Effectiveness of Certain Insecticides Against Cotton Aphid, *Aphis Gossypii* and Their Adverse Impacts on Two Natural Enemies

Sahar E. Eldesouky
Department of Cotton Pesticides Evaluation, Plant Protection Research Institute, Agricultural Research Center, El-Sabhia, Alexandria, Egypt
E-mail: Sahar_Eldesouky@yahoo.com
ID orcid: orcid.org/0000-0003-4823-9013

Abstract: Efficacy of flonicamid, pyriproxyfen and buprofezin against the field strain of cotton aphid, *Aphis gossypii* adults was tested under laboratory and field conditions. The joint toxic action of flonicamid with pyriproxyfen or buprofezin was also evaluated. The adverse effects of these insecticides on two natural enemies, *Coccinella undecimpuctata* (Linnaeus) (Coleoptera: Coccinellidae) and *Chrysoperla carnea* (Stephens) (Neuroptera: Crysopidae) were also assessed in the field during 2017 and 2018 cotton seasons. Under laboratory conditions, flonicamid was the most toxic followed by pyriproxyfen and buprofezin with LC_{50} values 0.58, 3.42 and 4.26 mg L^{-1}, respectively. Potentiating effect was obtained when flonicamid at LC_{25} was mixed with pyriproxyfen or buprofezin each at LC_{25} and LC_{10} with co-toxicity factors ranged from 23.08 to 37.52. Mixtures of flonicamid at LC_{10} with pyriproxyfen or buprofezin at LC_{25} gave an additive effect with co-toxicity factors 18.16 and 10.02, respectively. The highest mean reduction percentages of *A. gossypii* were achieved by flonicamid/pyriproxyfen mixture (90.45 and 87.15%) followed by flonicamid/buprofezin mixture (87.47 and 81.34%) and flonicamid (84.31 and 77.89%) in both seasons 2017 and 2018, respectively. All insecticide treatments were classified as harmless or slightly harmful on *C. undecimpuctata* and *C. carnea* in the two seasons. Finally, the obtained results indicated that flonicamid and its binary mixtures with pyriproxyfen or buprofezin could be considered as promising candidates for the management of *A. gossypii* because of their higher efficacy and lower toxicity on associated natural enemies.

Keywords: flonicamid, pyriproxyfen, buprofezin, cotton aphid, adverse effects.

1.Introduction

Cotton aphid, *Aphis gossypii* (Glover) (Homoptera: Aphididae), is an important polyphagous pest on cotton, many of the field crops and vegetables worldwide **(Konar *et al.*, 2013; Ahmad *et al.*, 2016)**. It causes serious damage and threat to cotton plants through sucking phloem sap, causing crinkled, wilted leaves and hindering plant growth, beside honeydew production and virus transmission **(Leclant and Denguine, 1994)**. The excretion of honeydew causes a condition known as “sticky cotton”, reduce yield and quality of cotton fibers, and cause problems during fiber processing and spin manufacturing **(Denguine *et al.*, 2000)**. In addition, honeydew acts as a medium for the sooty mold fungus growth that diminishes the photosynthetic activity and thus plants lose their vigor and growth becomes stunted **(Sarwar *et al.*, 2014)**.

On a hand, pesticides remain a very important component among the strategies for effective control of cotton aphid. On the other hand, the continuous and unwise uses of pesticides resulted in the development of resistance, particularly to pyrethroids and neonicotinoids **(Wang *et al.*, 2002; Mushtaq and Arif, 2008)**. To counteract the resistance problem and achieving an effective control with lower doses of used insecticides many researchers resorted to the insecticide mixtures with other control agents such as IGRs **(Ghoneim *et al.*, 2012; Basit *et al.*, 2013)**. Furthermore, pesticides can pose environmental hazards. The common neonicotinoid pesticide, thiamethoxam, impairs the physical ability of honey bee to fly and navigation **(Henry *et al.*, 2015; Tosi *et al.*, 2017)**.

