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RESEARCH ARTICLE

Influence of some new insecticides on sweetpotato whitefly, *Bemisia tabaci* and American serpentine leafminer, *Liriomyza trifolii* and their residues in cucumber fruits

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Abstract

Toxicity of three modern insecticides (etofenprox, imidacloprid and spirotetramat) was tested against the adults of sweetpotato whitefly, *Bemisia tabaci* and American serpentine leafminer, *Liriomyza trifolii* under greenhouse conditions. The results showed that imidacloprid was the most toxic against the adults of sweetpotato whitefly and American serpentine leafminer followed by etofenprox and spirotetramat after three treatments. The percent of corrected efficacy of sweetpotato whitefly was 98, 93.5, and 1.7%, respectively. The percent of adults reduction was 98.4, 95.7 and 16%, respectively. The corresponding results with American serpentine leafminer were 78.7, 57.1 and 18.4%, respectively. The percent of leafmines reduction was 77, 54.5 and 11.7%, respectively. Dissipation rate of recommended field rate of all tested insecticides in cucumber fruits was determined after the first, second and third applications. The residue level in cucumber fruits was increased after 24 hrs from the third treatments to 0.94, 1.99 and 1.02 mg/kg for etofenprox, imidacloprid and spirotetramat, respectively. The dissipation rate of all tested insecticides was 100, 91 and 100% for etofenprox, imidacloprid and spirotetramat, respectively, after 7 days of the third treatment. The results showed that imidacloprid was suitable for insect control in cucumber fields (high efficacy against pests and low residues) compared with etofenprox and spirotetramat. The results recommended that a waiting period of 3 days is suggested for safe consumption of cucumber treated by all tested insecticides**.**

INTRODUCTION

Cucumber, *Cucumis sativus* is the most widely grown vegetable in the world and also the most important items of the vegetables processing sector.

The sweetpotato whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), is a major pest of economically important crops worldwide (Gerling et al., 1980). *B. tabaci* damages crops by feeding on phloem sap, and the large amounts of sticky honeydew produced can lower the rate of leaf photosynthesis. This species of whitefly is also a vector of many plant viruses (Simon et al., 2003).

The American serpentine leafminer, *Liriomyza trifolii* (Burgess) attacks crops causing aesthetic damage to leaves when larvae feed on leaf mesophyll producing serpentine mines. It was reported to be a major pest in Ontario floriculture greenhouses in the late 1970s (Broadbent, 1982).

Etofenprox is usually employed to prevent and control insects with sucking mouth parts, particularly planthopper, leafhopper, aphid, and thrips on crops such as tomato, fruit trees, cotton, and rice (Cao et al., 2010). As a systemic insecticide, it can be absorbed by roots and leaves and transmitted to the plant tissues. Therefore, etofenprox might cause food contamination and is a potential threat to human health (Qian et al., 2011).

Imidacloprid is a systemic chloronicotinyl insecticide with soil, seed, and foliar uses for the control of sucking pests (Sanyal et al., 2006). Faheem and Khan (2010) stated that imidacloprid is an insecticide generally prepared to control sucking insects including termites, aphids, soil insects, and some chewing insects.

Spirotetramat is an innovative new insecticide used to control scale insects. It distributes via the phloem and xylem in plants, to eliminate sucking insect pests (Brück et al., 2009). McKenna et al. (2013) carried out a field study in 2010–11 and the effectiveness of a postharvest application was investigated.

The intensive use of pesticides on cucumber may cause accumulation of pesticide residues more than the permitted levels and hence needs frequent field evaluations. Accurate measurements of dissipation or degradation rates of various pesticides under field conditions will be helpful in their optimal application (Fenoll et al., 2009; Omirou et al., 2009). Governments and international organizations are regulating the use of pesticides and are setting the acceptable the maximum residue level (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. Also, dissipation studies for a given crop under the open field conditions of each growing area are necessary to test if the pesticide residue levels soon after the pre-harvest interval (PHI) are below the maximum residue limit (MRL). PHI, which is defined as the period between the last pesticide application and harvesting the crop, after which the pesticide residue level is expected to be below the established maximum residue level (MRL), is one of the important pesticide registration requirements in Egypt (Abdellseid and Abdel. Rahman, 2014)

This work aims to study the toxicity of some insecticides on sweetpotato whitefly adult and American serpentine leafminer, and their reduction effect on both insects. This work also, determine the dissipation rate and pre-harvest interval (PHI) of all tested insecticides under the greenhouse conditions to test if the insecticides have residue levels soon after the pre-harvest interval (PHI) are below the maximum residue limit (MRL).

