Journal of Environmental & Analytical Toxicology

Elrazik, J Environ Anal Toxicol 2018, 8:3
DOI: 10.4172/2161-0525.1000569

Research Article | Open Access

Efficacy and Residues of Imidacloprid against Whitefly, *Bemisia tabaci* in Tomato Plants

Elrazik MAA*

Department of Pesticides, Faculty of Agriculture, Menoufia University, Egypt

***Corresponding author:** Elrazik MAA, Department of Pesticides, Faculty of Agriculture, Menoufia University, Egypt, Tel: +20482222170; E-mail: new1folder@yahoo.com

Received: April 07, 2018; **Accepted:** April 20, 2018; **Published:** April 28, 2018

Abstract

The present work was conducted to evaluate the efficacy of neonicotinoide insecticide, imidacloprid against the whitefly, *Bemisia tabaci* infesting tomato plants under field conditions and its residues in leaves and fruits after different periods of application. There were significant differences between treated and untreated seedlings, as well as between treated and untreated seeds, where treating seedlings was more effective in decreasing whitefly stage population, where the highest mean reduction percentages was recorded with nymph stages of white fly (82.3%) comparing with (68.7%) at treated seed treatment and were (74.9%) in eggs compared with (47.6%) at treated seeds. The treated seedling roots protected tomato seedlings from whitefly stages up to 10 weeks after planting, as well as treated seeds protected seedlings for 7-8 weeks after sowing. The reduction percentages of egg, nymph and adult stages in treated seedlings and sprayed with half and field recommended rates were more than that in untreated seedlings. The recommended rate was more effective than half rate in decreasing white fly adult stages. The increase percentage in fruit yield was recorded with treated tomato seedlings sprayed with the recommended rate of imidacloprid giving 61.4%, and it was 55.4% in untreated seedlings and sprayed, compared to control. Residues of imidacloprid in leaves and fruits in treated seedlings sprayed with field rate were more than untreated seedlings and sprayed, as well as the residues of imidacloprid were higher in leaves than fruits, where the initial residues were 0.66 mg/kg, decreased to 0.65, 0.34, 0.19, 0.1, 0.09 and 0.08 mg/kg in tomato fruits of treated seedlings and prayed, 0.3 mg/kg and was decreased to 0.26, 0.11, 0.07, 0.07, 0.04 and 0.02 mg/kg in untreated seedlings and sprayed after 1 hr, 2,5,7,9,15 and 21 day, respectively.

Keywords: Efficacy; Residues; Imidacloprid; Tomato; *Bemisia tabaci*

Introduction

Tomato plants infested with many pests and diseases especially piercing sucking insects as aphid and white fly which play important role in transmitting the pathogen of diseases. Whitefly, *Bemisia tabaci* is the mainly severe pest for many field crops, horticultural and protected crops causing major troubles [1,2]. White fly insects feed on the phloem juice of more than 500 host plant species [3], causing great failure in the yield. Due to the continuous apply of insecticides, *B. tabaci* has developed variable levels of resistance to nearly all the applied conventional insecticides mainly organophosphorous and pyrethroids, therefore the resistance to *B. tabaci* against conventional insecticides was managed by neonicotinoids insecticides like acetamiprid, imidacloprid and thiamethoxam in USA on different crops [4]. A neonicotinoid insecticide Imidacloprid is the chloro-nicotinyl nitroguanidine chemical family [5,6], and a systemic insecticide with translaminar activity, and commonly used to control sucking insects. Due to its low soil persistence and insecticidal activity at low application rate, imidacloprid become commonly used worldwide as insecticide for crop protection, Chao et al. [7]. As a result of low selectivity for insects and apparent safety for human, imidacloprid achieved a highest increasing in sales as insecticide worldwide [8,9]. The present study was conducted to evaluate the efficacy of neonicotinide insecticide, imidacloprid, under field conditions and its potency to reduce the population of whitefly, *Bemisia tabaci* and its residue contents in tomato leaves and fruits after different periods of the insecticide application.

Materials and Methods

Tested insecticide and chemicals

- Imidacloprid (Admire 20% SC) (1-[(6-chloro-3-pyridyinyl) methyl]-N-nitro-2-imidazolidinimine)) was obtained from Bayer Company in Egypt
- The standard of imidacloprid (>97% purity) was provided from the Central Laboratory of Pesticides, Egypt.
- All solvents were HPLC grade and were obtained from pharmaceutical companies in Egypt.