Thus, the trend towards using of environmental safer insecticides has become a new awakening attention and unabated challenge in controlling cotton insect pests. Among these insecticides, flonicamid is a systemic insecticide that belongs to the chemical group of pyridinecarboxamides. Flonicamid shows selective activity against aphids and other sap-sucking insects **(Roditakis *et al.,* 2014)**. It causes irreversible inhibition of feeding behavior to adult aphids, and acute toxicity to aphid nymphs. Flonicamid has no negative impact on pollinating insects or natural enemies, so the use of this insecticide is ideal for pest management programs **(Morita *et al.*, 2007; 2014)**. Furthermore, European Food Safety Authority (EFSA) investigated that uses of flonicamid are unlikely to pose a consumer health risk **(EFSA, 2015)**.

The insect growth regulators (IGRs) pyriproxyfen and buprofezin are molt inhibitors for a wide range of insects. Pyriproxyfen is a potent juvenile hormone mimic affecting the hormonal balance in insects resulting thereby in strong suppression of embryogenesis, metamorphosis, and adult formation **(Koehler and Patterson, 1991)**. Buprofezin interferes with chitin formation by blocking the polymerisation process of N-acetyl glucose amine units. In addition, when the adult females were exposed to these two IGRs, reduction of fecundity and egg hatching was observed **(Uchida *et al.* 1985)**.

From these points of view, laboratory and field experiments were carried out with the aim to reduce the doses of pesticides, increase their effectiveness and consequently minimize the environmental hazards. In this respect, the efficacy of selected insecticides with different modes of action and their binary mixtures against *A. gossypii* infesting cotton plants were assessed. The adverse effects of these treatments on the associated natural enemies; *C. undecimpuctata* and *C. carnea* were also investigated.

2.Materials and Methods

2.1. Experimental insect:

The field strain of *A. gossypii* was collected from unsprayed plots during the early cotton growth period at the Experimental Farm of the Faculty of Agriculture, Alexandria University, Egypt. The heavily infested leaves and shoots of cotton plants with aphid colonies were picked and transferred to the laboratory in paper bags and used for the bioassay experiments.

Table (1): Tested insecticides against *A. gossypii* and its natural enemies

Common name	Trade name	Manufacturer	Field rate (100 L^{-1} water)
Flonicamid	Teppeki® 50% WG	Soulfotechnica S. B. A.	20 g
Pyriproxyfen	Admiral® 10% EC	Sumitomo Chemicals	50 mL
Buprofezin	Applaud® 25% SC	Nihon Nihyaku	40 mL

2.2. Tested insecticides:

The common names of the selected insecticides, trade names, manufacturer and field recommended rates are listed in Table (1).

2.3. Laboratory experiments:

Efficacy of flonicamid, pyriproxyfen and buprofezin were evaluated against the field strain of *A. gossypii* adults under laboratory conditions using the leaf-dip bioassay technique **(Moores *et al.*, 1996)**. Six serial concentrations of each insecticide were freshly prepared in water. Cotton leaf discs were collected from untreated field, washed, dried, dipped for 10 seconds in each concentration and allowed to dry for 30 min. For control treatment, leaf discs immersed in water only. Two treated leaf discs were placed in each Petri dish (9 cm diameter) containing filter paper. Ten apterous adult cotton aphids of same size were transferred to the treated leaf discs by a hair brush. Each concentration was replicated four times. The Petri dishes were reserved at 25 ± 2 °C, RH 65 ± 5% and 12:12 (light: dark) photoperiod. Mortality percentages were recorded after 24 h from treatment and subjected to probit analysis **(Finney, 1971)**. LC_{10}, LC_{25} and LC_{50} values, their confidence limits and slope ± SE were calculated.

The binary mixtures of flonicamid at LC_{25} and LC_{10} with pyriproxyfen or buprofezin at LC_{25} and LC_{10} against *A. gossypii* were evaluated. Three control groups were subjected to calculate the expected mortalities. The co-toxicity factors of tested mixtures were calculated according to **Mansour *et al.*, (1966)**, as follows:

$$\text{Co-toxicity factor} = \frac{\text{observed \% mortality} - \text{expected \% mortality}}{\text{expected \% mortality}} \times 100$$

This factor was used to categorize the results into three categories as follow: Co-toxicity factors ≥ +20 meant potentiation; co-toxicity factors < -20 meant antagonism and co-toxicity factors between -20 and +20 meant additive effect.

