Brazilian Journal of Biology®

ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

Original Article

Efficacy of novel insecticides against piercing sucking insects and their natural enemies on sweet pepper plants under field conditions

Eficácia de novos inseticidas contra insetos sugadores perfurantes e seus inimigos naturais em plantas de pimentão em condições de campo

Z. M. Al Dhafar[a,b], M. A. A. Abdel Razik[c*], M. A. Osman[a,b], M. E. Sweelam[d] and N. O. Swelam[d]

[a]Imam Abdulrahman Bin Faisal University, College of Science, Department of Biology, Dammam, Saudi Arabia
[b]Imam Abdulrahman Bin Faisal University, Basic and Applied Scientific Research Center, Dammam, Saudi Arabia
[c]Menoufia University, Faculty of Agriculture, Pesticides Department, Shebin El-Kom, Egypt
[d]Menoufia University, Faculty of Agriculture, Economic Entomology & Agriculture Zoology Department, Shebin El-Kom, Egypt

Abstract

Piercing sucking pests attacking sweet pepper plants cause significant losses to its yield. Considering the undesirable effects of synthetic pesticides, field studies were conducted to evaluate the impact of new pesticides against piercing sucking insect pests of sweet pepper, as well as, their effects on some predators and pepper yield along two seasons of 2021-2022. The obtained results indicated that all tested pesticides effectively suppressed the sucking insect populations (aphids, white fly, thrips) 1,7,14 and 21 days after treatment along two sprays during two seasons. Imidacloprid proved to be the superior one over all other treatments where it recorded mean reduction% (98.91 and 97.27%) & (94.8 and 95.19%), (86.23 and 76.64%) & (80.92 and 88.55%) and (77.68 and 78.44%) & (90.70 and 68.57%) in white fly, aphids and thrips, respectively at 1st and 2nd sprays at 2021 and 2022 seasons, respectively. As for side effects of tested insecticides on natural enemies, Dimethoate induced the highest decrease (60.85 and 69.33%) & (54.02 and 63.41%), (65.52 and 64.74%) & (59.23 and 58.38%) and (64.24 and 59.48%) & (61.66 and 60.8%) on *Chrysoperla carnea*, *Paederus alfierii* and *Coccinella* spp at 1st and 2nd sprays at 2021 and 2022 seasons, respectively. On contrary, Spintoram induced the lowest effects on *Chrysoperla carnea*, *Paederus alfierii* and *Coccinella* spp, recording decrease percent (25.41 and 19.84%) & (15.02 and 12.50%), (11.94 and 11.24%) (16.99 and 18.02%) and (18.73 and15.07%) & (18.35 and18.38%) at1st and 2nd sprays at 2021 and 2022 seasons, respectively. With respect to the effect of tested insecticides on pepper yield, all tested insecticides increased the yield of green pepper fruits compared with control. Imidacloprid achieved the highest fruit yields along two seasons 6.43 and 6.52 (ton / fed.4200 m^2) with increase percent 34.53 and 36.04% in yield over control at 2021 and 2022 seasons, respectively.

Keywords: efficacy, insecticides, sucking insects, natural enemies, sweet pepper.

Resumo

As pragas sugadoras perfurantes do pimentão causam perdas significativas em sua produção. Considerando os efeitos indesejáveis dos pesticidas sintéticos, foram realizados estudos de campo para avaliar o impacto de novos pesticidas contra pragas de insetos sugadores perfurantes do pimentão, bem como os seus efeitos sobre alguns predadores e a produção de pimentão durante as épocas 2021 e 2022. Os resultados obtidos indicaram que todos os pesticidas testados suprimiram efetivamente as populações de insetos sugadores após 1,7,14 e 21 dias de tratamento ao longo de duas pulverizações durante duas temporadas. O Imidaclopride mostrou-se superior a todos os outros tratamentos quando registrou-se redução média (%) (98,91 e 97,27%) & (94,8 e 95,19%), (86,23 e 76,64%) & (80,92 e 88,55%) e (77,68 e 78,44%) & (90,70 e 68,57%) em mosca branca, pulgões e tripes, respectivamente, nas primeira e segunda pulverizações após a temporada de 2021 e 2022, respectivamente. Quanto ao efeito colateral dos inseticidas testados sobre os inimigos naturais, o Dimetoato induziu a maior diminuição (60,85 e 69,33%) & (54,02 e 63,41%), (65,52 e 64,74%) & (59,23 e 58,38%) e (64,24 e 59,48%) & (61,66 e 60,8%) em *Chrysoperla carnea*, *Paederus alfierii* e *Coccinella* spp. nas primeira e segunda pulverizações após as temporadas de 2021 e 2022, respectivamente. Pelo contrário, Spintoram induziu o menor efeito em *Chrysoperla carnea*, *Paederus alfierii* e *Coccinella* spp., registrando porcentagem de diminuição (25,41 e 19,84%) e (15,02 e 12,50%), (11,94 e 11,24%) & (16,99 e 18,02%) e (18,73 e 15,07%) e (18,35 e 18,38%) nas primeira e segunda pulverizações após as temporadas de 2021 e 2022, respectivamente. Com relação ao efeito dos inseticidas testados na produção de pimenta, todos os inseticidas testados aumentaram a produção de frutos de pimenta verde em comparação com o controle. O Imidaclopride alcançou os maiores rendimentos de frutos ao longo de duas temporadas (6,43 e 6,52 toneladas/alimentado) com aumento percentual no rendimento de 34,53 e 36,04% em relação ao controle após duas temporadas 2021 e 2022, respectivamente.

Palavras-chave: eficácia, inseticidas, insetos sugadores, inimigos naturais, pimentão.

*e-mail: new1folder@yahoo.com
Received: March 9, 2024 – Accepted: June 10, 2024

1. Introduction

Sweet pepper, bell pepper, green pepper or capsicum, *Capsicum annuum* is one of the most popular vegetable crops grown all over the world. There are about 35 species of insect and mite pests reported in capsicum, a few viz., thrips (*Scirtothrips dorsalis* Hood, *Thrips palmi* Karny), aphids *(Aphis gossypii* Glover, *Myzus persicae* Sulzer), whitefly (*Bemisia tabaci* Gennadius), fruit borers (*Helicoverpa armigera* Hubner), mites (*Tarsonemus latus* Banks, *Tetranychus cinnabarinus* Boisd.) and other minor pests. Vos and Frinking (1998), Sorensen (2005). Aphids, thrips and mites are considered the major pests in capsicum Berke et al. (2003) Sunitha (2007). (Reddy et al., 2005) reported that chilli mite, *Polyphagotarsonemus latus* and thrips, *Scirtothrips dorsalis* as the main pests in sweet pepper. Souza et al. (2019) reported that sweet pepper (*Capsicum annuum* L.) is one of the important crops in Brazil, and infested by many insect pests, causing undesirable effects on the quantity and quality of fruits, and this creates a production problem.

The whitefly, *B. tabaci* causes direct damage through phloem feeding and injection of toxins and indirect damage due to its ability to transmit plant viruses (Pereira et al., 2004; Brown 2010).

The green peach aphid, *M. persicae* (Sulzer) (Hemiptera: Aphididae) is a worldwide distributed insect pest causing both direct and indirect damage on several crops (Blackman and Eastop, 2000).

The chemical control becomes less effective due to development of insecticide resistant populations (Siebert et al., 2012). Imidacloprid induced a good reduction in the mean number of *B. tabaci* and *M. persicae*. Chemical control of the whitefly with conventional insecticides (organophosphates, carbamates and pyrethroids) is widely popular with tomato farmers and producers in Egypt. Thorat et al. (2020) and Simkhada and Paneru (2010) revealed that imidacloprid effectively reduced the whitefly population. Additionally, the plants treated with imidacloprid recorded the lowest whitefly population (2.18 adults /leaf). Thiacloprid, Thiamethoxam and Dinotefuran are the same effect, as agonist of the nicotinic acetylcholine receptor, affecting the synapses in the insect central nervous system.

For management of sucking pests, several chemistries with novel modes of action have been introduced with most significant being the neonicotinoids, spiromesifen, pymetrozine (Palumbo, 2009).

The use of chemical insecticides to control *M. persicae*, making it the most resistant pest (Bass et al., 2014). Neonicotinoid insecticides are the most effective group against sucking pests. Neonicotinoids provide an excellent control either applied as seed or foliar treatments against piercing sucking insects, such as aphids, whiteflies, thrips, jassid and others (Prasanna et al., 2004). The neonicotinoid insecticides reduced the cotton aphid effectively (up to 14 days) under field conditions (Shi et al., 2011; El-Naggar and Zidan, 2013).

From the previous preview, this work was conducted under field conditions to study the effects of newer insecticides against piercing sucking pests infesting green pepper plants as well as to study the effect of insecticides on the natural enemies viz. *Chrysoperla carnea, Paederus alfierii* and *Coccinella* spp at a private farm of Elmenoufia Governorate, Egypt, during two successive seasons of 2021 & 2022 years.

2. Materials and Methods

2.1. Field experiments and sampling procedure

The effect of newer insecticides (Table 1) against piercing sucking pests infesting green pepper plants under field conditions were evaluated at a private farm of El Menoufia Governorate, Egypt, during seasons 2021 & 2022.

Seedlings of sweet pepper variety Top star, one month old, were transplanted at the 1st of March month in plots each plot 20 m^2 each plot was divided into four rows consisting of 10 m length x 0.5 m width in a randomized block design with three replications.

All management processes except plant protection against sucking pests were adopted per the recommended package of practices.

First spray application of each insecticide was sprayed at the appearance of the pests (1st April) and subsequently second spray after 30 days, using manually operated knapsack sprayer having duromist nozzle with slight runoff stage. Different insecticides were evaluated against piercing sucking insects (whitefly, aphids and thrips) during morning hours. The first spraying of insecticides was

Table 1. Tested insecticides against piercing sucking insects infecting sweet pepper.

Common name	Trade name	Chemical group	Manufacture
Imidacloprid	Admire 20% SC	Neonicotinoid	Bayer Company
Thiamethoxam	Actara 25% WG	Neonicotinoid	Syngenta Company. Switzerland
Spiromesfen	Tormalin 24% SC	Tetronic Acid	Hektas Ticaret T.A.S. Turkey
Acetamprid	Mospilan 20% SP	Neonicotinoid	Nippon Soda Chemical Industry Co. Ltd.
Chothinidin	Supertox-1® 48%SC	Neonicotinoid	Jiangs Jiag chemical industry Co. Ltd China
Pymetrizine	Tido 50% WG	Triazine	Nanjing Huazhou Pharm. Co.,Ltd.-China.
Spinoteram	Radiant 12% SC	Spinosyn	Corteva Agriscience
Dimethoate	Rogor 40% EC	Organophosphate	New Pack Agro Chem 238/1/A, GIDC Panoli - 394 115 Dist. – Bharuch Gujarat State (INDIA)

done during the vegetative phase of the crop. The second spraying of insecticides was done during the reproductive phase of the crop. Observations on the whitefly, aphids and thrips incidence were recorded one day before the spraying as pre-treatment count and 1, 7, 14 and 21 days after spraying as post- treatment counts. The population of nymphs and adults were counted during early morning hours on terminal six leaves from 5 randomly selected plants in each plot to get a representative sample of each plot. Reduction percentages of white fly, aphids and thrips stages were determined according to Henderson and Tilton (1955) equation (Equation 1).

$$Corrected\ \% = \left(1 - \frac{n\ in\ Co\ pretreat\ *\ n\ in\ T\ post\ treat}{n\ in\ Co\ post\ treat\ *\ n in\ T\ pre-treat}\right) \quad (1)$$

Where, n = insect population Co = control T= treatment

To study the effects of insecticides on the natural enemies viz. *Chrysoperla carnea, Paederus alfierii* and *Coccinella* spp, leaf samples were observed from five randomly selected plants per plot, 24 hours before spraying as pre-treatment sample and 1, 7, 14 and 21 days of application as post treatment samples, and decrease % was computed according to the following formula (Equation 2):

$$Decrease\ percentage\ =\ initial\ numbers - final\ numbers\ /\ initial\ numbers\ x100 \quad (2)$$

The green pepper fruit yield was weighted by picking wise from each plot. The obtained data for tested insect pests were statistically analyzed using an analysis of variance (ANOVA) at 5% probability, and the measurements were divided using Duncan Multiple Range Test through the Costat software program (Version 6.400)1989-2008 (COSTAT, 2008).

