was also effective against a variety of sap-feeding insect that are resistant to other types of insecticides, such as buprofezin [23-27].

Table 5: Efficacy of different treatments against nymph stage of whiteflies infesting cucumber plants during 2nd season under field conditions.

Treatments	Mean number of whitefly nymph/30 leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay® 10% EC)	21.06^{e}	18.12^{b}	75.33^{c}	15.14^{c}	101.10^{e}	46.15
sulfoxaflor (Closer® 24% SC)	25.95^{d}	5.89^{d}	51.50^{d}	12.90^{c}	123.06^{d}	43.86
spirotetramat (Movento® 10 %SC)	39.06^{b}	21.30^{b}	44.77^{e}	21.23^{b}	153.06^{c}	55.88
buprofezin (Primo®10% SC)	30.45^{c}	11.56^{c}	79.06^{b}	11.85^{c}	217.03^{b}	69.99
Control	255.43^{a}	259.30^{a}	258.20^{a}	49.30^{a}	240.66^{a}	212.57
LSD $_{(0.05)}$	4.05	3.88	5.09	3.96	4.55	4.30

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.5. The efficiency percentages of tested compounds against the adults of whitefly on cucumber during 1st season

The effectiveness of the treatments against adult of whiteflies that infested cucumber plants in 2021 is shown in Table 6 under field circumstances. At 1, 2, 5, 7 and 10 days after treatment, it was obtained all tested insecticides were still effective against whitefly eggs in the field. Significant variations can also be seen among all tested insecticides. After 1, 2, 5, 7, and 10 days of treatment, the adult whitefly population has significantly decreased as compared to the control. The data showed that, Closer® 24% SC exhibited the greatest reduction (76.52 adults/30 leaves), followed by Antiflay® 10% EC (90.67 adults/30 leaves), Movento® 10% SC (94.65 adults/30 leaves), and Primo® 10% SC (132.79 adults/30 leaves), compared to the control (364.29 adults/30 leaves). The chitin synthesis inhibitor, buprofezin significantly effected on *Spodoptera litura* larvae. In the current investigation, the response of nymph mortalities brought on by these CSI was noted. The present results clearly demonstrated that *S. litura* larval moulting failure was the direct cause of death. This impact is mostly induced by suppressing chitin production [28]. As a result, aberrant endocuticular deposition and erroneous moulting were caused [29]. Buprofezin is a chitin synthesis inhibitor that aids in the growth and development of insects during moulting. Because of its lipophilic characteristics, it can directly interfere with the chitin in the exoskeleton. Higher amounts also have an antifeeding effect. According to Morita et al. [30], buprofezin was extremely efficient against *Aphis gossypii* and completely prevented aphid feeding within 0.5 hr of the treatment.

Table 6: Efficacy of different treatments against adult stage of whitefliesinfesting cucumber plants during 1st season under field conditions.

Treatments	Mean number of whitefly adult/30leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay® 10% EC)	11.40^{b}	59.70^{bc}	62.06^{b}	80.60^{b}	239.60^{bc}	90.67
sulfoxaflor (Closer® 24% SC)	33.20^{b}	27.70^{c}	49.60^{b}	43.10^{d}	229.00^{c}	76.52
spirotetramat (Movento® 10 %SC)	47.31^{b}	69.00^{b}	71.60^{b}	45.10^{cd}	240.25^{bc}	94.65
buprofezin (Primo® 10% SC)	59.60^{b}	41.30^{bc}	64.06^{b}	67.60^{bc}	395.40^{a}	132.79
Control	541.60^{a}	490.00^{a}	299.67^{a}	220.00^{a}	270.20^{b}	364.29
LSD $_{(0.05)}$	40.57	26.46	34.54	15.97	22.50	28.00

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.6. The efficiency percentages of tested compounds against the adults of whitefly on cucumber during 2nd season

As listed in Table 7, all tested pesticides were successful destroyed whitefly eggs in the field at 2, 5, 7 and 10 days after application. Significant variances were also seen between the examined insecticides. After 1, 2, 5, 7, and 10 days of application, all treatments significantly reduced the population of whitefly adult compared to the control. Based on the results, Antiflay® 10% EC exhibited the greatest reduction (74.98 adults/30 leaves), followed by, Closer® 24% SC (88.86 adults/30 leaves), Movento® 10% SC (94.38 adults/30 leaves), and Antiflay 10% EC (98.79 adults/30 leaves), compared to the control (382.57 adults/30 leaves). These outcomes are consistent with those of Sharaf et al. [31], who found that none of the compounds examined-diafenthiuron, buprofezin, imidacloprid, and triazophoshad any effect on any of the tested adversary, including genuine spiders, *Coccinellaundecimpunctata*, *Chrysoperlacarnea*, and *Paederusalfierii*. Spirotetramat had a negligible impact on Panonychus*citri* egg hatch, hence the assessment of mortality had to be delayed until the hatched larvae died at 11 days of treatment [32]. According to numerous studies, sulfoxaflor is also effective against a variety of sap-feeding insect pests that are resistant to other types of pesticides, including those that are resistant to neonicotinoids **[23-27]**.