2. MATERIALS AND METHODS

Test insecticides

1-Etofenprox: Non-ester pyrethroid and trade name is Primo 10% SC. This insecticide was obtained from Bessen Chemical CO., LTD. China. The mode of action of this insecticide is similar to pyrethroids. It acts as sodium channel blocker. The recommended field rate is 200 ml/200 L of water per acre.

2-Imidacloprid: Trade name is Commando 35% SC. This insecticide was obtained from Fabco Company, Gordon. This product is a neonicotinoid insecticide in the chloronicotinyl nitroguanidine chemical family. It acts on several types of post-synaptic nicotinic acetylcholine receptors in insect nervous system following binding to the nicotinic receptor; nerve impulses are spontaneously discharged at first, followed by failure of the neuron to propagate any signal (Schroeder and Flattum, 1984). The recommended field rate is 200 ml/200 L of water per acre.

3-Spirotetramat: Trade name is Movento 10% SC. This insecticide was obtained from Bayer Crop AgroScience Company (Germany). This insecticide belongs to lipid biosynthesis inhibitor group. It acts as inhibitor of lipogenesis in treated insects, resulting in decreased lipid contents, growth inhibition of younger insects, and reduced ability of adult insects to reproduce. The recommended field rate is 200 ml/200 L of water per acre.

Test insects

Two insects were investigated in this work:

1- The sweetpotato whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae). The adult of this insect was tested against all tested insecticides under greenhouse condition
2- The American serpentine leafminer, *Liriomyza trifolii* Burgess (Diptera: Agromyzidae). The cucumber leaves were treated by all tested insecticides and leafmines per leaf counted after all applications.

Greenhouse experiment

This experiment was carried out in the Central Laboratory for Agriculture Climate, Dokki, Giza, Egypt during November 2014 to January 2015. The seedling of cucumber, *Cucumis sativus* L. (cv. Hashem) were transferred to greenhouse on 10 November. The experiment was designed as plots area 8 x 6 m and 0.2 m plant to plant distance. Three plots were used for insecticides treatment and another one as a control (treated by water). Each plot was divided into three replicates and treated by the recommended field rate of insecticide. Each plot was treated three times and one week interval. Irrigation and fertilization were made according to the crop schedule. Plants treatments were carried out using a knapsack sprayer motor (20 liter).

The sweetpotato whitefly

The number of adults per 10 leaves randomly was counted in each replicate and mean numbers obtained after each application by 24 hrs. Corrected efficacy of adult whitefly was calculated according to **abbott's formula 1925:**

$$\textbf{Corrected efficacy} = 1 - \left(\frac{\textbf{No. in control – No. in treatment}}{\textbf{No. in control}} \right) \times 100$$

The percent of adults reduction was calculated by:

$$\textbf{Percent of reduction } \% = \frac{\textbf{Original No. – New No.}}{\textbf{Original number}} \times 100$$

The American serpentine leafminer

Ten tagged and randomized leaves in upper leaves in each replicate were counted after 24 hrs of application and mean numbers of leafmines in each treatment counted. The corrected efficacy and percent of leafmines reduction were calculated also. This work was achieved after the first, second and third applications.