3. Results

1-Efficacy of tested pesticides on white fly, *Bemisia tabaci*:

The obtained data in Tables 2 and 3 show the effect of two sprays of tested pesticides on white fly infesting pepper plants after 1, 7, 14 and 21 days at 2021 and 2022 seasons.

First season 2021: The statistical analysis of the data in Table 2 revealed that no significant differences were recorded in white fly numbers among all tested insecticides after 1st and 2nd sprays, where there were significant variations in white fly population between treatments and control.

The grand mean of white fly stages per leaf was ranged between (0.69-7.0) and (0.31-3.19) after 1st and 2nd sprays. Application of Imidacloprid resulted in the highest decrease in *B. tabaci* mean numbers after both sprays of the seasons recording 0.69 and 0.31 white fly stages/ leaf after 1st and 2nd sprays. With respect to reduction percentages of white fly stages after 1st and 2nd sprays at 2021season, data in Table 3 revealed that all tested pesticides induced higher reduction % in white fly numbers after 1st and 2nd sprays, where the reduction % mean were ranged between (88.59-98.91) and (85.27-97.27) after 1st and 2nd sprays with tested pesticides.

The highest increases in reduction (98.91 and 97.27%) were recorded after treated with imidacloprid at 1st and 2nd sprays.

Second season 2022: The data in Tables 2 and 3 show the effect of tested pesticides on mean numbers of white fly stages and reduction % after 1st and 2nd sprays during 2022 season. The *B. tabaci* numbers were not significantly differed among pesticide treatments, where there were significant differences between all treatments and control.

The minimum number of white fly stages Table 2 was detected with imidacloprid (2.31 and 0.75 white fly stages/ leaf) and thiamethoxam (2.88 and 0.75 white fly stages/ leaf) treatments after 1st and 2nd sprays. The data in Table 3 indicated that the tested pesticides induced higher increase in reduction % of white fly stages after 1st and 2nd sprays, where the grand mean of reduction % ranged between (88.59-98.91%) and (82.93-95.19%) after 1st and 2nd sprays. The highest increase in grand mean of reduction % was detected with imidacloprid and thiamethoxam recording (94.81 and 93.54%) and (95.19 and 95.12%) after 1st and 2nd sprays, respectively.

2-Efficacy of tested insecticides on aphid, *Aphis gossypii*:

The insecticidal activity of tested insecticides applied against aphid, *A. gossypii* on pepper plants were evaluated under field conditions.

Data presented in Tables 4 and 5 show the effect of tested insecticides in suppressing the aphid populations on pepper plants 1, 7, 14 and 21 days of spraying along two sprays at 2021 and 2022 seasons.

First season 2021: The statistical analysis of data in Table 4 revealed that no significant differences were recorded in *A. gossypii* numbers among all tested insecticides after 1st and 2nd sprays, where there were significant variations in *A. gossypii* population between all treatments and control.

The grand mean of *A. gossypii* stages per leaf was ranged between (3.08 -5.68) and (2.92 -6.59) after 1st and 2nd sprays. Application of Imidacloprid resulted in the highest decrease in *A. gossypii* mean numbers after the two sprays of each season recording 3.08 and 2.92 *A. gossypii* stages/ leaf after 1st and 2nd sprays.

With respect to reduction percentages of *A. gossypii* stages after 1st and 2nd sprays at 2021season, data in Table 4 revealed that all tested pesticides induced higher reduction in *A. gossypii* after 1st and 2nd sprays, where the reduction % were ranged between (68.16-86.23%) and (53.48-53.48%) after 1st and 2nd sprays with tested pesticides.

The highest increases in reduction percentage (86.23and 76.64%) was recorded after treated with imidacloprid at 1st and 2nd sprays.

Second season 2022: The data in Tables 4 and 5 show the effect of tested pesticides on mean numbers of *A. gossypii* stages and reduction % after 1st and 2nd sprays during 2022 season. There were no significant differences between *A. gossypii* numbers among all pesticide treatments, where there were significant differences between pesticides and control.

The minimum numbers of *A. gossypii* stages Table 4 were detected with imidacloprid (2.31 and 0.75 *A. gossypii* stages/

Table 2. Effect of two sprays of different pesticides against white fly infesting pepper plants along 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean numbers of white fly stages/ 5 leaves					
	Pre Treatment	Days after spray				Grand mean
		1	7	14	21	
Season 2021						
Imidacloprid	27.8	0	0	0.8	2.0	0.7 c (0.3b)
	(5.0)	0	0	(0.3)	-1	
Thiamethoxam	27.3	0	0.3	0.8	3.3	1.1 c (1.2b)
	(9.0)	0	(0.8)	(2.0)	(2.0)	
Spiromesfen	28.1	0	1.0	1.3	3.0	1.3 c (1.8b)
	(8.0)	0	(1.0)	(2.0)	(3.0)	
Acetamprid	29.1	0	2.0	4.0	6.0	3.0 bc
	(10.0)	0	(0.3)	(1.0)	(2.0)	(0.8b)
Chothinidin	28.4	0	0.8	2.0	6.0	2.2 c (1.8b)
	(10.0)	0	(1.0)	(2.0)	(3.0)	
Pymetrizine	29.1	1.0	2.0	4.0	5.0	3.0 bc (1.7b)
	(9.0)	0	(1.3)	(2.0)	(3.0)	
Spinoteram	28.3	2.0	3.0	6.0	9.0	5.0 bc
	(12.0)	(1.0)	(2.8)	(4.0)	(5.0)	(3.2b)
Dimethoate	27.8	1.0	5.0	9.0	13.0	7.0 b
	(14.0)	(1.0)	(2.0)	(4.0)	(5.0)	(3 b)
Control	26.8	31.9	49	55.9	67.6	51.1 a (49.3a)
	(29.2)	(30.7)	(43.5)	(56.9)	(66.0)	
LSD 5%						3.1 (1.8)
Season 2022						
Imidacloprid	26.91	1.0	1.5	3.1	3.62	2.3 b
	(6.0)	0	0	(1.0)	(2.0)	(0.8b)
Thiamethoxam	26.7	1.0	2.5	3.0	5.0	2.9 b
	(5.0)	0	0	(1.0)	(2.0)	(0.8b)
Spiromesfen	28.4	1.0	3.3	4.0	6.0	3.6 b
	(9.0)	0	(1.0)	(2.0)	(3.0)	(1.5b)
Acetamprid	26.3	2.0	2.6	4.0	5.4	3.5 b
	(7.0)	(1.0)	(2.0)	(3.0)	(4.0)	(2.5 b)
Chothinidin	29.1	3.3	5.0	7.0	9.0	6.1 b
	(9.0)	0	(1.5)	(2.0)	(2.0)	(1.4 b)
Pymetrizine	28.9	4.0	4.4	5.0	5.4	4.7 b
	-9	(1.0)	(2.0)	(3.0)	(4.0)	(1.4 b)
Spinoteram	26.2	3.1	3.9	4.2	4.7	4 b
	(8.0)	(1.0)	(1.5)	(2.5)	(4.0)	(2.3b)
Dimethoate	25.3	2.0	3.5	4.5	3.7	3.4 b
	(8.0)	0	(1.0)	(2.0)	(3.0)	(1.5 b)
Control	26.9	27.3	36.5	46.3	56.2	41.6 a
	(30.3)	(31.1)	(41.7)	-53	(62.1)	(47a)
LSD 5%						2.7 (1.8)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 3. Reduction percentages of white fly infesting pepper plants after two sprays of different pesticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Reduction percentages of white fly									
	Days after spray				Grand mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	100	100	98.9	97.8	98.9	100	100	97.9	91.1	97.3
Thiamethoxam	100	99.4	98.9	96.3	98.5	100	94.4	94.3	90.2	94.7
Spiromesfen	100	97.5	97.4	96.7	97.9	100	91.6	83.2	83.4	89.5
Acetamprid	100	95.2	94.3	93.6	95.8	100	98.3	94.9	91.1	96.1
Chothinidin	100	98.1	97.1	93.4	97.2	100	93.3	89.7	86.7	92.4
Pymetrizine	97.1	96.8	93.5	93.1	95.2	100	90.7	88.6	85.2	91.1
Spinoteram	95.0	92.5	91.2	90.1	88.6	92.1	84.6	82.9	81.5	85.3
Dimethoate	96.5	87.3	86.6	85.5	89.0	93.2	90.4	85.3	81.6	87.6
season 2022										
Imidacloprid	96.3	95.9	93.3	93.7	94.8	100	100	92.7	88.0	95.2
Thiamethoxam	96.3	93.3	93.5	91.0	93.5	100	100	92.7	88.0	95.1
Spiromesfen	96.5	91.6	90.6	89.9	92.1	100	100	90.1	84.0	93.5
Acetamprid	92.5	92.7	91.2	90.1	91.6	100	90.8	85.5	82.0	89.6
Chothinidin	89.0	87.3	86.0	85.2	86.9	100	87.7	87.1	84.0	87.3
Pymetrizine	86.4	89.4	90.0	91.1	89.2	89.0	83.6	80.6	78.7	83.0
Spinoteram	88.2	89.0	90.6	91.5	89.8	87.7	86.2	81.8	76.1	82.9
Dimethoate	91.2	89.9	89.6	87.2	89.2	100	89.0	87.1	84.0	90.0

leaf) and thiamethoxam (2.88 and 0.75 A. *gossypii* stages/ leaf) treatments after 1st and 2nd sprays.

The data in Table 5 indicated that the tested pesticides induced high increase in reduction % of *A. gossypii* stages after 1st and 2nd sprays, where the grand mean of reduction % ranged between (59.04-80.92%) and (64.78-86.12%) after 1st and 2nd sprays. The highest increase in grand mean of reduction % was detected with imidacloprid and thiamethoxam which recorded (80.92 and 78.88%) and (88.55and 86.12%) after 1st and 2nd sprays, respectively. Imidacloprid recorded the highest mean reduction after 1st and 2nd sprays along two tested seasons.