Table7: Efficacy of different treatments against adult stage of whiteflies infesting cucumber plants during 2nd season under field conditions.

Treatments	Mean number of whitefly nymph/30 leaves					
	Days after exposure					
	1	2	5	7	10	Mean
pyriproxyfen (Antiflay® 10% EC)	29.98^{d}	28.95^{d}	44.30^{d}	41.60^{d}	230.10^{d}	74.98
sulfoxaflor (Closer® 24% SC)	14.22^{e}	55.60^{b}	60.70^{c}	75.30^{b}	238.50^{c}	88.86
spirotetramat (Movento® 10 %SC)	43.45^{c}	58.06^{b}	67.06^{b}	64.00^{c}	239.33^{d}	94.38
buprofezin (Primo®10% SC)	60.30^{b}	41.00^{c}	52.60^{c}	70.06^{bc}	270.00^{b}	98.79
Control	530.12^{a}	477.30^{a}	289.20^{a}	215.16^{a}	401.10^{a}	382.57
LSD $_{(0.05)}$	5.30	7.10	4.03	5.67	4.27	5.27

-Mean followed by the same letters in a column for each period not significantly differences at 0.05 level of probability.

3.7. Validation

With three replicates each, the calibration curve demonstrated good linearity and calculated recovery was satisfied (88.24 to 95.67 percent) for the three levels of 0.1 to 1 mg/kg, demonstrating the method's suitability and guaranteeing accuracy and trueness. LOD, or the lowest level of detection, is 0.05 mg/kg, and LOQ, or the highest level of accuracy [33].

3.8. Depletion and risk evaluation

The examination of pyriproxyfen exhaustion in cucumber natural products under field conditions utilizing novel methodology. One hr after treatment, the underlying pyriproxyfen store in cucumbers was 2.02 mg/kg, then, at that point, 1.15 mg/kg after 1 day, and 0.62, 0.10, and 0.03 mg/kg following 3, 5 and 7 days of treatment, separately. Ten days following application, pyriproxyfen lingering levels were beneath the limits for discovery. Five days prior to the recommended dose application, the EU 2023 MRL was used to estimate the PHI value. The half-life of pyriproxyfen was 1.69 days.

Table 8: Depletion behavior and residue levels of pyriproxyfen in cucumber under open field conditions

Time after application (days)	Residues (μg/g)	% loss	% persistence
0	2.02	0.00	100
1	1.15	43.06	56.94
3	0.62	57.85	42.15
5	0.10	95.04	4.96
7	0.03	98.51	1.49
10	ND	---	
MRL mg/kg (EU 2023)	0.1		
PHI (days)	5		
RL_{50} (days)	1.69		

- RL_{50}: Half life period. MRL: Maximum residue level. PHI: Pre-harvest interval

In terms of risk assessment, long-term exposure expressed as risk quotient is regarded as high risk for the initial one, three, and ten days because RQ values ranged from 4.3 to 1.3, which are higher than 1, whereas RQ values of less than 1 for the five, seven, and ten days indicate acceptable consumable risk.

Table 9: Long-term exposure risk expressed as risk quotient (RQ) for pyriproxifen on cucumber.

Days after treatment	Residues (mg/kg)	NEDI	RQ
0	2.02	0.43	4.34
1	1.15	0.25	2.47
3	0.62	0.13	1.33
5	0.1	0.02	0.22
7	0.03	0.006	0.06
10	ND	ND	ND