Sampling of cucumber fruits for determination of insecticides residues

After cucumber fruit emerged, all tested insecticides were treated. Samples of cucumber with similar ripening stage, size, and shape were located and tagged. Samples of cucumber fruits were taken randomly during three applications after 1h, 24 hrs and 7 days (Samples about 1.0 kg divided into three replicate) of each treatment. A control sample was taken in each sampling time. The entire sample (1 kg) of cucumber was chopped and homogenized for 5 min at high speed in a laboratory homogenizer and extracted according to the procedure described and modified by Lehotay et al. (2010). Briefly, 10 g of the homogenized sample was weighed into a 50-ml centrifuge tube. Ten milliliters of 1.0% acidified acetonitrile with acetic acid was added; the screw cap was closed and vigorously shaken for 1 min using a vortex mixer at maximum speed. Afterwards, 4 g of anhydrous $MgSO_4$, 1 g of NaCl, 1 g sodium citrate dihydrate, and 0.5 g disodium hydrogen citrate sesquihydrate were added, then extract by shaking vigorously on vortex for 2 min and centrifuged for 10 min at 5,000 rpm. An aliquot of 3 ml was transferred from the supernatant to a new clean 5-ml centrifuge tube and cleaned by dispersive solid-phase extraction with 75 mg of PSA and 500 mg of magnesium sulfate. Afterwards, centrifugation was carried out at 6,000 rpm for 5 min. An aliquot (2 ml) from the supernatant was filtered through a 0.2-μm PTFE filter (Millipore, USA) and then analyzed by Agilent 1100 HPLC-DAD.

Apparatus and Chromatographic Analysis

Pesticide residue analysis was performed with Agilent technologies HP-1100 series high-performance liquid chromatographic system (Agilent Technologies, USA) equipped with a diode array detector and quaternary pump. The separation was performed on a C_{18} column (150×4.6 mm, 5 μm). The mobile phase, flow rate, and detection wavelength of each pesticide are mentioned in Table 1. Data analysis was performed using Chemistation software.

Method validation

The validation of the proposed analytical method (HPLC-DAD) was carried out according to the SANCO document 10684/2009. Linearity was evaluated by constructing matrix matched calibration curves in the range of 0.1–20 μg /l for HPLC-DAD. Method sensitivity and recovery were determined by using samples spiked with the tested pesticides at three different levels (0.05, 0.01 and 0.001mg/kg). Fortified samples were extracted as described earlier and the average recovery percentages for fortified samples were determined. Limits of detection (LOD) and quantification (LOQ) were evaluated as the pesticide concentration that produces a peak signal-to-noise ratio of 3:1 and 10:1, respectively. The previous procedures were presented in (Table, 1).

Reference standards of all tested insecticides were of >98% purity and obtained from Central Agricultural Pesticides Laboratory (Egypt). Stock solutions of pesticides were prepared in acetonitrile and stored at −18 °C. All HPLC grade organic solvents, methanol, and acetonitrile were purchased from Sigma (Sigma GmbH, Germany). Primary secondary amine (PSA, 40 μm Bondesil) sorbent was purchased from Supelco (Supelco, Bellefonte, USA). Sodium acetate and anhydrous magnesium sulfate were of analytical reagent grade and purchased from Merck Ltd. These were activated by heating at 150 °C overnight and kept in desiccators

Residue half-life estimation ($t_{1/2}$):

The half-life time ($t_{1/2}$) for each investigated insecticides were calculated using the following equation of **(**Moye et al., 1987**).**

$$RL_{50}\ (t_{1/2}) = \ln 2/K` = 0.6932/K`$$
$$K = 1/t_x * \ln a/b_x$$

Whereas:

$k' = 1/t_x \times \ln (a/b_x)$ k' = rate of decomposition t_x = time in days

a = initial residue b_x = residue at x time

Statistical analysis

Data were subjected to the analysis of variance test (ANOVA) and analysis of variance (one ways classification ANOVA) followed by a least significant difference, LSD at 5% (Costat Statistical Software 1990).

3. Results

3. 1.Toxicity of the tested insecticides against the sweetpotato whitefly, *Bemisia tabaci*

Cucumber fruits were treated by etofenprox, imidacloprid and spirotetramat three times during this experiment. After the first application, the numbers of whitefly adults are decreased from 53 and 43.3 to 21.3 and 18.3 adult /10 plants in etofenprox and imidacloprid, respectively. The corrected efficacy is 66.9 and 71.5 % in etofenprox and imidacloprid, respectively, with the percent of infestation reduction 59.8 and 57.7 (Table 2). The numbers of whitefly adults in spirotetramat are increased from 41.3 before application to 47 after the first application. After the second and third applications the number of whitefly adults is slightly decreased in spirotetramat treatment from 47 to 40. 7 and 34.7 adult /10 plants, respectively. After the third application, the percent of adult reduction is 95.7, 98.4 and 16% in etofenprox, imidacloprid and spirotetramat, respectively.