Field experiments and sampling methods

These experiments were conducted at a private farm of Eldelngat, Elbehira Governorate, Egypt, during the period from March 2015 to December 2015 where the total area of about 1000 m^2 were divided into equal plots each plot was about 20 m^2 which consists of 10 m length and 2 m width and classified into 4 rows. Two rows of land were left without plants as a barrier to prevent the contamination and the interference during the experiment processes for all experimental plots. Tomato seeds, *Lycopersicon esculentum* Miller, Variety Beto 86 were planted in the nursery. Seedlings of tomato, 30 days old, were used in the experiments.

Population of *Bemisia tabaci* stages infested tomato leaves as affected by seedling and seed treatments with imidacloprid

To conduct this experiment, three plots were cultivated with tomato seedlings treated with the imidacloprid 20% SC where seedling roots were dipped in the insecticide solution (3 ml/liter water) (0.6 g a.i./kg seeds) for 5 minutes [10], and other three plots were planted with untreated seedlings as control. In addition, 3 plots were planted with seedlings produced from seeds soaked for 5 minutes in insecticide solution (3 ml/l water) for 5 minutes, removed and left to dry until it cultivated in the next day. Treatments were arranged in a complete randomized design with three replicates. Samples of 25 leaves were random collected from each replicate early at the morning at 2nd week from planting in open field. All samples were placed in paper bags and transport to the laboratory for examination, where the number of eggs and nymphs were counted using binuclear microscope, until the 12 week post planting. The percentages of reduction were calculated according to Abbott formula [11].

R%=(1-no. in T after treatment/no. in Co. after treatment) × 100

Where: n=Insect population, T=treated, Co=control

Population of *B. tabaci* stages infested tomato seedlings as affected by foliar spraying with imidacloprid at two rates under field conditions

To conduct this experiment, 9 plots were cultivated with tomato seedlings produced from untreated seeds, then each 3 plots were sprayed two months after planting by imidacloprid 20% SC, at the recommended field rate (125 ml/100 liter water) and other 3 plots were sprayed at the half recommended rate (62.5 ml/100 liter water) while the rest 3 plots were sprayed with water and left without any treatments as control. Samples of 25 leaves per replicate (75 leaves/treatment) were collected randomly before spraying and at 1, 3, 5, 7, 9, 11, 13, 15 and 21 days after pesticide spraying. The number of white fly adults were observed and counted in the field at early morning before flight activity. All samples were placed in paper bags and transport to the laboratory where white fly egg and nymph stages were counted using binuclear microscope. Reduction percentages of white fly stages were determined according to the equation of Henderson et al. [12].

Imidacloprid residues and loss% in tomato leaves and fruits after sprayed with field recommended rate

Three plots were cultivated with tomato seedlings treated with the imidacloprid 20% SC where seedling roots were dipped in the pesticide solution (3 ml/1 liter water) and other 3 plots were cultivated with untreated tomato seedlings. Plots were sprayed at fruiting period by the insecticide at recommended field rate and arranged in a complete randomized block design with 3 replicates. At the time of spraying the insecticide, one kilogram of tomato fruits and 100 tomato leaves were randomly collected from each treatment at intervals of one hour after application (zero time), 2, 5, 7, 9, 15 and 21 days after treatment, and transferred to the laboratory where it was immediately subjected to analysis in order to determine imidacloprid residues.

Analytical processes

Extraction and clean up: Fifty grams from different collected tomato fruit and tomato leaf samples were mixed with 200 ml of acetonitrile using electrical blender for 3-5 min at high speed. The mixture was vacuum-filtered through a 12 cm Buchner filter. The filtrate was transported into a 500 ml separating funnel and 10 ml of phosphate buffer solution pH 7, then the separating funnel was shaken strongly for 1 min and the filtrate was separated into two phases. The acetonitrile phase was clarified through a layer of sodium sulfate (anhydrous) located on glass-wool. The acetonitrile extract was evaporated via a rotary evaporator at 40°C in water bath. The dried extract was dissolved in a final volume of 5 ml of actonitrile:water and then sonicated for 5 min and extracts were filtered using a 2 ml dark HPLC glass vial using a 1 ml syringe and a 0.2 µm nylon filter and was used for HPLC analysis [13].