2.4. Field experiments:

Two field experiments were conducted during 2017 and 2018 cotton seasons at Abees, Alexandria, Egypt. Cotton variety Giza 86 was sown following standard agronomic practices at the first of April in the both seasons. Five treatments in addition to control were arranged in a randomized complete block design (RCBD) with 4 replicates (175 m^2 each). Knapsack sprayer equipment (CP3) was used for treatments application at the rate of 200 liter per feddan. Insecticides were applied on May 14 and May 27 at 2017 and 2018 seasons, respectively. Control was sprayed by water only. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Mixtures of flonicamid/pyriproxyfen and flonicamid/buprofezin were mixed at the half field rates for each insecticide alone. Ten plants per plot were selected randomly and inspected in the morning for the aphids and natural enemies' counts. The sampling was made just before the spraying and 1, 3, 5, 7, 9 and 12 days after treatment. Reduction percentages of aphids and predators populations were calculated according to **Henderson and Tilton's equation (1955)**. Insecticide treatments used in this study were categorized as their effects on the natural enemies according to the International Organization of Biological Control (IOBC) classification to three categories as following: N= harmless or slightly harmful (reduction field and semi-field 0-50%, laboratory <30%), M= moderately harmful (reduction field and semi-field 51-75%, laboratory 30-79%), and T= harmful (reduction field and semi-field >75%, laboratory ≥ 80%) **(Boller *et al.*, 2005)**. The efficiency of treatments was compared with each other using one way ANOVA with $LSD_{0.05}$ **(CoStat Statistical Software, 1990)**.

3.Results

3.1. Laboratory bioassay:

Efficacy of flonicamid, pyriproxyfen and buprofezin against the field strain of *A. gossypii* adults using leaf-dip bioassay technique were investigated. Data presented in (Table 2) demonstrated the LC_{10}, LC_{25} and LC_{50} values, their confidence limits and slope ± SE for the selected insecticides after 24 h of treatment. Results showed that, toxicity of flonicamid (LC_{50} = 0.58 mg L^{-1}) was 5.9 times more toxic than pyriproxyfen (LC_{50} = 3.42 mg L^{-1}) and 7.34 times more toxic than buprofezin (LC_{50} = 4.26 mg L^{-1}). There was no a significant difference between pyriproxyfen and buprofezin against the field strain of *A. gossypii.*

3.2. Joint toxic action:

The joint toxic action of flonicamid with pyriproxyfen or buprofezin at different concentrations against the *A. gossypii* field strain after 24 h of treatment was shown in (Table 3). It was clear that, the higher potentiating effect was obtained when flonicamid at concentration equivalent to LC_{25} was mixed with pyriproxyfen or buprofezin at LC_{25} with co-toxicity factors 37.52 and 35.70, respectively. Also, mixtures of flonicamid at LC_{25} with pyriproxyfen or buprofezin at LC_{10} resulted in potentiating effect with co-toxicity factors 27.27 and 23.08, respectively. Whereas, mixtures of flonicamid at LC_{10} with pyriproxyfen or buprofezin at LC_{25} gave an additive effect with co-toxicity factors were 18.16 and 10.02, respectively.

3.3. Field efficacy of various insecticide treatments against *A. gossypii*:

Reduction percentages of *A. gossypii* caused by flonicamid, pyriproxyfen, buprofezin, flonicamid/pyriproxyfen and flonicamid/buprofezin mixtures after

Table (2): The lethal and sublethal concentrations of tested insecticides against the adults of *A. gossypii* field strain after 24 h of treatment by leaf-dip technique

Insecticide	LC_{10} (mg L^{-1}) Confidence limits	LC_{25} (mg L^{-1}) Confidence limits	LC_{50} (mg L^{-1}) Confidence limits	Slope ± SE*
Flonicamid	0.11 0.09-0.15	0.26 0.18-0.64	0.58 0.38-0.86	1.28 ± 0.21
Pyriproxyfen	0.68 0.52-0.94	1.54 1.36-1.78	3.42 1.80-5.34	1.66 ± 0.28
Buprofezin	0.85 0.70-1.23	1.92 1.68-2.26	4.26 2.34-6.82	1.70 ± 0.32