Statistical analysis shows that there is no significant difference between etofenprox and imidacloprid, while a significant difference between both of these insecticides and spirotetramat. This means that both etofenprox and imidacloprid are more toxic on *B. tabaci* than spirotetramat.

3.2. Toxicity of the tested insecticides against the American serpentine leafminer

As mentioned in Table 3 the mean numbers of mines in 10 upper cucumber leaves are 32.3, 31.7, 31.7 and 32.0 mines/10 leaves in etofenprox, imidacloprid, spirotetramat and control, respectively, before the first application. After the first application the mean number of mines is no affected by all tested insecticides. The percents of mines reduction are 0.0, 1.3 and 1.3% in etofenprox, imidacloprid and spirotetramat, respectively. After the second application the percents of mines reduction are increased to 24.2, 42.4 and 11.2, respectively. After the third application the mean numbers of mines in 10 leaves are 14.7, 7.3, 28 and 34.3 in etofenprox, imidacloprid, spirotetramat and control, respectively. The percents of reduction in mines are 54.5, 77 and 11.7%, respectively. This means that imidacloprid is the most effective insecticide against American serpentine leafminer compared with other insecticides. Statistical analysis shows that after the first application no significant difference among all treatments. After the second application there is a significant difference between imidacloprid and other tested insecticides. After the third application no significant difference is observed between imidacloprid and etofenprox, while significant difference between imidacloprid and spirotetramate observed.

3.3. Determination of tested insecticides residues in cucumber fruits

The dissipation behavior of insecticides in cucumber under Egyptian climatic conditions has not previously explored systematically. To ensure the safe use of this insecticide, it is necessary to determine their Preharvest intervals (PHI), i.e. the time period (in days) required for dissipation of the initial residue levels to below their corresponding maximum residue limits (MRL). As expected, gradual and continuous declines of insecticides residues in cucumber fruits were observed as a function of time after each application. Insecticides residues in cucumber fruits after all application were determined as mentioned in Table 4. The results shows that after 1 hr (zero time) of the first application mean of residues level in cucumber fruits is 0.91, 1.06 and 0.81 mg kg^{-1} for etofenprox, imidacloprid and spirotetramat, respectively. The insecticides residues are decreased after 24 hrs in all tested insecticides. After 7 days from the first application and before the second application the residues levels are decreased to no detectable residue, 0.11 mg $kg^{-1}$and no detectable residue, respectively. This means that the percents of dissipation rate are 100, 89.6 and 100%, respectively. After 1hr of the second application the residue level is 0.95, 1.88 and 0.98, respectively. This means that the residues level is increase compared with zero time after the first application (0.91, 1.06 and 0.81 mg kg^{-1}) in all tested insecticides. The residue level also, increased after zero time of the third application in imidacloprid and spirotetramat only. The residue level is 1.99 and 1.02 mg kg^{-1}, respectively. The residue level in etofenprox is decreased after zero time of the third application (0.94 mg kg^{-1}) compared with 0.95 mg kg^{-1} after zero time of the second application. The percent of dissipation rate is 100, 92.0 and 100%; and 100, 91 and 100% after 7 days of the second and third application, respectively. The maximum residue level (MRL) of etofenprox, imidacloprid and spirotetramat was determined by EU Pesticides database. According to EU Pesticides database the maximum residue level of was 0.2, 1.0 and 0.2 mg kg^{-1}, respectively. It can thus be concluded that the pre-harvest interval (PHI) of Imidacloprid, spirotetramat and etofenprox calculated in cucumber fruit were (3.016, 2.950 and 3.010 -days), respectively, after the last application.

Table 1. HPLC conditions and Percent recovery from fortified cucumber samples and the minimum detection limits (mg/ kg) for various pesticides.

Pesticides	Mobile Phase (v/v)	Flow Rate (ml/min)	Detectors Wave length (nm)	Recovery %	LOD*	LOQ**	r^2
Imidacloprid	acetonitrile/ water = 40/60	0.8	270	96.3	0.01	0.03	0.993
spirotetramat	acetonitrile/methanol/ammonium acetate = 45 /45 /10	0.8	246	92.8	0.01	0.03	0.996
Etofenprox	methanol/water = 92/8	0.8	220	94.6	0.003	0.01	0.991

LOD* Limits of detection
LOQ** The limit of quantification

Table 4. Dissipation rate of pesticides residues, mean ± SD (mg/kg) detected in cucumber fruits under green house conditions.