Measurement and residues via HPLC: Estimation of imidacloprid residues were completed on a Perkin Elmer (series 200) HPLC prepared with a diode array uv detector at 270 nm. Approximately 20 µl of samples were injected into a Nucleosil 100-5 reverse phase (C18) 5 µm, 250 × 4 mm column. Mobile phase was acetonitrile: water (25/75 v/v) and the flow rate was 1 ml/min retention time of imidacloprid was 4.8 minutes.

Recovery of imidacloprid: Untreated tomato fruits and leaves were spiked with three known amounts of technical grade of imidacloprid prior to extraction and clean up for recovery test. Three replicates of each treatment were passes through the process of extraction, clean up and analysis as described previously. The recovery values were calculated, and the obtained results were corrected agreeing to the recovery percentages.

Calculation of half-life time values:Half-life time ($t_{1/2}$) in days was calculated according to [14]:

$t_{1/2}$=ln2/k=0.693/k, k (apparent rate constant)=1/t × ln a/m

t=time in days, m=residue at × time, a=initial residue.

Effect of imidacloprid on fruit yield of tomato plants: To conduct this experiment, 3 plots were cultivated with untreated seedlings and sprayed by imidacloprid 20% SC at recommended field rate (125 ml /100 liter water) two months after cultivation, other 3 plots were planted as previous mentioned and sprayed with the half recommended rate, in addition, 3 plots were cultivated with treated seedlings and sprayed by imidacloprid 20% SC at recommended field rate,two months after cultivation, other 3 plots were planted as previous mentioned and sprayed with the half recommended rate, while another 3 plots were sprayed with water and left without any treatments as control. At the end of the experiment, ten plants of each of tomato treated seedling and untreated seedling and sprayed with field and half recommended rate of imidacloprid and control plants were chosen randomly and tomato fruits were weighted to determine the average weight fruits/plant (g) and% increase of yield.

Statistical analysis: The obtained data was statistically analyzed using analysis of variance (ANOVA) at 5% probability. The measurements were divided using Duncan's Multiple Range Test through CoStat software program (Version 6.400) [15].

Results and Discussion

Population numbers of *Bemisia tabaci* stages infested tomato leaves as affected by seedling and seed treatment with imidacloprid

Data presented in Table 1 show the effect of seedling and seed treating with imidacloprid on the numbers of *Bemisia tabaci* stages infested tomato leaves. Results indicated that the average numbers of white fly stages increased as the periods after planting increased. The highest number of eggs and nymph stages were recorded after 11 and 12 weeks from planting. Statistical analysis of the obtained data indicated that eggs and nymph stages of *B. tabaci* numbers were significantly different between treated seedling and seeds and untreated seedling (control). There were significant differences in the numbers of eggs and nymphs in treated seeds and treated seedlings among the periods of sampling nearly at all treatments except after 2-5 weeks of planting for egg numbers and 2-7 weeks after planting for nymph numbers. The egg and nymph numbers were decreased in treated seedlings more than in treated seeds.

Treatments and Insecticide rate	Stages	Average numbers of white fly stages per 25 leaves and (Reduction%) at weekly intervals											Grand mean
		Periods after sowing (week)											
		2	3	4	5	6	7	8	9	10	11	12	No. (R%)
Seeds 3 ml/l	Egg	7 m (86.5)	13 m (82.7)	21 lm (77.4)	38 klm (66.0)	134 hi (59.9)	287 g (53.5)	514 e (30.5)	611 d (15.7)	756 bc (18.4)	787 bc (19.8)	817 b (12.7)	362.27 B (47.6)
	nymph	0 l (100)	0 l (100)	0 l (100)	0 l (100)	7 kl (89.7)	30 jkl (73.5)	75 h (53.13)	102 g (52.1)	217 cd (32.8)	235 c (28.1)	257 b (25.2)	83.9 1 B (68.7)
Root-seedling 3 ml/l	Egg	3 m (94.2)	7 m (92.7)	12 m (87.1)	25 lm (77.7)	53 jklm (84.1)	99 ijk (83.9)	144 hi (80.5)	177 h (75.6)	423 f (54.4)	519 e (47.1)	502 e (46.4)	178.55 C (74.9)
	nymph	0 l (100)	0 l (100)	0 l (100)	0 l (100)	3 l (95.3)	12 kl (89.5)	30 jkl (81.2)	51 ij (76.1)	122 fg (62.2)	140 f (57.2)	195 d (43.31)	50.3 C (82.3)
control	Egg	52 jklm	75 jklm	93 ijkl	112 ij	334 g	617 d	740 c	725 c	927 a	982 a	936 a	508.5 A
	nymph	16 kl	25 jkl	32 jkl	36 jkl	64 hi	114 g	160 e	213 cd	323 a	327 a	344 a	150.36 A
LSD (0.05%)		for egg stage=47.1; for nymph stage=18.4; for total egg stage=34.6; for total nymph stage =9.9											
Data between brackets are the percent reduction according to Abbott et al. The different letters for each stage means significant difference at 5% level													