3-Efficacy of tested insecticides on thrips, *Thrips tabaci*:

The insecticidal activity of tested pesticides, as a foliar treatment against thrips, *T. tabaci* at 1, 7, 14 and 21 days after spraying, and the reduction percentages after the two sprays during 2021 and 2022 seasons is shown in Tables 6 and 7.

First season 2021: The statistical analysis of data in Table 6 revealed that no significant differences were recorded in thrips numbers among all tested insecticides after 1st and 2nd sprays, where there were significant variations in white fly population between insecticides and control.

The grand mean of thrips stages per leaf was ranged between (3.15 -7.14) and (2.09 - 4.82) after 1st and 2nd sprays. Application of Imidacloprid resulted in the highest decrease in thrips mean numbers after both sprays of the two seasons recording 3.15 and 2.09 thrips stages/ leaf after 1st and 2nd sprays.

With respect to reduction percentages of thrips stages after 1st and 2nd sprays at season 2021, data in Table 7 revealed that all tested pesticides induced higher reduction % in thrips after 1st and 2nd sprays, where the reduction % mean were ranged between (64.95-77.68%) and (53.73-78.44%) after 1st and 2nd sprays with tested pesticides, where the highest reduction % (77.68 and 78.44%) was recorded with imidacloprid at 1st and 2nd sprays.

Second season 2022: The data in Tables 6 and 7 show the effect of pesticides on thrips stages and reduction % after 1st and 2nd sprays during 2022 season.

There were no significant differences between the thrips numbers between different pesticide treatments, where there were significant differences between pesticides and control.

The minimum numbers of thrips stages (Table 6) were detected with imidacloprid (2.49 and 3.51 thrips stages/ leaf) and thiamethoxam (3.07 and 3.48 thrips stages/ leaf) after 1st and 2nd sprays.

The data in Table 7 indicated that the tested pesticides induced high increase in reduction % of thrips stages after

Table 4. Effect of two sprays of different pesticides against aphid stages infesting pepper plants at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean number of aphid stages/3 leaves					
	Pre treatment	Days after spray (application)				Grand mean
		1	7	14	21	
season 2021						
Imidacloprid	8.1	2.2	2.4	3.6	4.1	3.1b
	(7.1)	(2.1)	(3.3)	(3.1)	(3.2)	(2.9 b)
Thiamethoxam	7.2	2. 8 (3.6)	3.1	3. 8	4.6	3.56 b
	(7.3)		(3.5)	(4.2)	(4.1)	(3.9 b)
Spiromesfen	7.6	4.0	4.3	4.3	5.5	4.5 b
	(8.5)	(4.1)	(4.6)	(4.6)	(4.8)	(4.5 b)
Acetamprid	7.8	4. 4	4.7	4.9	5.0	4.7 b
	(8.9)	(4.5)	(4.4)	(4.5)	(4.7)	(4.6 b)
Chothinidin	7.8	5.4	5.5	6.0	6.0	5.7 b
	(8.1)	(5.3)	(5.1)	(5.9)	(6.7)	(5.7b)
Pymetrizine	7.4	3.2	3.9	3.5	4.1	3.7 b
	(7.8)	(3.1)	(3.4)	(3.9)	(4.1)	(3.6 b)
Spinoteram	7.4	5.6	5.42	4.9	6.2	5.53 b
	(8.1)	(6.0)	(6.7)	(6.7)	(6.9)	(6.6b)
Dimethoate	7.0	3.1	3.7	3.8	4.0	3.7 b
	(8.5)	(3.2)	(3.5)	(4.1)	(4.3)	(3.8 b)
Control	8.7	10. 8	18.9	32.9	49.8	28.1 a
	(21.3)	(23.1)	(37.2)	(48.2)	(52.1)	(40.2 a)
LSD 5%						3.4 (3.3)
season 2022						
Imidacloprid	8.7	2.5	3.1	4.0	4.1	3.4 b
	(8.0)	(2.1)	(2.2)	(2.5)	(2.6)	(2.4 c)
Thiamethoxam	8.9	3.3	3.4	3.7	4.1	3.6 b
	(8.1)	(3.2)	(3.4)	(3.6)	(3.9)	(3.5bc)
Spiromesfen	8.1	4.1	4.3	4.3	5.1	4.5 b
	(8.4)	(4.3)	(4.6)	(4.5)	(4.6)	(4.5 bc)
Acetamprid	8.5	6.1	6.3	6.0	6.2	6.2 b
	(8.3)	(5. 8)	(6.1)	(6.0)	(6.6)	(6.1 b)
Chothinidin	9.1	5.2	5.1	5.4	5.0	5.2 b
	(7.2)	(3.3)	(3.5)	(3.6)	(3.8)	(3.5 bc)
Pymetrizine	8. 9	5.1	4.8	3.9	4.1	4.5 b
	(7.3)	(3.3)	(3.8)	(4.7)	-5	(4.2 bc)
Spinoteram	7.6	4.4	5.6	5.1	6.1	5.3 b
	(8.8)	(5.3)	(5.5)	(6.1)	(6.5)	(5.8b)
Dimethoate	8.3	3.2	3.3	3. 6	3.9	3.5 b
	(8.0)	(2.2)	(3.0)	(3.3)	(3.7)	(3.1 bc)
Control	9.1	9.1	15.4	26.8	37. 8	22.3 a
	(19.4)	(29.4)	(38.1)	(47.2)	(6.0)	(42.7 a)
LSD 5%						2 (2)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 5. Reduction percentages of aphid stages infesting pepper plants two sprays of different pesticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Reduction percentages of aphid stages									
	Days after spray				Grand mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	78.3	87.3	88.3	91.1	86.2	73.3	74.5	81.5	82.4	76.6
Thiamethoxam	68.7	81.5	87.4	88.9	81.6	65.3	76.4	78.7	79.3	74.9
Spiromesfen	57.0	74.3	84.8	87.5	75.9	55.5	68.8	76.3	77.2	69.4
Acetamprid	54.2	72.7	83.6	88.8	74.8	53.5	71.6	77.6	78.3	69.4
Chothinidin	44.0	67.5	79.6	86.5	69.2	39.8	63.9	63.6	66.3	58.4
Pymetrizine	64.7	82.2	87.7	90.3	81.2	63.2	74.8	74.5	78.4	72.7
Spinoteram	38.8	65.9	82.6	85.3	68.2	31.2	52.3	65.1	65.4	53.5
Dimethoate	64.3	76.2	85.6	90.1	79.0	55.9	72.9	74.6	77.0	70.1
season 2022										
Imidacloprid	71.6	78.9	84.6	88.7	80.9	82.6	86.2	87.1	88.6	86.1
Thiamethoxam	63.4	77.2	86.0	88.9	78.9	81.5	80.8	83.0	84.0	82.3
Spiromesfen	44.5	68.7	81.3	84.8	70.0	66.5	72.4	78.2	80.9	74.5
Acetamprid	27.7	56.1	70.0	82.3	59.0	53.8	62.3	70.6	72.4	64.8
Chothinidin	42.6	66.8	79.8	86.8	69.0	70.3	75.6	79.7	81.6	76.8
Pymetrizine	42.8	67.8	85.1	88.9	71.1	70.5	73.6	73.2	76.2	73.4
Spinoteram	42.5	56.2	77.1	80.5	64.1	60.6	68.6	71.6	74.8	68.9
Dimethoate	62.2	76.8	85.5	88.6	78.3	74.3	78.9	81.9	83.4	79.6

1st and 2nd sprays, where the grand mean reduction % ranged between (81.70-90.70%) and (50.28-68.57%) after 1st and 2nd sprays. The highest increase in grand mean of reduction was detected with imidacloprid recording (90.70%) and (68.57%) after 1st and 2nd sprays, respectively.

4- The side effect of tested pesticides on natural enemies:

Side effect of tested pesticides on Aphid lion, *Chrysoperla carnea*:

The side effect of Imidacloprid, Thiamethoxam, Spiromesfen, Acetamprid, Chothinidin, Pymetrizine, Spinoteram, and Dimethoate, as a foliar spray against *C. carnea* populations at 1, 7, 14 and 21 days after spraying, and the mean of the reduction % along two sprays during the 2021 and 2022 seasons is shown in Tables 8 and 9.

First season 2021: The foliar application of pesticides Table 8 showed significant differences in the mean numbers of *C. carnea* compared to untreated plots at different exposure dates after two sprays. Dimethoate induced the highest decrease in mean numbers of *C. carnea* (5.16 and 2.25 *C. carnea* per plant), followed by Imidacloprid which recorded (5.93 and 3.75 *C. carnea* per plant) and Thiamethoxam (6.74 and 3.53 *C. carnea* per plant) after 1st and 2nd sprays. On the other side Spinoteram induced the lowest effect recording mean numbers of *C. carnea* (9.66 and 5.48 *C. carnea* per plant) after 1st and 2nd sprays.

With respect to the mean decrease % of *C. carnea* Table 9 Dimethoate showed a significant decrease in *C. carnea* compared to untreated plots after the two spraying, where it decreased to 60.85 and 69.33% after 1st and 2nd sprays, followed by imidacloprid and thiamethoxam which induced moderate decrease (% 53.85 and 48.15%) and (53.05 and 49.88%) after 1st and 2nd sprays, respectively. On contrary, Spiromesfen, Acetamprid, Chothinidin, Pymetrizine, and Spinoteram induced low mean decrease % on *C. carnea* population after1st and 2nd sprays, recording decrease percentages as 36.75, 43.70, 39.07, 35.21 and 25.41% , respectively after 1st and 33.49, 39.31, 32.86, 32.96 and 19.84% after 2nd sprays, respectively. Spintoram induced the lowest effect on *C. carnea* population, recording the lowest decrease percent after 1st and 2nd sprays as 60.9 and 69.3%.

Second season 2022: The effect of tested pesticides on the decrease % of *C. carnea* population is shown in Tables 8 and 9. It was obvious that the mean numbers of *C. carnea* (Table 8) were significantly decreased in treated pepper plants compared to control, while no significant differences among tested pesticides.