Time treatment (day)	Residue level (mg kg-1)		
	Etofenprox	Imidacloprid	spirotetramat
Zero time *	0.91 ±0.042	1.06 ± 0.041	0.81 ± 00.15
After 24 hours	0.83 ± 0.05	0.62 ± 0.026	0.57 ± 0.024
Before 2nd application	ND	0.11 ± 0.03	ND
Dissipation rate %	100	89.6	100
Zero time **	0.95 ± 0.026	1.88 ± 0.038	0.98 ± 0.01
After 24 hours	0.76 ± 0.03	1.42 ± 0.01	0.69 ± 0.13
Before 3rd application	ND	0.15 ± 0.015	ND
Dissipation rate %	100	92.0	100
Zero time ***	0.94 ± 0.021	1.99 ± 0.06	1.02 ± 0.044
After 24 hours	0.36 ± 0.051	1.61 ± 0.019	0.88 ± 0.032
After 48 hours	0.27 ± 0.018	1.22 ± 0.015	0.51 ± 0.011
After 3 days	0.22 ±0.029	0.98 ± 0.016	0.21 ± 0.33
After 5 days	0.08 ± 0.005	0.88 ± 0.013	0.09 ± 0.011
After 7 days	0.01 ± 0.001	0.51 ± 0.021	0.02 ± 0.03
After 9 days	ND	0.18 ±0.03	ND
Dissipation rate %	100	91	100
MRL****	0.2	1	0.2
$t_{1/2}$	1.72	2.98	2.01
PHI(day)	3.016	2.95	3.01

Zero time * after one hour of the first treatment
Zero time ** after one hour of the second treatment
Zero time *** after one hour of the third treatment
Reg. (EC) No 149/2008
****http://ec.europa.eu/sanco_pesticides/public/index.cfm?event=pesticide.residue.CurrentMRL&language=EN

Table 2. Effect of tested insecticides on population reduction of sweet potato whitefly adult, *Bemisia tabaci* infested cucumber leaves (means ±SD)

Tested insecticides	Before treatment	After 1st treatment	Corrected efficacy %	% of reduction	After 2nd treatment	Corrected efficacy %	% of reduction	After 3rd treatment	Corrected efficacy %	% of reduction
Etofenprox	53.0±8	21.3±4.2^{c}	66.9	59.8	11.7±1.2^{b}	73	77.9	2.3±1.2^{b}	93.5	95.7
Imidacloprid	43.3±8.1	18.3±4.5^{c}	71.5	57.7	8.0±3.6^{b}	81.5	81.5	0.7±0.6^{b}	98.0	98.4
Spirotetramate	41.3±9.1	47.0±9.6^{b}	26.9	-13.8	40.7±2.5^{a}	6.0	-1.5	34.7±3.5^{a}	1.7	16.0
Control	47.7±3.5	64.3±6.1^{a}	----	-----	43.3±2.5^{a}	-----	-----	35.3±3.5^{a}	----	-----
F values	-----	34.5***	-----	-----	154.8***	------	-----	222.1***	-----	-----
$LSD_{0.05}$	-----	12.2	-----	-----	4.9	-----	-----	4.2	-----	-----

Corrected efficacy % = (1- No. in control - No. in treatment / No. in control) x100 Abbots formula
Percent of reduction = original number– new number /original number x 100 = %
Means in columns followed by the same letter do not differ significantly according to LSD test
*** p<0.001

Table 3. Effect of tested insecticides on serpentine leafminer, *liriomyza trifolii* infested cucumber leaves (means ±SD)

Tested insecticides	Before treatment	After 1st treatment	Corrected efficacy %	% of reduction	After 2nd treatment	Corrected efficacy %	% of reduction	After 3rd treatment	Corrected efficacy %	% of reduction
Etofenprox	32.3±3.1	32.3±3.1^{a}	-3.2	0.0	25.0±3.0^{bc}	24.2	22.6	14.7±3.5^{b}	57.1	54.5
Imidacloprid	31.7±1.2	31.3±3.5^{a}	0.0	1.3	19.0±2.0^{c}	42.4	40.1	7.3±1.5^{b}	78.7	77.0
Spirotetramate	31.7±1.2	31.3±2.9^{a}	0.0	1.3	29.3±5.1^{ab}	11.2	7.6	28.0±3.0^{a}	18.4	11.7
Control	32. ±1.0	31.3±3.5^{a}	---	-----	33.0±2.0^{a}	----	-----	34.3±7.1^{a}	----	-----
F values	-----	0.07^{ns}	---	-----	10.0**	---	-----	24.5***	---	-----
$LSD_{0.05}$	-----	6.1	---	-----	6.2	---	-----	8.1	---	-----