Table 1: Field efficacy of imidacloprid as tomato seed and seedling treatment against white fly, *Bemisia tabaci*.

Regarding to reduction percentages of *B. tabaci* egg and nymph stages infested tomato leaves of seedlings and seeds treated with imidacloprid, results in Table 1 reported that the reduction percentages were decreased by increasing the periods after planting. Treated seedlings were better than treated seeds treatment. The reduction percentages ranged between (46.4-94.23%) and (43.3-100%) for egg and nymph stages, respectively, in treated seedlings, while it were (12.7-85.5%) and (25.2-100%) for egg and nymph, respectively in treated seeds treatment. The highest mean of reduction percentages were recorded with nymph stages of white fly (82.3%) in treated seedlings comparing with (68.7%) at treated seeds treatment, while the mean reduction percentages of eggs were (74.9%) in treated seedlings comparing with (47.6%) in treated seeds.

The obtained results show that root treating seedlings protected tomato plants from whitefly stages at least 10 weeks after planting, as well as treated seeds protected seedlings at least 7-8 weeks after sowing. The obtained results are in agreement with those of Sharf et al. [16], who found that imidacloprid induced the highest initial activity on immature stages of white fly. Also, El-Dewy et al. [17] reported that imidacloprid had good effects against the previous sucking pest than thiamethoxam, and imidacloprid proved to be a superior compound against aphids, jassids and whitefly (adults). Moreover, El-Naggar et al. [18] reported that cotton seedlings protected from thrips infestation for at least 6 weeks from seed planting by seed treatment with imidacloprid and thiamethoxam and induced a fast-initial effect on whitefly stages. Recently, Maurya et al. [19] found that thiamethoxam can protected tomato seedlings from the infestation with aphids and thrips when it treated as seed treatment, and Somasundar et al. [20] assessed the influence of seed treatment on insect pests in green gram, and found that thiamethoxam at 4.3 g/kg and 8.6 g/kg was greatly effective against sucking piercing insects as aphids, thrips, leaf hoppers, where the leaf damage was decreased in thiamethoxam, imidacloprid, acetamiprid treatments. Smith et al. [21] reported that egg and nymph densities were significantly lower on tomato seedling treated with insecticides than untreated control, whether whitefly adults were introduced 3, 7 or 14 days after the insecticides on treated plants tended to be very low. It could be reported that, seedling treatment gave better results in white fly control compared to seed treatment due to the complete protection of seedlings at planting time and it considered as means to place the pesticides into the root zone whereby the roots are providing a water-rich coating, having a surface satisfactorily dry and moisture become constant so, it permit the seedlings to remain protected and to domain the reliability of the coating during planting operation, but sufficiently moisture-sensitive so that soon after planting, the coating splits and releases the pesticide, thus providing the plant excellent protection from pests for a long time.

Population of *B. tabaci* stages infested treated and untreated tomato seedlings as affected by spraying imidacloprid at two rates under field conditions

As for the effect of two imidacloprid rates (recommended and half rates) sprayed on tomato plants, the obtained data in Table 2 indicated that there were no significant differences in the mean number of whitefly egg and nymph stages between two rates, while there were significant differences between both of the two rates and untreated seedlings (control).