Dimethoate induced the highest decrease in mean numbers of *C. carnea* (2.71 and 2.98 *C. carnea* /plant) after 1st and 2nd sprays, while mean numbers of *C. carnea*

Table 6. Effect of two sprays of different pesticides against thrips stages infesting pepper plants along two month of spraying at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean numbers of thrips stages/ 3 leaves					
	Pre treatment	Days after spray (application)				Grand mean
		1	7	14	21	
season 2021						
Imidacloprid	8.1	4.1	3.5	2.9	2.1	3.2 b
	(5.3)	(2.1)	(2.1)	(2.4)	(1.7)	(2.1b)
Thiamethoxam	8.2	4.3	3.9	4.6	2.3	3.8 b
	(5.7)	(3.1)	(2.9)	(2.4)	(3.2)	(2.9 b)
Spiromesfen	8.5	4.1	5.0	3.9	4.5	4.4 b
	(6.2)	(2.8)	(3.2)	(4.3)	(4.4)	(3.7 b)
Acetamprid	9.2	6.3	6.2	5.4	4.9	5.7b
	(6.7)	(4.4)	(4.3)	(5.3)	(5.0)	(4.7 b)
Chothinidin	9.1	7.1	6.7	6.2	5.8	6.5 b
	(6.5)	(2.7)	(2.2)	(3.2)	(4.1)	(3.1b)
Pymetrizine	8.9	6.1	5.3	5.9	6.4	5.9 b
	(6.0)	(2.0)	(2.7)	(3.1)	(3.0)	(2.7b)
Spinoteram	9.4	4.2	4.1	4.0	5.0	4.32b
	(6.4)	(3.1)	(3.7)	(4.3)	(4.4)	(3.9 b)
Dimethoate	9.7	7.4	7.1	7.0	7.1	7.14b
	(6.4)	(5.3)	(5.1)	(4.8)	(4.0)	(4.8 b)
Control	9.1	9.9	15.1	29.5	41.3	24 a
	(12.8)	(13.1)	(27.2)	(31.3)	(43.9)	(28.9a)
LSD 5%						2(1.9)
season 2022						
Imidacloprid	8.2	2.1	2.3	2.6	3.0	2.5 c
	(5.4)	(2.2)	(2.9)	(3.2)	(3.9)	(3.1b)
Thiamethoxam	8.4	3.4	3.8	3.9	4.4	3.5bc
	(5.9)	(2.8)	(3.2)	(3.5)	(3.9)	(3.5 b)
Spiromesfen	8.9	4.9	5.3	5.7	3.0	4.7 bc
	(5.8)	(3.7)	(3.9)	(4.2)	-5	(4.2 b)
Acetamprid	9.3	3.2	4.2	4.2	4.4	4 bc
	(6.4)	(4.3)	(4.8)	(5.0)	(5.2)	(4.8 b)
Chothinidin	9.1	4.5	4.6	5.7	6.1	5.2 bc
	(6.1)	(3.8)	(4.6)	(5.2)	(5.9)	(4.9 b)
Pymetrizine	9.7	5.2	6.0	6.0	6.3	5.8 b
	(5.9)	(4.3)	(4.8)	(5.3)	(6.0)	(5.1 b)
Spinoteram	8.9	2.7	3.8	4.2	4.6	3.8 bc
	(6.4)	(3.1)	(3.4)	(4.2)	(4.4)	(3.8 b)
Dimethoate	9.4	5.5	6.1	6.4	6.2	6.1b
	(5.5)	(2.1)	(2.7)	(3.7)	(4.3)	(3.2 b)
Control	10.1	10.2	13.8	25.9	39.8	22.4a
	(13.7)	(13.9)	(19.4)	(33.1)	(44.2)	(27.7a)
LSD 5%						1.3 (1.5)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 7. Reduction percentages of thrips stages infesting pepper plants sprayed two times with different pesticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Reduction percentages of thrips									
	Days after spray				Grand mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	53.0	74.2	88.9	94.3	77.7	60.9	81.0	81.3	90.5	78.4
Thiamethoxam	51.8	71.3	78.0	94.0	73.8	46.0	75.8	82.6	83.5	72.0
Spiromesfen	55.8	64.7	85.9	88.4	73.7	60.2	75.8	83.4	84.7	76.0
Acetamprid	37.1	59.8	87.0	88.8	68.2	36.5	69.9	67.2	78.3	63.0
Chothinidin	28.3	55.7	79.2	86.0	62.3	59.0	78.2	79.8	81.5	74.6
Pymetrizine	36.9	64.3	79.5	84.1	66.2	67.6	78.6	78.7	52.7	69.4
Spinoteram	56.4	73.8	87.1	89.5	76.7	52.3	72.7	72.3	72.3	67.4
Dimethoate	30.2	55.8	77.9	83.9	65.0	26.2	58. 6	61.8	68.3	53.7
season 2022										
Imidacloprid	74.5	79.2	87.8	90.7	83.1	59.2	62.2	75.2	77.7	68.6
Thiamethoxam	37.7	67.3	81.9	86.7	68.4	52.8	62.3	75.7	79.5	67.6
Spiromesfen	62.0	69.1	82.9	87.4	75.3	37.4	52.5	70.2	73.5	58.4
Acetamprid	65.6	67.0	82.2	87.9	75.7	34.3	47.0	67.8	74.8	56.0
Chothinidin	51.4	62.8	75.4	82.8	68.1	38.1	46.5	64.8	70.0	54.8
Pymetrizine	46.8	55.4	75.9	83.6	65.4	27.7	42.2	62.6	68.6	50.3
Spinoteram	69.5	68.5	81.5	86.9	76.6	52.2	62.2	72.9	78.7	66.5
Dimethoate	41.9	52.2	73.6	81.7	62.4	62.4	65.2	72.0	76.1	68.9

ranged between (4.31-6.44) and (4.76-6.96) for other tested insecticides after 1st and 2nd sprays, respectively.

Dimethoate induced the highest mean decrease % (54.02 and 63.41%) in *C. carnea* population after 1st and 2nd sprays (Table 9). On contrast, the other tested pesticides exhibited low mean decrease %, ranged between (15.02-45.28%) and (12.50-41.01%) after 1st and 2nd sprays, respectively.

The lowest decrease % (15.02 and 12.50%) in *C. carnea* population was detected with Spinoteram after 1st and 2nd sprays.

In conclusion, the effect of all tested pesticides were ranged between moderate to low effect on *C. carnea* and Spinoteram induced the lowest mean decrease % after 1st and 2nd sprays during two pepper seasons, in contrast, Dimethoate was the most toxic compound .

Side effect of tested pesticides on rove beetle, *Paederus alfierii* :

Data in Tables 10 and 11 show the effect of tested pesticides on decrease % of *P. alfierii* population after two sprays at intervals 1,7,14 and 21 days during the two seasons compared to control.

First season 2021: The data in Table 10 revealed that there were no significant differences among tested pesticides on *P. alfierii* population, where there were significant difference between tested pesticides and control. Dimethoate induced the highest decrease on the mean number of *P. alfierii* population per plant, where the mean numbers were (1.58 and 1.87 *P. alfierii* / plant) after 1st and 2nd sprays.

It was clearly that nearly all tested pesticides had low effect on *P. alfierii* (Table 11), where the decrease % ranged between (12.88-38.47%) and (11.24 and 34.15%) after 1st and 2nd sprays, respectively. Dimethoate induced the highest effect recording decrease % (65.52 and 64.74%) after 1st and 2nd sprays. Spinoteram was the most safety compound where it induced the lowest mean decrease % (11.94 and 11.24%) of *P. alfierii* after 1st and 2nd sprays

Second season 2022: The data in Table 10 revealed that there was no significant difference between tested pesticides, whereas there were significant difference between pesticides and control. Dimethoate induced the highest decrease in the mean number of *P. alfierii* population (2.24and 2.43 *P. alfierii* / plant) after 1st and 2nd sprays.

All tested pesticides induced low decrease % in *P. alfierii*, where it ranged between (16.99 - 36.05%) and (18.02-35.18%) after 1st and 2nd sprays. On contrary, Dimethoate induced the highest effect on *P. alfierii*, where the mean decrease % was (59.23 and 58.38%) after 1st and 2nd sprays. Spinoteram induced the lowest decrease % (16.99 and 18.02%) on *P. alfierii* after 1st and 2nd sprays.

Table 8. Mean umbers of *Chrysoperla carnea* on pepper leaves after two sprays of insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean numbers of *Chrysoperla carnea* per plant					
	Pre treatment					Grand mean
			7	14	21	
			season 2021			
Imidacloprid	6.2	3.2	5.2	6.2	9.2	5.9 c
	(6.1)	(3.4)	(3.3)	(5.1)	(3.2)	(3.8bc)
Thiamethoxam	6.4	3.6	5.4	7.5	10.4	6.7 bc
	(6.2)	(3.6)	(3.4)	(3.6)	(3.5)	(3.5 bc)
Spiromesfen	6.7	4.2	6.3	7.4	12.5	7.6 bc
	(6.0)	(4.4)	(4.3)	(4.5)	(5.7)	(4.7 abc)
Acetamprid	6.3	3.9	5.9	3.7	11.8	6.3 bc
	(6.3)	(4.4)	(3.6)	(4.5)	(4.6)	(5.9 ab)
Chothinidin	6.8	4.0	6.0	4.1	12.9	6.7bc
	(6.2)	(3.9)	(4.3)	(4.8)	(5.9)	(4.7 abc)
Pymetrizine	6.8	4.6	6.5	4.4	13.6	7.3 bc
	(6.1)	(4.2)	(4.6)	(5.0)	(5.2)	(4.8 abc)
Spinoteram	7.0	5.3	7.4	10.6	15.3	9.7 b
	(6.2)	(5.4)	(5.5)	(5.6)	(5.4)	(5.5 ab)
Dimethoate	6.8	2.7	4.0	5.7	8.2	5.1 c
	(6.9)	(2.3)	(2.0)	(2.4)	(2.3)	(2.3 c)
Control	6.8	7.1	10.2	14.7	19.8	13 a
	(6.4)	(6.5)	(6.6)	(7.1)	(8.2)	(7.1 a)
LSD 5%						2.1 (1)
			season 2022			
Imidacloprid	7.0	3.4	3.2	4.5	5.3	4.0 b
	(6.3)	(3.5)	(4.3)	(5.2)	(6.0)	(4.8 bc)
Thiamethoxam	6.7	3.6	3.7	5.0	4.9	4.3 b
	(6.3)	(4.3)	(4.9)	(5.6)	(6.3)	(5.3 abc)
Spiromesfen	6.4	4.1	4.6	5.8	5.7	5.0ab
	(6.1)	(4.4)	(5.0)	(5.8)	(6.2)	(5.4 abc)
Acetamprid	6.2	3.9	4.4	4.9	5.5	4.7 b
	(6.3)	(4.5)	(4.9)	(5.5)	(5.6)	(5.2 abc)
Chothinidin	6.4	4.2	4.1	5.3	5.7	4.8 ab
	(6.1)	(4.4)	(5.1)	(6.0)	(7.0)	(5.6 abc)
Pymetrizine	6.2	5.3	5.5	6.3	6.2	5.8 ab
	(6.2)	(5.9)	(5.1)	(6.5)	(7.2)	(6.2 ab)
Spinoteram	6.5	5.7	6.0	7.1	7.0	6.4 ab
	(6.3)	(6.1)	(6.2)	(7.4)	(8.1)	(7.0 ab)
Dimethoate	6.8	2.0	3.1	2.4	3.3	2.7 b
	(6.3)	(2.3)	(2.5)	(3.2)	(4.0)	(3.0 c)
Control	6.4	6.9	7.3	8.0	9.0	7.8a
	(6.4)	(6.9)	(7.2)	(8.4)	(9.3)	(8.0 a)
LSD 5%						3.2 (1.8)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 9. Decrease percentages of *Chrysoperla carnea* stages on pepper leaves after two sprays of different insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Decrease percentages of *Chrysoperla carnea*									
	Days after spray				Grand Mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	54.5	49.3	57.8	53.8	53.9	47.2	50.6	53.4	61.0	53.1
Thiamethoxam	49.5	46.9	48.8	47.4	48.2	44.6	48.5	49.2	57.3	49.9
Spiromesfen	35.4	38.7	36.0	36.8	36.8	32.3	34.6	36.7	30.5	33.4
Acetamprid	45.0	42.0	47.4	40.5	43.7	32.4	45.3	36.4	43.7	39.3
Chothinidin	47.1	36.1	38.1	35.0	39.1	35.6	35.3	32.4	28.1	32.9
Pymetrizine	35.2	38.3	36.1	31.3	35.2	35.5	30.2	29.7	36.5	33.0
Spinoteram	25.2	27.3	27.1	22.1	25.4	19.5	16.7	21.2	21.9	19.8
Dimethoate	62.0	61.2	61.2	59.0	60.9	69.5	69.7	66.2	71.9	69.3
season 2022										
Imidacloprid	50.2	53.6	43.6	33.8	45.3	49.1	40.1	39.3	35.5	41.0
Thiamethoxam	47.3	46.3	37.3	38.6	42.4	37.5	31.5	32.9	32.6	33.6
Spiromesfen	36.3	34.2	27.5	28.5	31.6	35.9	30.6	30.8	33.7	32.8
Acetamprid	43.6	42.1	38.8	31.3	38.9	34.6	28.9	31.9	39.8	33.8
Chothinidin	39.1	33.4	33.6	28.8	33.5	37.0	23.9	29.9	24.7	28.7
Pymetrizine	23.0	20.3	21.1	22.9	21.8	21.2	21.2	22.6	22.5	21.9
Spinoteram	18.2	15.5	10.9	12.5	15.0	11.4	12.4	11.9	12.9	12.5
Dimethoate	18.2	69.5	69.9	58.5	54.0	66.7	64.8	61.9	60.3	63.4

Generally, all tested pesticides induced low side effects on *Paederus alfierii*, and Spinoteram induced the lowest mean decrease % after 1st and 2nd sprays during two pepper seasons except Dimethoate which exhibited the highest effect.