Our results are in agreement with Kumar et al. [34], who found that pyriproxyfen 10% EC has been evaluated at 20, 30, 40 and 50 g a. i/ha for control of tomato whitefly during the 2009 and 2010 crop seasons in Punjab. Compared with malathion 50% EC at rate 500 g a. i/ha standard check. Pooled analysis of 2 years of data showed a decrease in adult whitefly numbers on pyreproxyfen treatment at rate 50 g ingredient. i/ha (50.94%) which was at par with malathion (50.24%) and pyriproxyfen at rate 40 g a. i/ha (45.24%) 3 days after spraying. Similarly, the maximum number of whitefly adults was recorded in pyriproxyfen at rate 50 g a. i/ha (76.33%) after 7 days of spraying which was significantly better than malathion (49.60%). After 10 days of spraying, maximum whitefly populations were recorded in pyreproxyfen at the above rate (82.48%) which was at par with pyreproxifen at rate 40 g a. i/ha (75.00%), but was significantly better than malathion (43.84%). Finally, pyriproxyfen at rates 40 and 50 g a. i/ha was significantly higher than all other treatments. Pyriproxyfen has also been found to be a safe compound on tomatoes. The decrease in the number of natural enemies was significantly less in pyriproxyfen at rate 50 g a. i/ha after 3, 7 and 10 days of spraying: 54.51, 57.58 and 60.09, respectively, compared to malathion: 63.66, 66.41 and 68.28. No phytotoxicity was observed on tomato even with doubling the dose of the tested insecticide, and the results showed that the improved QuEChERS-UPLC-MS/MS method was a simple, rapid, sensitive, accurate, effective, economical and safe method that was detected simultaneously. Multiple pesticide residues through one time sample treatment, it had some advantages such as more pesticides per detection, simple and convenient handling and lower dose of solvent to be suitable for rapid quantitative screening and confirmation of pesticide residues in fruits and vegetables [35]. Pesticide residues in crops were affected by climatic changes, doses and intervals between use and harvest. However, high temperatures are the key to reducing pesticide residues on plant surface. Light also has a significant impact on the behaviour of pesticides in the environment. Climatic conditions such as sunlight and temperature affect how quickly sprayed pesticides dissipate. Furthermore, the degradation of pesticides may be caused by biological, chemical or physical processes, or, if they are still present in the field, by limiting crop growth [36, 37].

In China, pyriproxyfen was used to control whitefly, the behavior of residues, and the dietary risk of pyriproxyfen in tomato under field conditions. The 5-day pre-harvest interval (PHI) for sampling is recommended by Good Agricultural Practices (GAP). In the meantime, QuEChERS was used to analyze tomato samples for pyriproxyfen residues. At the recommended PHI (5 days), the analytes found in tomato samples had terminal residue levels below 0.19 mg/kg of pyriproxyfen, which was lower than China's maximum residue limits. The dietary gamble appraisal was likewise completed in light of field preliminary outcomes, toxicological information, and Chinese dietary example. Pyriproxyfen posed a low risk to consumers' health because its acute risk quotient (1.14%, general population, >1 year) and chronic risk quotient (26.59%) were well below 100 percent [38].

4. Conclusion

According to earlier findings, the insecticides used are quite efficient against cucumber whitefly eggs, nymphs, and adults. All of the studied chemicals showed a considerable decrease in the number of whiteflies, and there were significant differences between them all as well. After 10 days of treatment, the results showed that the tested insecticides considerably decreased the amount of whitefly eggs, nymphs, and adults. The RL_{50} estimated 1.69 days. After 5 days of pyriproxyfen application, cucumber can be harvested with minimal risk probability for human health.

5. Conflicts of interest

The authors declare no conflicts of interest.

6. Reference

1- Jones D R, Plant viruses transmitted by whiteflies. *European Journal of plant pathology*, 109(3), 195-219 (2003).

2- Amjad M, Bashir M H, and Afzal M, Comparative resistance of some cotton cultivars against sucking insect pests. *Pakistian Journal of Life Society Science*, 7(2), 144-147 (2009).

3- Leili M, Pirmoghani A, Samadi M T, Shokoohi R, Roshanaei G, and Poormohammadi A, Determination of Pesticides Residues in Cucumbers Grown in Greenhouse and the Effect of Some Procedures on Their Residues. *Iranian Journal of Public Health*, 45(11), 1481-1490 (2016).

4- Siebert M W, Thomas J D, Nolting S P, Leonard B R, Gore J, Catchot A, Lorenz G M, Stewart S D, ook D R, Walton L C, Lassiter R B, Haygood R A, and Siebert J D, Field evaluations of sulfoxaflor: A novel insecticide against tarnished plant bug (Hemiptera: Miridae) in cotton. *Journal of Cotton Sciences,* 16,129–143 (2012).