*SE means Standard Error

Table (3): Joint toxic action of flonicamid with pyriproxyfen or buprofezin against the adults of *A. gossypii* field strain after 24 h of treatment

Mixtures	Concentration	Expected (%)	Observed (%)	Co-toxicity	Action
Flonicamid + Pyriproxyfen	$LC_{25} + LC_{25}$	53.33	73.33	37.52	Potentiation
	$LC_{25} + LC_{10}$	36.67	46.67	27.27	Potentiation
	$LC_{10} + LC_{25}$	36.67	43.33	18.16	Additive
Flonicamid + Buprofezin	$LC_{25} + LC_{25}$	46.67	63.33	35.70	Potentiation
	$LC_{25} + LC_{10}$	43.33	53.33	23.08	Potentiation
	$LC_{10} + LC_{25}$	33.33	36.67	10.02	Additive

*Co-toxicity factor = [(observed (%) mortality – expected (%) mortality)/expected (%) mortality] × 100 (**Mansour *et al.*, 1966**). Co-toxicity factors ≥ +20 meant potentiation; co-toxicity factors < -20 meant antagonism and co-toxicity factors between -20 and +20 meant additive effect.

1, 3, 5, 7, 9 and 12 days of treatment were evaluated in 2017 and 2018 cotton seasons (Tables 4 and 5). All insecticides were applied alone at their recommended field rates and mixed at their half field rates for each. The highest mean reduction percentages of *A. gossypii* were achieved by flonicamid/pyriproxyfen mixture (90.45 and 87.15%) followed by flonicamid/buprofezin mixture (87.47 and 81.34%) and flonicamid (84.31 and 77.89%) in 2017 and 2018 seasons, respectively. The lowest mean of reduction percentages were 74.03, 70.59% at 2017 season and 69.77, 66.84% at 2018 season after application of pyriproxyfen and buprofezin, respectively. There was no significant difference between pyriproxyfen and buprofezin.

3.4. Adverse effects of various insecticide treatments on the associated natural enemies:

The side effects of flonicamid, pyriproxyfen, buprofezin and their mixtures on the associated natural enemies; *C. undecimpuctata* and *C. carnea* after 1, 3, 5, 7, 9 and 12 of treatment at 2017 and 2018 cotton seasons were investigated and presented in Tables (6, 7, 8, and 9). The highest mean reduction on *C. undecimpuctata* caused by flonicamid/pyriproxyfen mixture (41.75 and 39.17%) followed by flonicamid/buprofezin mixture (40.00 and 35.49%) and flonicamid (38.51 and 32.01%). While, pyriproxyfen (31.95 and 26.64%) and buprofezin (28.87 and 24.60%) in 2017 and 2018 seasons, respectively, demonstrated less toxicity to *C. undecimpuctata*. All insecticide treatments were classified as harmless or slightly harmful on *C. undecimpuctata* (Tables 6 and 7).

The highest adverse effects on *C. carnea* were caused by flonicamid/pyriproxyfen mixture (22.45 and 23.41%) followed by flonicamid/buprofezin mixture (20.29 and 19.48%), flonicamid (17.90 and 17.97%), pyriproxyfen (16.25 and 14.58%) and buprofezin (16.42 and 13.25%) in 2017 and 2018 seasons, respectively. All insecticide treatments showed slightly harmful effects on *C. carnea* in 2017 and 2018 seasons (Tables 8 and 9).

4.Discussion

Flonicamid is a highly selective insecticide for controlling a broad range of aphids and many other sucking insects as well as providing long-term control. This insecticide has been identified as rapidly suppress the feeding behavior of aphids and thus its mode of action was different from that of neonicotinoids which act as agonists on the insect nicotinic acetylcholine receptor (nAChR) **(Nauen *et al.*, 2001; Tomizawa *et al.*, 2007)**.