Side effect of pesticides on ladybird, *Coccinella* spp:

The side effect of two sprays of different pesticides, as a foliar treatment against *C.* spp at 1, 7, 14 and 21 days after spraying, and the reduction percentage along two sprays during 2021 and 2022 seasons is shown in Tables 12 and 13.

First season 2021: The effect of tested pesticides on the mean number of *C.* spp is shown in Table 12. The data revealed that there were significant differences between tested compounds and control. Whereas, there were no significant differences among tested compounds except Dimethoate which significantly differed compared with other tested compounds after 1st and 2nd sprays.

The lowest mean numbers of *C.* spp (2.28 and 6.41 *C.* spp / plant) were detected in Dimethoate after 1st and 2nd sprays.

All tested pesticides recorded low decrease percentages of *C.* spp populations, where it ranged between (18.73-38.31%) and (15.07-40.60%) after 1st and 2nd sprays. Moreover, Spinoteram recorded the lowest decrease % (18.73 and15.07%) after 1st and 2nd sprays. On contrary, Dimethoate revealed the highest mean decrease % (64.24 and59.48%) after 1st and 2nd sprays.

Second season 2022: The obtained results in Tables 12 and 13 recorded the side effect of tested pesticides on the mean numbers of *C.* spp at 1, 7, and 14 and 21 days after spraying, and the mean reduction percentages along two sprays of 2022 season. It was clear that the mean numbers of *C.* spp in all pesticides were significantly differed compared with control, where nearly, there were no significant differences among tested compounds after 1st and 2nd sprays except Dimethoate after 1st spray which significantly differed with other tested compounds.

The lowest mean numbers of *C.* spp (2.30 and 2.54 insect /plant) was recorded with Dimethoate after 1st and 2nd sprays

All tested pesticides recorded low mean decrease percentages of *C.* spp, where it ranged between (18.35-34.18%) and (15.07-40.60%) after 1st and 2nd sprays. Moreover, Spinoteram recorded the lowest mean of decrease % (18.35 and18.38%) after 1st and 2nd sprays. On contrary, Dimethoate revealed the highest mean decrease % (61.66 and 60.8%) after 1st and 2nd sprays.

5-Effect of tested pesticides on sweet pepper yield:

The data presented in Table 14 revealed that there were no significant difference between all treated plots, where there were significant dereferences between treated plots and control. All treated plots were significantly

Table 10. Mean numbers of *Paederus alfierii* on pepper leaves after two sprays of insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean numbers of *Paederus alfierii* per plant					
	Pre treatment	Days after spray (application)				Grand mean
		1	7	14	21	
season 2021						
Imidacloprid	4.3	2.9	2.3	3.2	3.3	2.9 ab
	(3.2)	(2.9)	(3.7)	(3.7)	(4.3)	(3.5 ab)
Thiamethoxam	4.4	2.5	2.9	3.1	3.2	2.9 ab
	(4.8)	(2.9)	(3.0)	(3.9)	(4.7)	(3.3)
Spiromesfen	4.5	3.5	3.6	3.7	3.6	3.6 ab
	(4.6)	(3.5)	(3.6)	(4.2)	(4.8)	(4 ab)
Acetamprid	4.3	3.0	3.4	3.7	3.5	3.4 ab
	(4.6)	(3.5)	(3.7)	(4.3)	(5.0)	(4.1 ab)
Chothinidin	4.4	3.1	3.9	2.9	4.0	3.5 ab
	(4.5)	(3.3)	(3.4)	(3.9)	(4.5)	(3.8ab)
Pymetrizine	4.6	3.0	3.8	4.0	4.0	3.70ab
	(4.7)	(3.5)	(2.7)	(4.3)	(5.0)	(3.9 ab)
Spinoteram	4.4	3.6	4.3	4.5	4.5	4.2 ab
	(4.7)	(4.2)	(4.4)	-5	(5.7)	(4.8 a)
Dimethoate	4.5	1.3	1.4	1.9	1.7	1.6 b
	(4.6)	(1.4)	(1.5)	(2.0)	(2.5)	(1.9 b)
Control	4.6	4.2	4.9	5.1	5.3	4.9 a
	(4.8)	(5.0)	(5.6)	(5.6)	(6.4)	(5.4 a)
LSD 5%						1.7 (1.71)
season 2022						
Imidacloprid	4.4	3.3	3.3	3.8	4.0	3.6 ab
	(4.7)	(3.8)	(4.0)	(4.5)	(5.1)	(4.4 ab)
Thiamethoxam	4.6	3.0	3.5	3.7	4.1	3.6 ab
	(4.7)	(3.5)	(3.9)	(4.4)	(4.8)	(4.2 ab)
Spiromesfen	4.6	3.7	3.6	4.0	4.6	4 ab
	(4.8)	(4.3)	(4.7)	(5.0)	(2.0)	(4.8 ab)
Acetamprid	4.4	3.8	3.6	3.9	4.52	4ab
	(4.5)	(4.2)	(4.3)	(4.8)	(5.2)	(4.6 ab)
Chothinidin	4.7	3.3	3.7	4.2	4.4	3.9 ab
	(4.6)	(4.8)	(5.2)	(5.2)	(5.6)	(5.1 a)
Pymetrizine	4.5	3.8	3.7	4.3	5.0	4.2 ab
	(4.2)	(4.9)	(4.2)	(4.9)	(5.4)	(4.7ab)
Spinoteram	4.7	4.1	4.2	4.7	5.2	4.5 ab
	(4.8)	(4.6)	(5.1)	(5.5)	(5.8)	(5.3 a)
Dimethoate	4.3	1.8	2.1	2.3	2.7	2.2 b
	(4.6)	(2.4)	(2.6)	(1.7)	(3.0)	(2.4 b)
Control	4.7	4.8	5.2	5.6	6.2	5.5 a
	(4.9)	(4.9)	(5.2)	(6.7)	(7.0)	(6 a)
LSD 5%						1.7 (1.5)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 11. Decrease percentages of *Paederus alfierii* stages on pepper leaves after two sprays of different insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Decrease percentages of *Paederus alfierii*									
	Days after spray				Grand mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	30.9	38.8	37.0	35.6	33.7	33.5	34.3	34.6	32.7	33.7
Thiamethoxam	40.4	40.8	39.3	33.4	38.5	39.7	39.4	30.3	27.2	34.2
Spiromesfen	16.9	27.1	28.4	29.8	25.5	26.8	27.0	25.1	24.6	25.9
Acetamprid	23.7	30.6	27.6	28.3	27.6	27.6	26.1	23.0	21.9	24.6
Chothinidin	26.4	20.2	23.3	21.9	23.1	31.2	31.1	31.0	29.7	30.8
Pymetrizine	21.6	22.2	21.7	21.7	21.8	27.0	25.7	23.4	21.9	24.5
Spinoteram	14.5	10.2	11.9	14.9	12.9	12.3	10.7	11.1	10.9	11.2
Dimethoate	68.9	71.4	62.8	66.9	65.5	68.4	69.3	60.8	60.5	64.7
season 2022										
Imidacloprid	31.2	36.2	32.0	35.6	33.8	36.3	35.8	32.6	27.1	33.0
Thiamethoxam	37.6	37.5	35.1	34	36.1	39.1	37.0	34.3	30.3	35.2
Spiromesfen	22.9	30.7	23.8	25.8	25.8	28.0	24.2	25.5	25.7	25.8
Acetamprid	20.8	31.1	30.4	27.2	27.4	29.0	30.8	28.5	25.9	28.5
Chothinidin	31.4	28.2	25.3	22.9	26.9	22.3	22.7	27.5	20	23.1
Pymetrizine	22.0	25.0	23.3	19.5	22.5	29.8	32.6	27.3	22.6	28.1
Spinoteram	14.8	19.2	17.3	16.8	17.0	19.9	17.9	17.4	16.9	18.0
Dimethoate	62.0	59.7	58.9	56.4	59.2	59.4	58.1	58.7	57.1	58.4

recorded more fruit yield of pepper over control during both 2021 and 2022seasons. During first year 2021 the maximum yield of pepper (6.43 ton/fed) was obtained in the plots treated with imidacloprid, and thiamethoxam (6.21 ton/fed), Spinetoram (5.91ton/fed), acetamprid (5.75 ton/fed), Dimethoate (5.61ton/fed), chothinidin (5.51 ton/fed), Spiromesfen (5.45 ton/fed) and pymetrizine (5.24 ton/fed) and these were statistically at par to each other and significantly superior to the untreated control and recording increase % 34.53, 32.21, 28.76, 26.78, 24.96, 23.59, 22.75, and 19.66% in yield over control , respectively. The minimum yield (5.24 ton/fed) was obtained in the plots treated with pymetrizine. Similarly, at 2022season the highest yield was also obtained in the plots treated with imidacloprid (6.52 ton/fed) followed by thiamethoxam (6.34 ton/fed), spinoteram (5.98 ton/fed), acetamiprid (5.91 ton/fed), Dimethoate (5.70 ton/fed), chothinidin (5.68 ton/fed) and Spiromesfen (5.58 ton/fed) and these were statistically at par to each other and significantly superior to the untreated control , recording increase % as 36.04, 34.22,. 30.27, 29.44, 26.84, 26.58, 25.29 and 21.76%, in yield over control. The minimum yield of 5.68 ton/fed was obtained in the plots treated with chothinidin.

Pooled data of both years also revealed that the maximum fruit yield of pepper fruits (12.9 tons/fed) was obtained in the plot treated with imidacloprid followed by thiamethoxam (12.6 ton/fed), spinoteram (11.9 ton/fed), acetamprid (11.7 ton/fed), Dimethoate (11.3 ton/fed), chothinidin (11.2 ton/fed), Spiromesfen (11.1 ton/fed) and pymetrizine (10.5 ton/fed), respectively and these were comparable to each other. Generally, all tested insecticides increased the yield of green pepper fruits compared with control, and Imidacloprid achieved the highest fruit yields.