5- Arnaudov V, and Petkova R, Spirotetramat (Movento®): new systemic insecticide for control of green peach aphid, *Myzuspersicae* (Sulzer) (Hemiptera: Aphidae) on peach. *BulgarIan Journal of Agricultural Science*, 26(2), 431-434 (2020).

6- Invest J F, and Lucas J R, Pyriproxyfen as a mosquito larvicide. *In Proceedings of the sixth international conference on urban pests* (pp. 239-245) (2008).

7- Mitchell P L, Gupta R, Singh A K, Kumar P, Behavioural and developmental effects of neem extracts on *Clavigrallascutellaris*(Hemiptera:Heteroptera: Coreidae) and its egg parasitoid, *Gryonfulviventre*(Hymenoptera: Scelionidae). *Journal of Economic Entomology*, 97, 916-923 (2004).
8- Kumar P, Poehling H M, and Borgemeister C, Effects of different application methods of azadirachtin against sweetpotato whitefly *Bemisiatabaci*Gennadius (Hom., Aleyrodidae) on tomato plants. *Journal of Applied Entomology,* 129(9-10), 489-497 (2005).
9- Kumar P, Poehling H M, and Borgemeister C, Effects of different application methods of azadirachtin against sweetpotato whitefly *Bemisiatabaci*Gennadius (Hom., Aleyrodidae) on tomato plants. *Journal of Applied Entomology,* 129(9-10), 489-497 (2005).
10- Henderson C F, and Tilton E W, Tests with acaricides against the brown wheat mite. *Journal Economic Entomology*, 48(2), 157-161 (1955).
11- Anastassiades M, Lehotay S J, Tajnbaher D, and Schenck J F, Fast and easy multiresidues method employing acetonitrile extraction/partitioning and "dispersive solid-phase extraction" for the determination of pesticide residues in produce. *Journal AOAC International,* 86, 412-430 (2003).
12- Gomez K A, and Gomez AA, Statistical Procedures for Agricultural Research. *John Wiley and Sons, Inc., New York,* pp: 680 (1984).
13- Seni A, Sahoo A K, Efficacy of certain insecticides on papaya mealybug, Paracoccusmarginatus Williams &Granara de Willink (Hemiptera: Pseudococcidae). *Journal of Entomology and Zoology Studies,* 3(4), 14-17 (2015).
14- Ghelani M K, Kabaria B B, and Chhodavadia S K, Field efficacy of various insecticides against major sucking pests of *Bt* cotton. *Journal of Biopesticides,* 7, 27 (2014).
15- Mahmoud H A, El-Hefny D E, and Helmy R M A, Environmental view for chlorothalonil on tomato and pepper fruits and soil field in Egypt: Risk assessment and pre-harvest gap, *International Journal of Environmental Analytical Chemistry,* 101(5), 639-647 (2021).
16- Hilton M J, JarvisT D, and Ricketts D C, The degradation rate of thiamethoxam in European field studies. *Pest Managment Science,* 72, 388-397 (2014).
17- Alexander A, Krishnamoorthy S V, and Kuttalam S, Toxicity of insecticides to the coccinellid predators, *Cryptolaemus montrouzieri*Mulsant and *Scymnuscoccivora* Ayyar of papaya mealy bug, *Paracoccusmarginatus* Williams and Granara de Willink. *Journal of Biological Control,* 27(1), 18-23 (2013).
18- Wang G, McCain M L, Yang L, He A, Pasqualini F S, Agarwal A, and Pu W T, Modeling the mitochondrial cardiomyopathy of Barth syndrome with induced pluripotent stem cell and heart-on-chip technologies. *Nature Medicine, 20*(6), 616-623 (2014).
19- Dhadialla T S, Retnakaran A, and Smagghe G, Insect growth-and development-disrupting insecticides. In L I Gilbert, I Kostas, and S S Gill (Eds.), Comprehensive insect molecular science,6,55–115 *Oxford, UK: Pergamon;* Elsevier (2005).
20- Megahed, N A, and Ghoneim E M, Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture. *Environmental Research,* 193, 110471 (2021).
21- Abdel-Razek, A. S.; El-Ghany, N. M. A.; Djelouah, K. and Moussa, A. (2017). An evaluation of some eco-friendly biopesticides against Bemisiatabaci on two greenhouse tomato varieties in Egypt. *Journal of Plant Protection Research*, 57 (1), 9-17 (2007).
22- 22- Al-Kazafy H, Abd-El Rahman T A, and Abolmaaty S M, Influence of some new insecticides on sweet potato whitefly, *Bemisiatabaci* and American serpentine leafminer, *Liriomyzatrifolii* and their residues in cucumber fruits. *International Journal*, 3(10), 1874-1881 (2015).
23- Zhu Y, Loso M R, Watson G B, Sparks T C, Rogers R B, Huang J X and Thomas J D, Discovery and characterization of sulfoxaflor, a novel insecticide targeting sap-feeding pests. *Journal of Agriculture and Food Chemistry, 59*(7), 2950-2957 (2011).
24- Sparks T C, Watson G B, Loso M R, Geng C, Babcock J M, and Thomas J D, Sulfoxaflor and the sulfoximine insecticides: chemistry, mode of action and basis for efficacy on resistant insects. *Pesticides Biochemistry and Physiology,* 107(1), 1-7 (2013).
25- Jeschke P, Nauen R, Gutbrod O, Beck M E, Matthiesen S, Haas M, and Velten R, Flupyradifurone (Sivanto™) and its novel butanolide pharmacophore: Structural considerations. *Pesticides Biochemistry and Physiology,* 121, 31-38. (2015).
26- Liao X, Mao K, Ali E, Zhang X, Wan H, and Li J, Temporal variability and resistance correlation of sulfoxaflor susceptibility among Chinese populations of the brown plant hopper *Nilaparvatalugens* (Stål). *Crop Protection,* 102, 141-146 (2017).
27- Wang W, Wang S, Han G, Du Y, and Wang J, Lack of cross-resistance between neonicotinoids and sulfoxaflor in field strains of Q-biotype of whitefly, *Bemisiatabaci*, from eastern China. *Pesticides Biochemistry and Physiology,* 136, 46-51 (2017).
28- Abdel-Rahman S M, Hegazy E M, and ElweyA E, Direct and latent effects of two chitin synthesis inhibitors to *Spodoptera littoralis* larvae (Boisd). *American Eurasian Journal of Agriculture and Environmental Science,* 2(4), 457-467 (2007).
29- Mulder R, Gijswijt M J, The laboratory evaluation of two promising new insecticides which interfere with cuticle deposition. *Pesticides Science, 4*(5), 737-745 (1973).