Though field testing is important for the insecticide performance at the farm level but also laboratory bioassay is useful for explaining insecticide effectiveness. Therefore, laboratory and field experiments were carried out to investigate the effectiveness of flonicamid, pyriproxyfen, buprofezin and their mixtures against the field strain of *A. gossypii*. Under laboratory conditions, LC_{50} values showed that flonicamid exhibited the highest toxicity against the field strain of *A. gossypii* adults. Similar results were observed by **Morita *et al.*, (2007)** where they reported that, flonicamid showed a strong and rapid toxicity against different aphid species, *Myzus persicae*, *A. gossypii*, *Rhopalosiphum erysimi* and *Schizaphis graminum.* Also, flonicamid had the excellent performance to control of the pea aphid, *Acyrthosiphon pisum* and the pomegranate aphid, *Aphis punicae* under laboratory conditions. The rapid activity of flonicamid against aphids is promising as it can contribute in controlling

Table (4): Reduction percentages of *A. gossypii* after application with the selected insecticide treatments during 2017 cotton season

Treatments	%Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-days	12-days	
Flonicamid	78.53	80.72	83.18	85.64	87.36	90.43	84.31[b]
Pyriproxyfen	66.74	70.83	73.46	75.35	77.54	80.28	74.03[c]
Buprofezin	62.35	67.26	70.92	71.48	74.65	76.89	70.59[c]
Flonicamid + Pyriproxyfen	85.44	88.52	90.34	90.76	92.43	95.23	90.45[a]
Flonicamid + Buprofezin	82.78	83.43	86.27	88.52	90.18	93.64	87.47[ab]

*Means followed by the different letters are significantly different according to the $LSD_{0.05}$ = 5.27. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each.

Table (5): Reduction percentages of *A. gossypii* after application with the selected insecticide treatments during 2018 cotton season

Treatments	% Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-Days	12-days	
Flonicamid	67.39	72.68	76.93	80.24	83.62	86.48	77.89[b]
Pyriproxyfen	62.43	65.77	68.32	72.18	73.56	76.34	69.77[c]
Buprofezin	58.32	62.53	66.84	69.45	70.28	73.62	66.84[c]
Flonicamid + Pyriproxyfen	78.96	83.42	87.63	89.38	90.54	92.76	87.15[a]
Flonicamid + Buprofezin	73.25	76.34	80.17	82.63	86.12	89.54	81.34[ab]

*Means followed by the different letters are significantly different according to the $LSD_{0.05}$ = 6.95. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each.

Table (6): Reduction percentages of *C. undecimpuctata* after application with the selected insecticide treatments during 2017 cotton season

Treatments	% Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-days	12-days	
Flonicamid	28.64	30.39	36.28	43.16	45.68	46.92	38.51[a] N
Pyriproxyfen	27.36	28.34	30.56	33.21	35.29	36.93	31.95[b] N
Buprofezin	23.83	25.23	27.64	30.35	32.52	33.74	28.87[b] N
Flonicamid + Pyriproxyfen	37.62	40.47	42.58	43.92	43.66	42.25	41.75[a] N
Flonicamid + Buprofezin	34.58	37.45	40.62	42.33	44.28	40.76	40.00[a] N

*Means followed by the different letters are significantly different according to the $LSD_{0.05}$ = 5.60. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each. IOBC toxicity classification: N= harmless or slightly harmful (reduction field and semi-field 0-50%) **(Boller *et al.*, 2005)**.

Table (7): Reduction percentages of *C. undecimpuctata* after application with the selected insecticide treatments during 2018 cotton season

Treatments	%Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-days	12-days	
Flonicamid	27.32	28.34	30.56	33.21	35.67	36.93	32.01[b] N
Pyriproxyfen	21.65	23.93	24.38	26.42	30.23	33.54	26.64[c] N
Buprofezin	18.52	22.79	23.46	26.83	27.65	28.36	24.60[c] N
Flonicamid + Pyriproxyfen	34.05	36.48	39.34	40.14	42.27	42.76	39.17[a] N
Flonicamid + Buprofezin	30.52	33.37	35.18	36.86	38.79	38.24	35.49[ab] N

*Means followed by different letters are significantly different according to the $LSD_{0.05}$ = 4.46. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each. IOBC toxicity classification: N= harmless or slightly harmful (reduction field and semi-field 0-50%) **(Boller *et al.*, 2005).**

Table (8): Reduction percentages of *C. carnea* after application with the selected insecticide treatments during 2017 cotton season