Insecticide rate	Stages	No before treatment	Average numbers of white fly stages per 25 leaves and (Reduction%) at different intervals (in days)									Grand mean
			1	3	5	7	9	11	13	15	21	No (R%)
Imidacloprid 125 ml/100 l (1 FRR)	Egg	24 i	0 k (100)	0 k (100)	0 k (100)	0 k (100)	5 jk (82.6)	7 jk (76.2)	12 ijk (66.7)	14 ij (69.2)	20 i (69.1)	6.4 B (84.7)
	nymph	7 gh	0 j (100)	0 j (100)	0 j (100)	0 j (100)	3 ij (80.9)	5 hi (69.9)	6 hi (65.7)	8 gh (56.5)	10 fg (54.4)	3.6 B (80.8)
	Adult	368 cd	76 no (71.8)	120 lmn (65.9)	159 kl (52.0)	167 kl (41.2)	192 jk (37.6)	225 ij (31.1)	254 hi (29.5)	311 efg (28.2)	355 cdef (28.4)	206.6 C (42.9)
Imidacloprid 62.5 ml/100 l ($_{1/2}$ FRR)	Egg	20 i	0 k (100)	0 k (100)	0 k (100)	0 k (100)	0 k (100)	1 k (95.9)	2 jk (93.9)	2 jk (94.7)	7 jk (87.1)	1.3 B (96.8)
	nymph	10 fg	0 j (100)	0 j (100)	0 j (100)	0 j (100)	0 j (100)	3 ij (87.4)	5 hi (80)	5 hi (81)	8 gh (74.4)	2.2 B (91.4)
	Adult	362 cde	32 o (87.9)	84 no (75.7)	90 mn (72.4)	127 lmn (55.5)	143 klm (52.7)	155 kl (51.7)	190 jk (48.4)	225 ij (47.1)	252 hi (48.2)	144.2 B (60.0)
Control	Egg	66 fg	49 h	56 gh	67 efg	71 def	79 cde	81 cd	90 c	125 b	178 a	88.4 A
	nymph	8 gh	13 ef	15 de	15 de	16 cde	18 bcd	19 bc	20 b	21 b	25 a	18 A
	Adult	389 c	285 gh	372 cd	350 cdef	300 fgh	325 defg	345 cdef	396 c	458 b	524 a	372.8 A
LSD (0.05%)		for egg stage=12.2; for nymph stage=3.9; for adult stage=56.1; for total egg stage=3.9; for total nymph stage=2.3; for adult stage=33.4										
Data between brackets is a percent reduction according to Henderson et al. The different letters for each stage means significant difference at 5% level												

Table 2: Efficacy of foliar spray of two Imidacloprid recommended rates against *Bemisia tabaci* in tomato field.

It could be noticed that after foliar spraying with imidacloprid, whitefly stages were decreased at two rates comparing with control. Results in Table 2 indicated that the reduction percentages of whitefly eggs were ranged between (69.1-100%) and (87.1-100%) for half and field recommended rates, respectively, and it was ranged between (54.4-100%) and (74.4-100%) in numbers of nymph stages after sprayed with half and field recommended rates, respectively, where the reduction percentages in the numbers of adults were ranged between (28.4-71.8%) and (48.2-87.9%) after foliar spraying with half and field recommended rates, respectively. The total mean reduction percentages of egg, nymph and adults of whitefly were increased after spraying with field recommended rate compared with half recommended rate, recording mean reduction percentages (84.7, 80.8 and 42.9%) and (96.8, 91.4 and 60%) after treated with half and field recommended rates, respectively.

In addition, reduction percentages in whitefly egg and nymph stages were more than that of adults in all periods at the two rates. The obtained results are in agreement with those of Schuster et al. [22] who found that foliar applications of Imidacloprid 1.6 F at 3.75 oz/acre at a threshold of 5 whitefly nymphs/10 leaflets gave significant control of nymphs of *Bemisia argentifolii*, on tomato. In addition, Sharf et al. [16,17] found that imidacloprid induced the highest initial activity on immature stages of white fly. Also, El-Naggar et al. [18] evaluated the effectiveness of imidacloprid and thiamethoxam as foliar applications on the sucking insects infesting cotton and found that imidacloprid and thiamethoxam protected cotton seedlings from thrips infestation for at least 6 weeks. Moreover, the obtained results revealed that the efficiency of tested compound against nymph and egg stages of whitefly was more than the effect on the mature stages, which are in harmony with El Dewy et al. who reported that the adults usually visit plants early in the morning to feed and then leave seedlings to hide surrounding crops, thus the adults are in contact with the treated seedling for short time to feed, while the immature stages were found to be in almost continuous contact with treated seedlings for a long time, and picked up more toxicants.