4. Discussion

The obtained results are in agreement with El-Sayed (2013) who found that imidacloprid achieved a good decrease in the mean number of *Bemisia tabaci* and *Myzus persicae* 0.97 and 1.22, respectively. Also, Kumawat et al. (2015) revealed that two sprays of imidacloprid 17.8 SL was very effective against aphid, whitefly and jassid population and causing 91.05, 88.64 and 90.02% mean reduction. Also, Singh et al. (2004) and Bharpoda et al. (2014) found that imidacloprid was the most effective insecticide between nine synthetic tested insecticides against *B. tabaci* in chilli plants. Kumawat (2015) reported that two applications of imidacloprid 17.8 SL at 22.5 g a.i. /ha was significantly effective and resulting in 88.64 mean reduction % in population of whiteflies. Sangle et al. (2017) found that imidacloprid, acetamiprid and triazophos were

Table 12. Mean numbers of *Coccinella* spp on pepper leaves after two sprays of different insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray (Second spray)					
	Mean numbers of *Coccinella* spp per plant					
	Pre treatment	Days after spray (application)				Grand mean
		1	7	14	21	
2021 season						
Imidacloprid	5.5	3.9	4.0	4.4	4.9	4.3b
	(5.3)	(4.0)	(4.2)	(4.5)	(4.9)	(4.4 bc)
Thiamethoxam	5.9	3.1	3.6	4.2	4.7	3.9 b
	(5.7)	(3.3)	(3.6)	(4.1)	(4.7)	(3.9e)
Spiromesfen	5.9	4.0	4.2	4.7	5.2	4.5 b
	(5.6)	(3.0)	(4.3)	(4.9)	(5.4)	(4.4 bc)
Acetamprid	5.5	3.9	4.1	4.6	5.1	4.4 b
	(5.3)	(3.7)	(4.1)	(4.9)	(5.4)	(4.5 bc)
Chothinidin	5.5	4.2	4.3	5.1	5.7	4.8 ab
	(5.3)	(4.1)	(4.5)	(4.9)	(5.6)	(4.8 bc)
Pymetrizine	5.3	3.6	4.0	4.8	5.0	4.4 b
	(5.1)	(3.7)	(4.0)	(4.4)	(4.9)	(4.2 bc)
Spinoteram	5.6	4.4	4.2	5.3	6.0	5 ab
	(5.6)	(4.8)	(5.2)	(5.8)	(6.5)	(5.6 ab)
Dimethoate	5.5	1.7	2.0	2.4	3.0	2.3c
	(5.5)	(2.2)	(2.4)	(3.0)	(3.1)	(2.7 d)
Control	5.6	5.7	6.0	6.5	7.1	6.3 a
	(5.8)	(5.8)	(6.1)	(6.9)	(6.8)	(6.4 a)
LSD 5%						1.2 (1)
2022 season						
Imidacloprid	5.2	3.4	3.8	4.6	4.8	4.1b
	(5.2)	(3.7)	(3.9)	(4.4)	(3.6)	(3.9 ab)
Thiamethoxam	5.2	3.0	3.3	4.3	4.6	3.8 b
	(5.3)	(3.3)	(3.4)	(4.0)	(4.5)	(3.8 ab)
Spiromesfen	5.5	3.7	4.0	5.0	5.2	4.5 ab
	(5.4)	(3.9)	(4.1)	(4.6)	(5.2)	(4.5 ab)
Acetamprid	5.3	3.6	4.0	5.2	5.4	4.6ab
	(5.1)	(3.9)	(4.2)	(4.8)	(5.6)	(4.6 ab)
Chothinidin	5.4	4.0	4.4	5.3	5.6	4.8ab
	(5.1)	(4.3)	(4.5)	(5.0)	(5.5)	(4.8ab)
Pymetrizine	5.2	3.2	3.6	4.7	5.0	4.1 b
	(5.2)	(3.6)	(3.8)	(4.3)	(5.0)	(4.2 ab)
Spinoteram	5.2	3.8	4.6	5.9	6	5.1ab
	(5.2)	(4.3)	(4.9)	(5.5)	(6.0)	(5.1 ab)
Dimethoate	5.1	1.8	2.0	2.4	3.0	2.3 c
	(5.5)	(1.9)	(2.3)	(2.6)	(3.0)	(2.5 b)
Control	5.2	5.2	5.6	7.0	7.1	6.2 a
	(5.6)	(5.6)	(5.9)	(6.4)	(7.2)	(6.3 a)
LSD 5%						1.3 (1.6)

Means in column followed by different letter(s) are significantly different at 5% level.

Table 13. Decrease percentages of *Coccinella* spp populations on pepper leaves after two sprays of different insecticides at 2021 and 2022 seasons under open field conditions.

Pesticides	First spray					Second spray				
	Decrease % of *Coccinella* spp									
	Days after spray				Grand mean	Days after spray				Grand mean
	1	7	14	21		1	7	14	21	
season 2021										
Imidacloprid	31.2	32.1	32.4	31.3	31.7	31.2	31.0	34.5	32.3	32.2
Thiamethoxam	45.3	38.5	35.6	33.8	38.3	43.0	41.6	40.6	37.2	40.6
Spiromesfen	29.6	28.7	27.9	26.3	28.1	31.1	29.2	29.0	27.0	29.1
Acetamprid	30.9	30.1	29.1	28.2	29.7	35.8	32.3	29.1	26.9	31.0
Chothinidin	25.8	25.3	21.9	19.0	23.0	29.3	26.2	27.7	24.2	26.8
Pymetrizine	36.2	32.3	31.0	29.4	32.2	37.0	43.4	35.9	34.5	37.7
Spinoteram	22.4	20.2	18.3	14.1	18.7	17.4	14.9	15.8	12.2	15.1
Dimethoate	69.8	66.2	63.0	57.9	64.2	62.8	60.5	56.5	58.1	59.5
season 2022										
Imidacloprid	35.0	33.2	34.0	33.3	33.9	35.1	33.6	31.5	30.5	32.7
Thiamethoxam	42.6	41.2	38.1	36.1	39.5	42.4	41.9	38.4	37.3	40.0
Spiromesfen	30.2	28.7	28.4	26.8	30.8	31.0	29.8	28.2	27.3	29.1
Acetamprid	31.9	28.9	25.4	23.9	27.5	30.7	28.6	26.0	24.2	27.4
Chothinidin	23.5	22.5	23.6	20.7	22.6	24.7	23.3	22.6	24.1	23.7
Pymetrizine	38.6	35.7	32.5	29.9	34.2	37.1	35.3	33.8	30.0	34.0
Spinoteram	23.7	17.8	16.2	15.7	18.4	24.7	17.2	15.1	16.6	18.4
Dimethoate	66.5	64.4	57.9	57.9	61.7	65.8	60.8	59.2	58.4	60.8

Table 14. Effect of tested pesticides on pepper yields at 2021 and 2022 seasons under open field conditions.

Pesticides	Yield (ton/feddan 4200m^2)			Yield increase %	
	season 2021	season 2022	Pooled	season 2021	Season 2022
Imidacloprid	6.4 a	6.5 a	12.9 a	34.5	36.0
Thiamethoxam	6.2 a	6.3 a	12.6 a	32.2	34.2
Spiromesfen	5.5 a	5.6 a	11.1 a	22.8	25.3
Acetamprid	5.8 a	5.9 a	11.7 a	26.8	29.4
Chothinidin	5.5 a	5.7 a	11.2 a	23.6	26.6
Pymetrizine	5.2 a	5.3 a	10.5 a	19.7	21.7
Spinoteram	5.9 a	6.0 a	11.9 a	28.8	30.3
Dimethoate	5.6 a	5.7 a	11.3 a	25.0	26.8
Control	3.2 b	3.2 b	6.4 b	-	-
LSD 5%	1.3	1.7	1.7	-	-

the most effective tested insecticides against sucking insects viz., thrips (*Scirtothrips dorsalis*) and whitefly (*Bemisia tabaci*) in green chilli plants and the effectiveness of imidacloprid noticed against *S. dorsalis.*). Sarkar et al. (2013), Tukaram et al. (2017) and Mandi and Senapati (2009) reported that the thrips, population infesting chilli plants were effectively minimized by acetamiprid 20 SP and thiamethoxam 25 WG. Samota et al. (2017) found that acetamiprid was the most effective treatment against thrips population in chilli plants followed by

thiamethoxam, imidacloprid, fipronil. Guruprasad et al. (2019) found that spinetoram 12% SC effective reduced the thrips population and increased the fruit yield, moreover, it aceived low adverse effect on natural enemies in grape. Seal et al. (2006) reported that chlorfenapyr, spinosad, imidacloprid, and abamectin significantly reduced the larval populations of *S. dorsalis*.

Ameta and Sharma (2005) reported that imidacloprid 70 WG at 35 g a. i. /ha recorded the highest reduction in the population of aphids. Also, Sahoo (2012) reported that Imidacloprid and Thiamethoxam were found the most effective against mustard aphid Bengal under field condition. Similarly, Faheem et al. (2010) found that imidacloprid, endosulfan , and profenofos were found to be effective against cabbage aphid and resulted in 90.41, 77.01, and 69.84% efficacy, respectively. Abd-Ella (2013) and Ghelani et al. (2014) reported that flonicamid, acetamiprid, imidacloprid and dinotefuran were effectiveness against cotton aphids. El-Naggar and Zidan (2013) found that imidacloprid and thiamethoxam achieved high efficiency against *B. tabaci* and *A. gossypii* on cotton. Patil et al. (2014) reported that, thiamethoxam 25 WG @ 0.006% decreased aphids, leaf hoppers and whitefly population effectively on okra. Gaikwad et al. (2014) reported that, thiamethoxam 25WG @ 75 g a.i.ha^{-1} achieved high decrease in aphids and White flies recording percent reduction of 92.95% and 99.47% of and 83.80% and 96.67% of, respectively in first and second spray. Kumawat (2015) found that two applications of imidacloprid 17.8 SL at 22.5 g a.i. /ha proved significantly superior over all other treatments as it resulted in 91.05 mean reduction % in population of aphids. Gaber et al. (2015) found that the foliar application of neonicotinoid insecticides thiamethoxam, dinotefuran, acetamiprid and imidacloprid were the most effective insecticides in reducing cotton aphid *A. gossypii* population up to 21 days after treatment throughout two seasons and caused an average reduction percentage ranged from 73.58 to 96.42%. Also, Kumar et al. (2017) reported that Thiamethoxam 25WG @ 100g/ha-1was found most effective insecticide in reducing the population of whitefly followed by imidacloprid17.8 SL @ 100 ml/ha. El-Dewy et al. (2018) proved that imidacloprid, flonicamid and dinotefuran were recorded the highest mean reduction of aphids (92.95, 86.36 and 76.16%) at 2017 and (90.95, 82.48 and 78.44%) at 2018 season. El-Sherbeni et al. (2018) reported that imidacloprid and thiamethoxam recording reduction % ranged from 83.28 – 93.27% in *A. gossypii* infestation in cotton plants. Moreover, Karthik et al. (2020) reported that thiamethoxam 25% WG 25 g a.i. /ha were highly effective against aphid, whitefly and leaf hoppers after first and second spray, respectively. Shonga and Getu (2021) found that imidacloprid were the best treatment efficacy for cabbage aphid with 91.04% and the maximum leaf yield was obtained from imidacloprid (14.18 t/ha). Choudhary et al. (2022) found that application of spinosad @70 g a.i. /ha, Emamectin benzoate 5 sg@11 g a.i./ha, Imidacloprid 200 sl @40 g a.i./ha and Fipronil 5 SC @30 g a.i./ha were effective against thrips (*Scirtothrips dorsalis*) in chilli. Also, Al Dhafar et al. (2023) reported that Thiomethoxam insecticide achieved a high effect on the whitefly in its various stages, and at the same time it was safe for the environment and non-target organisms. This study recommended its safe use to control this insect.