Treatments	%Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-days	12-days	
Flonicamid	15.20	16.67	17.43	18.00	19.24	20.91	17.90^b N
Pyriproxyfen	12.94	14.15	16.35	17.10	18.65	18.32	16.25^b N
Buprofezin	12.63	15.22	17.75	18.11	18.54	16.27	16.42^b N
Flonicamid + Pyriproxyfen	20.36	22.78	23.60	23.83	22.52	21.62	22.45^a N
Flonicamid + Buprofezin	18.63	19.24	21.56	22.14	20.31	19.87	20.29^a N

*Means followed by the different letters are significantly different according to the LSD$_{0.05}$ = 2.24. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each. IOBC toxicity classification: N= harmless or slightly harmful (reduction field and semi-field 0-50%) **(Boller *et al.*, 2005)**.

Table (9): Reduction percentages of *C. carnea* after application with the selected insecticide treatments during 2018 cotton season

Treatments	%Reduction after						Mean*
	1-day	3-days	5-days	7-days	9-days	12-days	
Flonicamid	16.07	17.29	18.43	18.84	19.36	17.83	17.97^b N
Pyriproxyfen	11.62	12.83	14.58	15.76	16.42	16.25	14.58^c N
Buprofezin	10.33	12.46	13.54	14.92	14.87	13.38	13.25^c N
Flonicamid + Pyriproxyfen	21.35	23.84	24.32	24.76	23.65	22.54	23.41^a N
Flonicamid + Buprofezin	14.28	18.32	20.16	21.43	22.76	19.94	19.48^b N

*Means followed by the different letters are significantly different according to the LSD$_{0.05}$ = 2.28. Flonicamid, pyriproxyfen and buprofezin were applied at the recommended field rates. Flonicamid was mixed with pyriproxyfen or buprofezin at the half field rates for each. IOBC toxicity classification: N= harmless or slightly harmful (reduction field and semi-field 0-50%) **(Boller *et al.*, 2005)**.

virus transmission **(Sadeghi *et al.*, 2009; Rouhani *et al.*, 2013)**. In addition, the first three instars of turnip aphids, *Lipaphis erysimi* needed to be treated with high concentrations of pyriproxyfen to cause supernumerary molts and sterility **(Liu and Chen 2001)**. Moreover, **Richardson and Lagos (2007)** showed that pyriproxyfen adversely affect on the soybean aphid, *Aphis glycines* by causing direct mortality, reducing their longevity and fecundity, and inducing supernumerary molts under laboratory conditions.

Using of insecticides at mixtures is one of ways to reduce their quantities with increasing of their effectiveness **(Abdel Rahman and Abou-Taleb, 2007; Eldesouky *et al.*, 2018)**. In this study, mixtures of flonicamid with pyriproxyfen or buprofezin against *A. gossypii* were evaluated. Results revealed that, the mixtures of flonicamid at LC$_{25}$ with pyriproxyfen or buprofezin each at LC$_{25}$ or LC$_{10}$ resulted in potentiating effect. It was recorded that, the maximum potentiation ratio of the tested neonicotinoid insecticides with buprofezin or pyriproxyfen mixtures against the field strain of *Bemisia tabaci* occurred at the 1:1 ratio. But mixtures of these insecticides did not exhibit potentiation against the laboratory strain **(Basit *et al.*, 2013).**

Regarding to the results of tested insecticides effectiveness in the cotton field which supported by the laboratory evaluation, the highly mean reduction percentages of *A. gossypii* were achieved by flonicamid/ pyriproxyfen mixture and flonicamid/buprofezin mixture followed by flonicamid. These results were in accordance with those obtained by **Awasthi *et al.*, (2013)**; **Ghelani *et al.* (2014); Sathyan *et al.*, (2016)** when they reported that flonicamid was effective in controlling *A. gossypii* on cotton plants and safer to the natural enemies. Also, **Abou-Taleb and Barrania, (2014)** reported that highest reduction percentages of *A. gossypii* on the eggplant were achieved by imidacloprid/buprofezin mixture. The chitin synthesis inhibitors (pyriproxyfen and novaluron) achieved the least reduction percentages against *A. gossypii* in cotton field (**Barrania and Abou-Taleb, 2014)**. Furthermore, **El-Zahi *et al.*, (2017)** mentioned that flonicamid recorded the highest mean reduction against the adults and immature stages of *B. tabaci*. In another study, flonicamid at 125 mg L^{-1} caused 95% mortality to *B. tabaci* adults after 10 days from treatment **(Roditakis *et al.*, 2014)**. **Nemade *et al.*, (2017)** recorded that flonicamid at different field rates was effective in controlling the major sucking pests of Bt cotton and also gave higher yield.