Means in columns followed by the same letter do not differ significantly according to LSD test
NS – p>0.05, * – p<0.05,** - p<0.01, *** p<0.00

4. Discussion

These results were consistent with Van Iersel et al. (2000). The authors found that all imidacloprid treatments resulted in a significant decrease in both the survival of adult whiteflies and number of immature whiteflies on the plants. Yang et al. (2013) found that the neonicotinoid insecticide imidacloprid has been widely used to control of sweetpotato whitefly. Zhang et al. (2011) conducted greenhouse, laboratory and field experiments on the effect of imidacloprid and thiamethoxam to whitefly. The two compounds were equally effective with lower numbers of whiteflies than untreated controls. The authors concluded that imidacloprid and thiamethoxam were effective against *B. tabaci* for up to 45 days under laboratory and greenhouse conditions, and up to ~2 months under field conditions. Use of imidacloprid- and thiamethoxam-treated seeds can be an important alternative for management of whiteflies on cotton.

On the other hand, Vinoth et al. (2009) evaluated that spirotetramat 150 OD as foliar application for its bioefficacy against cotton whitefly. It was revealed that spirotetramat 75 g ai ha^{-1} reduced the whitefly population up to 89.7% over control. Imidacloprid 25 g ai ha^{-1} and acetamiprid 20 g ai ha^{-1} were also equally effective. The LC_{50} of spirotetramat to whitefly was 1.671 μg mL^{-1}. Foliar application of spirotetramat 150 OD against cotton white fly revealed that spirotetramat at 75 g ai ha^{-1} persisted up to 25 days. Deepak et al. (2013) found that insecticides like profenophos 50 EC was found most effective against American serpentine leafminer infestation on upper leaves and followed by thiamethoxam 20 SG, imidacloprid 600. Schuster and Morris (2002) found that imidacloprid reduced the number of mines per plants in tomato. These results showed that imidacloprid was the most toxic against *L. trifolii* followed by etofenprox and spirotetramat.

These results were consistent with Nasr et al. (2014). The authors revealed that the residual level of imidacloprid was less than the maximum residual level (MRL=1 mg/kg) which recommended by Codex Alimentration Commission, which recommended by Codex Alimentration Commission. The author found that the half life time ($t_{1/2}$) of imidacloprid was =2.2 days on cucumber fruits. Morowati, et al. (2013) found that imidacloprid residue reached below the maximum residue level (MRL) of 1 mg/kg two days after spraying. But for more confidence, the third day after spraying was considered as the pre-harvest period. Sampling for determination of Imidacloprid residue was performed in four greenhouses of Varamin region. The results showed that mean imidacloprid residue levels were above the MRL value in these greenhouses. Malhat et al. (2012) were estimated etofenprox residues by employing standardized QuEChERS technique in tomato. The etofenprox residue dissipated below its LOQ of 0.01 after 15 days at a single dosage. Half-life of etofenprox was observed to be 2.15 days. EFSA (2010) found that a slight concentration of spirotetramat residues was observed in soya bean and cotton seed meals. In refined oil, no residues above the LOQ occur.

These results are not in agreement with Mohapatra et al. (2012) who studied the persistence of spirotetramat in mango fruits following application of spirotetramat 12 % + imidacloprid 12 % (240 SC) at 90 and 180 g a.i.ha^{-1} and reported that the residues were found to be below determination limit of 0.05 mg kg^{-1} at 10 days for both the dosages. This may be due to variation in substrates in which pesticide applied and varied weather conditions.

These results recommended that using of imidacloprid in whitefly and American serpentine leafminer control and also etofenprox against whitefly. These results also, recommended that using of imidacloprid safely on cucumber fruits and a waiting period of 3 days is suggested for safe consumption of cucumber treated by all tested insecticides**.**

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