Effect of imidacloprid on fruit yield of tomato

As for the effect of imidacloprid on the fruit yield of tomato plants, the statistical analysis of the obtained results in Table 3 revealed that there were significant differences in the average weight of tomato fruits among all treatments, where the highest yield values were recorded with recommended rate, followed by half rate, while control treatment gave the least yield values. The highest increase percentage in fruit yield was recorded with the treatment of treated tomato seedlings and sprayed with the recommended rate of imidacloprid giving 61.4%, while it was 55.9% at untreated seedlings and sprayed with the recommended rate of imidacloprid in comparison with control. The least increase percentages in fruit yield were recorded in the treatment of half recommended rate giving 37.4% at treated seedlings plots and only 28.9% increase at untreated seedlings in comparison with control. The obtained results are in agreement with Maurya et al. [19] who reported that the highest tomato yield was recorded by Thiamethoxam 70%WS at rate of 4.2 g a.i./kg of seed followed by the rate of 3.85 g a.i./kg of seed as compared to untreated.

Field rates of spraying	Treated seedlings +Spraying		Untreated seedlings +Spraying	
	Average weight fruits/ plant(g)	*increase%	Average weight fruits/ plant (g)	*increase %
Half recommended rate	883 b	37.4	778 b	28.9
Recommended rate	1433 a	61.4	1254 a	55.9
Control	553 c	-	553 c	-
LSD 5%	139.67		176.50	
The different letters means significant difference at 5% level				

Table 3: Effect of treated and untreated tomato seedlings sprayed with imidacloprid at two rates against *B. tabaci* on the fruit yield under field conditions.

Recovery of imidacloprid

Results in Table 4 show that recovery percentage of imidacloprid in tomato leaves and fruits ranged between 101.1-104.8 and 101-104.4, respectively.

Applied amount (µg)	Found amount (µg)		% recovery	
	Leaves	Fruits	leaves	Fruits
0.25	0.262 c	0.261 c	104.8	104.4
0.50	0.511 b	0.516 b	102.2	103.2
1.00	1.014 a	1.010 a	101.4	101.0
LSD 5%	0.055	0.016	-	-
The different letters means significant difference at 5% level				

Table 4: Recovery percentages of imidacloprid insecticide from tomato leaves and fruits.

The obtained results are in agreement with those conducted by Fernandez-Alba et al. [13] who reported that the recovery percentage of imidacloprid were 123, 114 and 102% in pepper, tomato and cucumber fruits, respectively. In addition, Alfonso et al. [23] found that the average recovery rates of acetamprid, imidacloprid, thaicloprid and thiamethoxam were ranged between (80 to 105) and (73 to 102) at the two levels of 0.1 and 1.0 mg/kg for each pesticide, respectively in peach, pear, courgette, celery and apricot. Also, Nasr et al. [24] found that the recovery percentage of imidacloprid was 117.5% in cucumber fruits, and Nassar et al. [25] reported that the recovery percentage of imidacloprid in tomato fruits ranged between 103.2 to 113%.

Imidacloprid residues in tomato leaves and fruits in treated seedlings and sprayed with field recommended rate

Data in Table 5 show that the initial deposits (1 h after application) of imidacloprid were 0.8 and 0.66 mg/kg for leaves and fruits, respectively. Then, it was decreased to 0.78, 0.57, 0.35, 0.27, 0.1 and 0.01 mg/kg for leaves and 0.65, 0.34, 0.19, 0.1, 0.09 and 0.08 mg/kg for fruits after 2, 5, 7, 9, 15 and 21 day of spraying, respectively. Rate of imidacloprid% loss were 2.5, 28.8, 56.3, 66.3, 87.5 and 98.8% and 1.5, 47.7, 71.2, 84.8, 86.4 and 87.9% for leaves and fruits, after 2, 5, 7, 9, 15 and 21 days of treatment, respectively, and the half-life time ($t_{1/2}$) of this insecticide for leaves and fruits was 7.29 and 6.37 days, respectively.