Referring to the results of tested insecticides impacts on natural enemies, similar results were obtained by **Ghelani *et al.*, (2014)**. They stated that flonicamid was safer than thiamethoxam to coccinellids and chrysopids under field conditions. Flonicamid could be classified as harmless to the natural enemies **(Roditakis *et al.*, 2014)**, where it was significantly the most harmless to the associated predators **(El-Zahi *et al.*, 2017)**.

On the basis of overall findings, it was concluded that flonicamid and its binary mixtures with pyriproxyfen or buprofezin could be successfully incorporated in IPM programs to control *A. gossypii* in the cotton field, reduce their field doses besides keeping on environment safety.

References

Abdel-Rahman, SM, Abou-Taleb HK (2007). Joint action of spinosad and spinetoram with certain IGR compounds against cotton leafworm. Alex. J. Agric. Res. 52: 45-51.

Abou-Taleb, HK, Barrania AA (2014). Effectiveness of some insecticides for eggplant sucking-piercing insects' management with reference to their side effects on natural enemies. Alex. Sci. Exch. J. 35: 126-132.

Ahmad, T, Hassan MW, Jamil M, Iqbal J (2016). Population dynamics of aphids (Hemiptera: Aphididae) on wheat varieties (*Triticum aestivum* L.) as affected by abiotic conditions in Bahawalpur, Pakistan. Pakistan J. Zool. 48: 1039-1044.

Awasthi, NS, Bharkhade UP, Patil SR, Lande GK (2013). Comparative toxicity of some commonly used insecticides to cotton aphids and their safety to predatory coccinellids. The Bioscan 8: 1007-1010.

Barrania, AA, Abou-Taleb HK (2014). Field efficiency of some insecticide treatments against whitefly, *Bemisia tabaci*, cotton aphid, *Aphis gossypii* and their associated predator, *Chrysoperla vulgaris* in cotton plants. Alex. J. Agric. Res. 59: 105-111.

Basit, M, Saeed Sh, Saleem MA, Sayyed AH (2013). Can resistance in *Bemisia tabaci* (Homoptera: Aleyrodidae) be overcome with mixtures of neonicotinoids and insect growth regulators? Crop Protection 44: 135-141.

Boller, EF, Vogt H, Ternes P, Malavolta C (2005). Working Document on Selectivity of Pesticides: Explanations to the IOBC Database, IOBC/OILB. Available: http://www.iobc-wprs.org/ip_ipm/IOBC_IP_Tool_Box.

CoStat Statistical Software, (1990). Microcomputer program analysis version 4.20. CoHort Software, Monterey, California, USA.

Deguine, JP, Goze E, Leclant F (2000). The consequences of late outbreaks of the aphid *Aphis gossypii* in cotton growing in central Africa: towards a possible method for the prevention of cotton stickiness. International Journal of Pest Management 46: 85–89.

Eldesouky, SE, Hassan, SM, Farag, DA (2018). Toxicity of certain IGRs and conventional insecticides against cotton leafworm and their effects on the development and haemocyte counts. Alex. J. Agric. Sci. 63: 93-103.

El-Zahi, ES, El-Sarand EA, El-Masry GN (2017). Activity of flonicamid and two neonicotinoid insecticides against *Bemisia tabaci* (Gennadius) and its associated predators on cotton plants. Egypt. Acad. J. Biolog. Sci.10: 25- 34.

European Food Safety Authority, EFSA (2015). Reasoned opinion on the modification of the existing MRLs for flonicamid in several crops. EFSA Journal 13: 4103.

Finney, DJ (1971). Probit analysis, Cambridge Univ. Press, Cambridge.

Ghelani, MK, Kabaria BB, Chhodavadia SK (2014). Field efficacy of various insecticides against major sucking pests of Bt cotton. J. Biopest 7: 27-32.