With respect to the side effect of tested pesticides on natural enemies, the obtained results are in agreement with Aina Atirah et al. (2017) reported that neonicotinoid insecticides are more effective against insects and also relatively non-toxic to non-target species and very effective in control sucking insects. El-Zahi and Arif, (2011) found that imidacloprid was safely to insect predators. (Kumar et al. (2012). El-Dewy et al. (2018) reported that flonicamid, imidacloprid and dinotefuran have high activity against *Aphis gossypii* and *Bemisia tabaci*. Also, they were less harmful to the tested predators on cotton plants under field conditions. So, these insecticides represent an important choice to use in IPM programs to control these pests in cotton fields. Gaber et al. (2015) found that acetamiprid and dinotefuran induced reduction percent ranged from 28.28 to 56.52% in the population of *C. carnea*. Whereas, thiamethoxam and imidacloprid induced reduction percent ranged from 55.53 and 64.39%, on contrast, malathion and pirimicarb induced the highest reduction percent in the population which ranged from 67.15 to 96.57% during both seasons (Jansen 2000; Cabral et al., 2008; Jansen et al., 2011; Bacci et al., 2012).

Varghese and Mathew (2013) found that Spiromesifen was safely against natural enemies, where, dimethoate 30 EC 300 g a.i. ha^{-1} was unsafe to natural enemies. Guruprasad et al. (2019) reported that spinetoram 12% SC found to be effective in reducing the thrips population and also achieved higher fruit yield with low adverse effect on natural enemies build up like *Coccinellids* in grape. Choudhary et al. (2022) found that spinosad @70 g a.i./ha, Emamectin benzoate 5 sg@11 g a.i./ha, Imidacloprid 200 SL @40 g a.i./ha and Fipronil 5 SC @30 g a.i./ha were effective against thrips (*Scirtothrips dorsalis*) in chilli. Thus, Spinosad, Emamectin benzoate, Fipronil and Imidacloprid are recommended to manage *S. dorsalis* on rotational basis in chilli ecosystem. El-Sherbeni et al. (2018) reported that Flonicamid, Emamectin-benzoate, Imidacloprid and Thiamethoxam were the least harmful to the associated predators in cotton plants causing less than 50% mortality.

As for the effect of tested pesticides on sweet pepper yield the obtained results were in agreement with Sangle et al. (2017) who found that imidacloprid recorded the highest green chilli fruit yield (110.25 q/ha) followed by thiamethoxam (106.55 q/ha), triazophos (103.79 q/ha) and acetamiprid (102.91 q/ha), also, Manjunath et al. (2000) found that imidacloprid treatment showed significant reduction in mite population and higher yields in chilli. Kumar et al. (2017) reported the highest marketable yield of Chilli in imidacloprid treated plot. Also, Ghosh et al. (2009) reported that 54.03 and 53.20% increase in chilli yield over control were recorded in thiamethoxam and acetamiprid treated plots, respectively. Kumawat et al. (2015) found that Imidacloprid 17.8 SL at 22.5 g a.i./ha sprayed twice recorded significant increase in marketable yield of chilli (117.08 q/ha), while, the highest fruit yield (126.14 q/ha) were obtained from thiamethoxam treated plots. Nitenpyram and thiamethoxam are highly effective for controlling the piercing sucking pests (mainly aphids, mirids, thrips and whiteflies) (Wettstein et al.,

2016; Zhang et al., 2016). Manjunath et al. (2000) reported that imidacloprid treatment showed significant reduction in mite population and higher yields in chilli. Guruprasad et al. (2019) reported that spinetoram 12% SC effectively reduced thrips population and recorded higher fruit yield , moreover it achieved low adverse effect on natural enemies build up like Coccinellids in grape. Finally, Shonga and Getu (2021) reported that imidacloprid was the best efficacy treatment against cabbage aphid with 91.04%.

5. Conclusion

The present study showed that the selected pesticides, which were divided into different chemical groups, were highly effective on the tested sucking insects, aphids, white fly, thrips that infect pepper plants. The selected pesticides were safer against natural enemies, *Chrysoperla carnea*, *Paederus alfierii* and *Coccinella* spp compared to the organophosphorus pesticide dimethoate, which produced a high level of inhibition against them. Regarding the effect on productivity, treatments with the tested pesticides resulted in an increase in sweet pepper yield compared to the control. So, it can be suggested to use the tested pesticides in integrated management programs for the tested sucking insects, as they were highly effective on sucking insects, safer against natural enemies, and also achieved an increase in yields.

References

ABD-ELLA, A.A., 2013. Toxicity and persistence of selected neonicotinoid insecticides on cowpea aphid, *Aphis gossypii* Koch (Homoptera: aphididae). *Archives of Phytopathology and Plant Protection*, vol. 47, no. 3, pp. 366-376. http://doi.org/10.1080/03235408.2013.809919.

AINA ATIRAH, S., RASDI, Z., ISMAIL, R. and SHAFIQ, S., 2017. Evaluation of selected insecticides against Whitefly (*Bemisia tabaci*) on brinjal crops and their effect on natural enemies. *Journal of Advances in Agriculture*, vol. 7, pp. 4.

AMETA, O.P. and SHARMA, K.C., 2005. Evaluation of confidor for the management of sucking insect pests of cotton. *Pestology*, vol. 29, pp. 35-40.

AL DHAFAR, Z.M., ABDEL RAZIK, M.A.A., OSMAN, M.A. and SWEELAM, M.E., 2023. Determination of thiamethoxam residues and dissipation kinetic in tomato plants and its efficacy against *Bemisia tabaci* under open field eco system. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 83, pp. e273105. http://doi.org/10.1590/1519-6984.273105 PMid:37493783.

BACCI, L., ROSADO, J.F., PICANCO, M.C., PEREIRA, E.J., SILVA, G.A. and MARTINS, J.C., 2012. Concentration-mortality responses of *Myzus persicae* and natural enemies to selected insecticides. *Journal of Environmental Science and Health*, vol. 47, no. 12, pp. 1930-1937. http://doi.org/10.1080/03601234.2012.676494 PMid:22755540.

BASS, C., PUINEAN, A.M., ZIMMER, C.T., DENHOLM, I., FIELD, L.M., FOSTER, S.P., GUTBROD, O., NAUEN, R., SLATER, R. and WILLIAMSON, M.S., 2014. The evolution of insecticide resistance in the peach potato aphid, *Myzus persicae. Insect Biochemistry and Molecular Biology*, vol. 51, pp. 41-51. http://doi.org/10.1016/j.ibmb.2014.05.003 PMid:24855024.

BERKE, T.G., BLACK, L.L., MORRIS, R.A., TALEKAR, N. S. and WANG, J. F., 2003. Suggested Cultural Practices for Sweet Pepper. *AVRDC - The World Vegetable Center*, no. 99-497R, 5 p.

BHARPODA, T.M., PATEL, N.B., THUMAR, R.K., BHATT, N.A., GHETIYA, L.V., PATEL, H.C. and BORAD, P.K., 2014. Evaluation of insecticides against sucking insect pests infesting Bt cotton BG-II. *The Bioscan*, vol. 9, no. 3, pp. 977-980.

BLACKMAN, R.L. and EASTOP, V.F., 2000. *Aphids on the World's Crops: An Information and Identification Guide*. Chichester: John Wiley & Sons, 466 p.

BROWN, J.K., 2010. Phylogenetic biology of the *Bemisia tabaci* sibling species group. In: P.A. STANSLY and S.E. NARANJO, eds. *Bionomics and Management of a Global Pest*. Amsterdam: Springer, pp. 31-67.

CABRAL, S., GARCIA, P. and SOARES, A.O., 2008. Effects of pirimicarb, buprofezin and pymetrozine on survival, development and reproduction of Coccinella undecimpunctata (Coleoptera: coccinellidae). *Biocontrol Science and Technology*, vol. 18, no. 3, pp. 307-318. http://doi.org/10.1080/09583150801902072.

CHOUDHARY, J.S., KUMAR, M.R., RAGHAV, D.K. and KUMAR, A., 2022. Field efficacy of insecticides against chilli thrips (Scirtothrips dorsalis) and their effect on coccinellids. Singh. *Indian Journal of Agricultural Sciences*, vol. 92, no. 10, pp. 1196-1201. https://doi.org/10.56093/ijas.v92i10.121815.

COSTAT, 2008. *COSTAT 6.400 Statistical CoHort Software program, Copyright © 1998- 2008 CoHort Software*. Monterey: COSTAT.

EL-DEWY, M.E.H., SADEK, A.S. and EL-SARAND, E.A., 2018. Impact of synthetic insecticides against *Aphis gossypii* Glover, Bemisia Tabaci (Genn.) and their associated predators on cotton plants. *Alexandria Science Exchange Journal*, vol. 39, no. 4, pp. 669-675.

EL-NAGGAR, J.B. and ZIDAN, N.A., 2013. Field evaluation of imidacloprid and thiamethoxam against sucking insects and their side effects on soil fauna. *Journal of Plant Protection Research*, vol. 53, no. 4, pp. 375-387. http://doi.org/10.2478/jppr-2013-0056.

EL-SAYED, W., 2013. Field evaluation of plant extracts and certain insecticides against *Bemesia tabaci* (Gennadius) on tomato plants and *Myzus persicae* (Sulzer) on pepper plants. *Journal of Applied Sciences Research*, vol. 9, no. 3, pp. 2372-2377.

EL-SHERBENI, A.D., HAMED, S.A., EL-ZAHI, E.S. and KORISH, S.K.M., 2018. Efficacy of some Novel and Conventional Insecticides against *Aphis gossypii* Glover and their Side Effects on Non-Targeted Organisms and Plant Defense Enzymes of Cotton Plants. *Journal of Plant Protection and Pathology*, vol. 9, no. 6, pp. 343-350. http://doi.org/10.21608/jppp.2018.41675.

EL-ZAHI, E.S. and ARIF, S.A., 2011. Field evaluation of recommended insecticides to control bollworms on cotton aphid, *Aphis gossypii* and their side effects on associated predators. *Journal of Pest Control and Environment Sciences*, vol. 19, pp. 55-68.

FAHEEM, M., MUHAMMAD, A., FARZANA, P., NIKHAT, Y. and MUHAMMAD, F., 2010. Comparative management of cabbage aphid (*Myzus persicae*) through bio- and synthetic insecticides. *Pakistan Entomologist*, vol. 32, pp. 12-17.