Imidacloprid residues in tomato leaves and fruits in untreated seedling and sprayed with field recommended rate

Data in Table 5 indicated that the initial deposited (1 h after application) of imidacloprid in leaves and fruits of tomato was 0.38 and 0.30, respectively, and gradually decreased to 0.29, 0.28, 0.24, 0.07, 0.06 and 0.04 mg/kg for leaves and 0.26, 0.11, 0.07, 0.07, 0.04 and 0.02 mg/kg for fruit after 2, 5, 7, 9, 15 and 21 days of treatment, respectively. However, the results showed that the% loss were 23.6, 26.3, 36.8, 81.6, 84.2 and 89.5% for leaves and 13.3, 63.3, 76.7, 86.7 and 93.3% for fruits, after 2, 5, 7, 9, 15 and 21 days of treatment, respectively, and the half-life time ($t_{1/2}$) was 7.14 and 4.88 days, for leaves and fruits, respectively. Generally, it was observed that residues of imidacloprid in leaves and fruits in untreated seedlings was less than treated seedlings and sprayed with field recommended dose, as well as the residues of imidacloprid was increased in tomato leaves compared with fruits and the imidacloprid had low initial residues in tomato leaves and fruits.

Days after spraying	Treated seedlings+Spraying		Untreated seedlings +Spraying	
	Conc. (mg/kg)	Loss%	Conc. (mg/kg)	Loss%
Leaves				
1 hr.	0.8 a	-	0.38 a	-
2 day	0.78 a	2.5	0.29 b	23.6
5	0.57 b	28.8	0.28 b	26.3
7	0.35 c	56.3	0.24 b	36.8
9	0.27 c	66.3	0.07 c	81.6
15	0.1 d	87.5	0.06 c	84.2
21	0.01 d	98.8	0.04 c	89.5
LSD 5%	0.14	-	0.042	-
$t_{1/2}$ (day)	7.27	-	7.14	-
Fruits				
1 hr.	0.66 a	-	0.3 a	-
2 day	0.65 a	1.5	0.26 a	13.3
5	0.34 b	47.7	0.11 b	63.3
7	0.19 c	71.2	0.07 b	76.7

9	0.1 d	84.8	0.07 b	76.7
15	0.09 d	86.4	0.04 b	86.7
21	0.08 d	87.9	0.02 b	93.3
LSD 5%	0.023	-	0.07	-
$t_{1/2}$ (day)	6.37	-	4.88	-
The different letters means significant difference at 5% level				

Table 5: Imidacloprid residues and loss% in the leaves and fruits of tomato treated and untreated before sowing and sprayed at flower period (2 months of sowing) with field recommended rate.

The obtained results are confirmed with those of Nassar et al. who found that the residue amounts of imidacloprid in tomato fruits after different intervals of application was 0.316 mg kg-1 and decreased to be0.32, 0.23, 0.21, 0.14, 0.12 and 0.11 mg kg^{-1} after 1 h., 3, 5, 7, 10, 14 and 21 days of last spray, respectively, the residual amount of imidacloprid at zero time of last application was less than that in the European Maximum Residual Level (MRL=0.5 mg kg^{-1}) and also less than the American and Canadian tolerance level (MRL=1 mg kg^{-1}) [26].