30- Morita M, Ueda T, Yoneda T, Koyanagi T, and Haga T, Flonicamid, a novel insecticide with a rapid inhibitory effect on aphid feeding. *Pest Managment Science, formerly Pesticides Science,* 63(10), 969-973 (2007).

31- Sharaf F H, El-Basyouni S A, Hamid A M, Insecticidal efficiency of some chemical compounds on the whitefly, *Bemisiatabaci* (Gennad.) infesting cotton plant and its associated natural enemies. *Journal of Agricultural Sciences- Mansoura University,* (Egypt), 28(2), 1419-1423 (2002).

32- Ouyang Y, Montez G H, Liu L, Grafton-Cardwell E E, Spirodiclofen and spirotetramat bioassays for monitoring resistance in citrus red mite, *Panonychuscitri*(Acari: Tetranychidae). *Pests Managment Sciences, 68*(5), 781-787 (2012).

33- Mohamad E A, Rageh M, and Ahmed H, Curcumin provides skin Protection against UV radiation. *Egyptian Journal of Chemistry*, *65*(131), 1341-1343 (2022).

34- Kumar V, Singh C R, Bhullar H S, and Ashok D, Pyriproxyfen against whitefly, *Bemisiatabaci* (Gennadius) on tomato. *Pesticides Research Journal,* 26(2):144-149 (2014).

35- Waghulde P N, Khatik M K, Patil V T, and Patil P R, Persistence and dissipation of pesticides in chilly and okra at north maharashtra region. *Pesticides Research Journal,* 23(1), 23-26 (2011).

36- Christensen HB, Fungicides in food, analytical and food safety aspects. Ph. D. thesis. *Danish Institute for Food and Veterinary Research,* Denmark (2004).

37- Ismail, F., El Sharkawy, A. Z., Farghaly, D. S., Ammar, M., & El Kady, E. (2020). Population Fluctuation and Influence of Different Management Practices Against Bemisiatabaci (Genn.) on Cucumber Plant Under Greenhouse Condition. Egyptian Academic Journal of Biological Sciences, F. Toxicology & Pest Control, 12(2), 167-174.

38- Qin S, Hu J. (2023). Fate and dietary risk assessment of pyriproxyfen, dinotefuran, and its metabolites residues in tomato across different regions in China. Environ Sci Pollut Res Int., 30(3):7030-7039. doi: 10.1007/s11356-022-22129-2.