GABER, A.S., ABD-ELLA, A.A., ABOU-ELHAGAG, G.H. and ABDEL RAHMAN, Y.A., 2015. Field efficiency and selectivity effects of selected insecticides on cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) and its predators. *Journal of Phytopathology and Pest Mgt*, vol. 2, no. 11, pp. 22-35.

GAIKWAD, B.B., SHETGAR, S.S., SONKAMBLE, M.M., BHOSLE, A.B. and SHINDE, S.T., 2014. Efficacy of different insecticides against population of lady bird beetle on safflower. *Journal of Entomological Research*, vol. 38, no. 2, pp. 129-130.

GHELANI, M.K., KABARIA, B.B. and CHHODAVADIA, S.K., 2014. Field efficacy of various insecticides against major sucking pests of Bt cotton. *Journal of Biopesticides*, vol. 7, pp. 27-32.

GHOSH, A., CHATTERJEE, M.L., CHAKRABORTI, K. and SAMANTA, A., 2009. Field evaluation of insecticides against chilli thrips (*Scirtothrips dorsalis* Hood). *Annals of Plant Protection Sciences*, vol. 17, no. 1, pp. 69-71.

GURUPRASAD G. S., SHIVAYOGIYAPPA, GANGARAJU, P., NEGALUR, R., PRAMESH, D. and GOUDAR, S.B., 2019. Efficacy of Spinetoram 12% SC against thrips on grape. *Journal of Entomology and Zoology Studies*, vol. 7, no. 6, pp. 746-749.

HENDERSON, C.F. and TILTON, E.W., 1955. Tests with acaricides against the brow wheat mite. *Journal of Economic Entomology*, vol. 48, no. 2, pp. 157-161. http://doi.org/10.1093/jee/48.2.157.

JANSEN, J.P., 2000. A three-year field study on the short-term effects of insecticides used to control cereal aphids on plant-dwelling aphid predators in winter wheat. *Pest Management Science*, vol. 56, no. 6, pp. 533-539. http://doi.org/10.1002/(SICI)1526-4998(200006)56:6<533::AID-PS165>3.0.CO;2-S.

JANSEN, J.P., DEFRANCE, T. and WARNIER, A.M., 2011. Side effects of flonicamide and pymetrozine on five aphid natural enemy species. *Biological Control*, vol. 56, pp. 759-770.

KARTHIK, P., VINOTHKUMAR, B. and KUTTALAM, S., 2020. Field Evaluation of Thiamethoxam 25 WG against Sucking Pests in Okra. *Madras Agricultural Journal*, vol. 107, no. 7-9, pp. 307-313. http://doi.org/10.29321/MAJ.2020.000375.

KUMAR, A., SACHAN, S.K., KUMAR, S. and KUMAR, P., 2017. Efficacy of some novel insecticides against whitefly Bemisia tabaci(Gennadius) in brinjal. *Journal of Entomology and Zoology Studies*, vol. 5, no. 3, pp. 424-427.

KUMAR, R., KRANTHI, S., NITHARWAL, M., JAT, S.L. and MONGA, D., 2012. Influence of pesticides and application methods on pest and predatory arthropods associated with cotton. *Phytoparasitica*, vol. 40, no. 5, pp. 417-424. http://doi.org/10.1007/s12600-012-0241-5.

KUMAWAT, M., SHARMAU, S., LAL, J. and NAGAR, R., 2015. Bio-efficacy of some insecticides against insect pests of chilli. *Indian Journal of Applied Entomology*, vol. 29, no. 2, pp. 132-137.

MANDI, N. and SENAPATI, A.K., 2009. Integration of chemical, botanical and microbial insecticides for the control of thrips, *Scirtothrips dorsalis* infesting chilli. *Journal of Plant Protection Sciences*, vol. 1, no. 1, pp. 92-95.

MANJUNATH, M., MALLAPUR, C.P. and HANCHINAL, S.G., 2000. *Journal of Agricultural Sciences*, vol. 13, no. 4, pp. 993-995.

PALUMBO, J.C., 2009. Spray timing of spiromesifen and buprofezin for managing Bemisia whiteflies in cantaloupes. *Plant Health Progress*, vol. 88, pp. 1393-1400.

PATIL, S.R., LANDE, G.K., AWASTHI, S. and BARKHADE, U.P., 2014. Effect of different doses of newer insecticides against sucking pests of okra. *The Bioscan*, vol. 9, no. 4, pp. 1597-1600.

PEREIRA, M.F., BOIÇA JUNIOR, A.L. and BARBOSA, J.C., 2004. Spatial distribution of *Bemisia tabaci* (Genn.) biotype B (Hemiptera: Aleyrodidae) in common bean (*Phaseolus vulgaris* L.)]. *Neotropical Entomology*, vol. 33, pp. 493-498. http://doi.org/10.1590/S1519-566X2004000400015.

PRASANNA, A.R., BHEEMANNA, M. and PATIL, B.V., 2004. Evaluation of thiamethoxam 70 WS as seed treatment against leaf miner and early sucking pests on hybrid cotton. *Karnataka Journal of Agricultural Sciences*, vol. 17, pp. 238-241.

REDDY, A.V., SREEHARI, G.S.R. and KUMAR, A.K., 2005. Evaluation of certain new insecticides against *chilli thrips* (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemus latus*). *Research on Crops*, vol. 6, no. 3, pp. 625-626.

SAHOO, S., 2012. Incidence and management of mustard aphid (*Lipaphis erysimi* K.) in West Bengal. *Journal of Plant Protection Sciences*, vol. 4, pp. 20-26.

SAMOTA, R.G., JAT, B.L. and CHOUDHARY, M. D., 2017. Efficacy of newer insecticides and biopesticides against thrips, *Scirtothrips dorsalis* Hood in chilli. *Journal of Pharmacognosy and Phytochemistry*, vol. 6, no. 4, pp. 1458-1462.

SANGLE P.M., PAWAR, S.R., ANTU, M., and KORAT, D.M., 2017. Bio-efficacy studies of newer insecticides against sucking insects pests on chilli, *Capsicum annum* L. *Journal of Entomology and Zoology Studies*, vol. 5, no. 6, pp. 476-480.

SARKAR, P.K., TIMSINA, G.P., VANLALDIKI, H. and CHAKRABORTY, S., 2013. Arylpyrroleacaro insecticide Chlorfenapyr - a tool for managing yellow thrips and broad mite of chilli. *Journal of Crop and Weed*, vol. 9, no. 1, pp. 188-192.

SEAL, D.R., CIOMPERLIK, M., RICHARDS, M.L. and KLASSEN, W., 2006. Comparative effectiveness of chemical insecticides against the chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), on pepper and compatibility with natural enemies. *Crop Protection (Guildford, Surrey)*, vol. 25, no. 9, pp. 949-955. http://doi.org/10.1016/j.cropro.2005.12.008.

SHI, K., JIANG, L., WANG, H., QIAO, K., WANG, D. and WANG, K., 2011. Toxicities and sublethal effects of seven neonicotinoid insecticides on survival, growth and reproduction of imidacloprid resistant cotton aphid, *Aphis gossypii. Pest Management Science*, vol. 67, no. 12, pp. 1528-1533. http://doi.org/10.1002/ps.2207 PMid:21714058.

SHONGA, E. and GETU, E., 2021. Efficacy of plant derived and synthetic insecticides against cabbage aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) and their effect on coccinellid predators. *Sinet. An Ethiopian Journal of Science*, vol. 44, no. 1, pp. 27-37. http://doi.org/10.4314/sinet.v44i1.3.

SIEBERT, M.W., THOMAS, J.D., NOLTING, S.P., LEONARD, B.R., GORE, J., CATCHOT, A., LORENZ, G.M., STEWART, S.D., COOK, D.R., WALTON, L.C., LASSITER, R.B., HAYGOOD, R.A. and SIEBERT, J.D., 2012. Field Evaluations of Sulfoxaflor: A Novel Insecticide, Against Tarnished Plant Bug (Hemiptera: Miridae) in Cotton. *Journal of Cotton Science*, vol. 16, pp. 129-143.

SIMKHADA, R. and PANERU, R.B., 2010. Efficacy of pesticides against major pest of tomato grown at plastic house condition in the mid-hills of Nepal: a case of Kaski, Naudada. *Journal of the Institute of Agriculture and Animal Science*, vol. 31, pp. 63-68.

SINGH, S.W.A.R.O.O.P., CHOUDHARY, D.P. and MATHUR, Y.S., 2004. Efficacy of insecticides against whitefly, *Bemisia tabaci* on chilli, *Capsicum annum. Indian Journal of Entomology*, vol. 66, pp. 316-318.

SORENSEN, K.A., 2005 [viewed 9 March 2024]. *Vegetable insect pest management*. CES.NCSU. Availble from: www.ces.ncsu.edu /depts./ent/ notes / vegetables /veg37.html- 11k.

SOUZA, I.L., TOMAZELLA, V.B., SANTOS, A.J.N., MORAES, T. and SILVEIRA, L.C.P., 2019. Parasitoids diversity in organic Sweet Pepper (*Capsicum annuum*) associated with Basil (*Ocimum basilicum*) and Marigold (*Tagetes erecta*). *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 79, no. 4, pp. 603-611. http://doi.org/10.1590/1519-6984.185417 PMid:30540103.

SUNITHA, T.R., 2007. *Insect pests of Capsicum annuum var. frutescens (L.) and their management*. Dharwad: University of Agricultural Sciences. Master thesis.

THORAT, S.S., SUSHIL, K. and PATEL, J.D., 2020. Bio efficacy of different pesticides against whitefly (*Bemisia tabaci* Gennadius)

in tomato. *Journal of Entomology and Zoology Studies*, vol. 8, no. 4, pp. 1428-1431.

TUKARAM, C.V., KARNATAK, A.K. and SRIVASTAVA, R.M., 2017. Bio efficacy of newer insecticides molecules against pest complex of chilli. *Octa Journal of Environmental Research*, vol. 5, no. 2, pp. 129-139.

VARGHESE, T.S. and MATHEW, T.B., 2013. Bio efficacy and safety evaluation of newer insecticides and acaricides against chilli thrips and mites. *Journal of Tropical Agriculture*, vol. 51, no. 1-2, pp. 111-115.

VOS, J.G.M. and FRINKING, H.D., 1998. Pests and disease of hot pepper (Capsicum spp.) in tropical low lands of Java, Indonesia. *Journal of Plant Protection Tropical*, vol. 11, pp. 53-71.

WETTSTEIN, F.E., KASTEEL, R., DELGADO, M.F.G., HANKE, I., HUNTSCHA, S., BALMER, M.E., POIGER, T. and BUCHELI, T.D., 2016. Leaching of the neonicotinoids thiamethoxam and imidacloprid from sugar beet seed dressings to subsurface tile drains. *Journal of Agricultural and Food Chemistry*, vol. 64, no. 33, pp. 6407-6415. http://doi.org/10.1021/acs.jafc.6b02619 PMid:27529118.

ZHANG, Z., ZHANG, X., WANG, Y., ZHAO, Y., LIN, J., LIU, F. and MU, W., 2016. Nitenpyram, dinotefuran, and thiamethoxam used as seed treatments act as efficient controls against *Aphis gossypii* via high residues in cotton leaves. *Journal of Agricultural and Food Chemistry*, vol. 64, no. 49, pp. 9276-9285. http://doi.org/10.1021/acs.jafc.6b03430 PMid:27960287.