References

1. Brown JK, Frohlich DR, Rosell RC (1995) The sweetpotato or silverleaf whiteflies: biotypes of *Bemisia tabaci* or a species complex?. Annual Review of Entomology 40: 511-534.
2. Said AA, Shaheen FAH, Hamid AM, Elzahi ES (2005) Population dynamic of aphids, whitefly, some predators and seed cotton yield as inflected by cotton sowing date. Egypt J Agric Res 83: 813-830.
3. Hunter WB, Polston JE (2001) Development of a continuous whitefly cell line [Homoptera: Aleyrodidae: *Bemisia tabaci* (Gennadius)] for the study of begomovirus. Journal of Invertebrate Pathology 77: 33-36.
4. Palumbo JC, Horowitz AR, Prabhaker N (2001) Insecticidal control and resistance management for Bemisia tabaci. Crop Protection 20: 739-765.
5. Wismer T (2004) Novel Insecticides. Clinical Veterinary Toxicology, Mosby Inc, St Louis, USA, pp: 184-185.
6. Tomlin C (2006) The Pesticide Manual: A world compendium. 14th edn. British crop protection, Council, Surry, England, pp: 598-599.
7. Chao SL, Casida JE (1997) Interaction of imidacloprid metabolites and analogs with the nicotinic acetylcholine receptor of mouse brain in relation to toxicity. Pesticide Biochemistry and Physiology 58: 77-88.
8. Matsuda K, Buckingham SD, Kleier D, Rauh JJ, Grauso M, et al. (2001) Neonicotinoids: insecticides acting on insect nicotinic acetylcholine receptors. Trends in Pharmacological Sciences 22: 573-580.
9. Tomizawa M, Casida JE (2005) Neonicotinoid insecticide toxicology: mechanisms of selective action. Annu Rev Pharmacol Toxicol 45: 247-268.
10. Walstad JD, Hart JB, Cade SC (1973) Carbfuran-clay root protects loblolly Pine seedling from Debarking weevils. J Econ Entomol 66: 1219-1220.
11. Abbott WS (1925) A method of computing the effectiveness of an insecticide. J Econ Entomol 18: 265-267.
12. Henderson CF, Tilton EW (1955) Tests with acaricides against the brown wheat mite. Journal of Economic Entomology 48: 157-61.
13. Fernandez-Alba AR, Valverde A, Agüera A, Contreras M, Chiron S (1996) Determination of imidacloprid in vegetables by high-performance liquid chromatography with diode-array detection. Journal of Chromatography A 721: 97-105.
14. Moye HA, Malagodi MH, Yoh J, Leibee GL, Ku CC (1987) Residues of avermectin bla: rotational crops and soils following soil treatment with (C14) avermectin bla. Agric Food Chem 35: 859-864.
15. Manual C (1998) Version 6.400, 798 Lighthouse Ave. PMB 320, Monterey, CA, 93940, USA.
16. Sharaf FH, El-Basyouni SA, Hamid AM)2003) Insecticidal efficiency of some chemical compounds on the whitefly, Bemisia tabaci (Gennad.) infesting cotton plants and its associated natural enemies. J Agric Sci Mansoura Univ 28 :1419-1423.
17. El-Dewy MH (2015) Toxicological studies on some pests attacking cotton. Doctoral Dissertation, Faculty Agriculture, Kafr El-Sheikh University, Egypt.
18. El-Naggar JB, Zidan NE (2013) Field evaluation of imidacloprid and thiamethoxam against sucking insects and their side effects on soil fauna. Journal of Plant Protection Research 53: 375-387.
19. Maurya SK, Maurya RP, Singh D (2015) Evaluation of thiamethoxam 70% WS as seed treatment against early sucking pests of tomato. Journal of Applied and Natural Science 7: 763-767.
20. Somasundar U, Nukala NK, Prasd PR (2016) Studies on new seed dressing insecticides against insect pests of green gram. Inter J Agric Innovations Res 2319: 1473.
21. Smith HA, Giurcanu MC (2013) Residual effects of new insecticides on egg and nymph densities of Bemisia tabaci (Hemiptera: Aleyrodidae). Florida Entomologist 96: 504-511.
22. Locascio SJ, Gilreath JP, Dickson DW, Kucharek TA, Jones JP (2002) Comparison of imidacloprid and thiamethoxam for control of the silverleaf whitefly, Bemisia argentifolii, and the leafminer, Liriomyza trifolii, on tomato. Proc Fla State Hort Soc 115: 321-329.
23. Di Muccio A, Fidente P, Barbini DA, Dommarco R, Seccia S, et al. (2006) Application of solid-phase extraction and liquid chromatography–mass spectrometry to the determination of neonicotinoid pesticide residues in fruit and vegetables. Journal of Chromatography A 1108: 1-6.
24. Nasr HM, Abbassy MA, Marzouk MA, Mansy AS (2014) Determination of Imidacloprid and Tetraconazol Residues in Cucumber Fruits. J Poll Eff Cont 2: 1-5.
25. Nassar AM, Abbassy MA, Salem YM (2015) Mammalian detrimental effects of imidacloprid residues in tomato fruits. Research Journal of Environmental Toxicology 9: 149.
26. Health Canada (2013) Imidacloprid PMRL2013-61, Proposed Maximum Residue Limits, Health Canada Pest Management Regulatory Agency, Canada.