Ghoneim, YF, Singab M, Abou-Yousef HM, Abdel-Hai NS (2012). Efficacy of certain insecticides and their mixtures with the tested IGRs against a field strain of the cotton leafworm, *Spodoptera littoralis* (Boisd.) under laboratory conditions. Australian Journal of Basic and Applied Sciences 6: 300-304.

Henderson, CF, Telton EW (1955). Tests with acaricides against the brown wheat mite. J. Econ. Entomol. 48: 157-161.

Henry, M, Cerrutti N, Aupinel P, Decourtye A, Gayrard M, Odoux J-F, Pissard A, Rüger C, Bretagnolle V (2015). Reconciling laboratory and field assessments of neonicotinoid toxicity to honeybees. Proc. R. Soc. B 282: 20152110.

Koehler, PG, Patterson RS (1991). Incorporation of the IGR, pyriproxyfen, in a German cockroach (Dictyoptera: Blattellidae) management program. J. Econ. Entomol. 84: 917-921.

Konar, A, More KA, Ray SKD (2013). Population dynamics and efficacy of some insecticides against aphid on okra. Journal of Crop and Weed 9: 168-171.

Leclant, F, Deguine JP (1994). Cotton aphids, pp. 285-323. *In* Matthews, GA, Tunstall JP, [eds]. Insect pests of cotton. C.A.B., UK.

Liu, TX, Chen TY (2001). Effects of a juvenile hormone analog, pyriproxyfen, on the apterous form of *Lipaphis erysimi*. Entomologia Experimentalis et Applicata 98: 295-301.

Mansour, NA, Eldefrawi ME, Toppozada A, Zeid M (1966). Toxicological studies on the Egyptian cotton leafworm, *Prodenia litura.* VI. Potentiation and antagonism for organophosphorus and carbamate insecticides. J. Econ. Entomol. 59: 307-311.

Moores, GD, Gao X, Denholm WI, Devonshire AL (1996). Characterization of insensitive acetyl cholinesterase in insecticide-resistant cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae). Pesticide Biochemistry and Physiology 56: 102-110.

Morita, M, Ueda T, Yoneda Y, Koyanagi T, Haga T (2007). Flonicamid, a novel insecticide with a rapid inhibitory effect on aphid feeding. Pest Manag. Sci. 63: 969-973.

Morita, M, Yoneda T, Akiyoshi N (2014). Research and development of a novel insecticide, flonicamid. J. Pestic. Sci. 39: 179–180.

Mushtaq, A, Arif MI (2008). Susceptibility of Pakistani populations of cotton aphid *Aphis gossypii* (Homoptera: Aphididae) to endosulfan, organophosphorus and carbamate insecticides. Crop Protection 27: 523–531.

Nauen, R, Ebbinghaus-Kintscher U, Elbert A, Jeschke P, Tietjen K (2001). Acetylcholine receptors as sites for developing neonicotinoid insecticides. In: Ishaaya I., editor. Biochemical sites of insecticide action and resistance. Berlin: Springer Verlag; p. 77–105.

Nemade, PW, Rathod TH, Deshmukh SB, Ujjainkar VV, Deshmukh VV (2017). Evaluation of new molecules against sucking pests of Bt cotton. Journal of Entomology and Zoology Studies 5: 659-663.

Richardson, ML, Lagos DM (2007). Effects of a juvenile hormone analogue, pyriproxyfen, on the apterous from of soybean aphid (*Aphis gly-*

cines). Journal of Applied Entomology 131: 297 -302.

Roditakis, E, Fytrou N, Staurakaki M, Vontas J, Tsagkarakou A (2014). Activity of flonicamid on sweet potato whitefly *Bemisia tabaci* (Homoptera: Alerodidae) and its natural enemies. Pest Manag. Sci. 70: 1460-1467.

Rouhani, M, Samih MA, Izadi H, Mohammadi E (2013). Toxicity of new insecticides against pomegranate aphid, *Aphis punicae*. International Research Journal of Applied and Basic Sciences 4: 496-501.

Sadeghi, A, Van Damme EJ, Smagghe G (2009). Evaluation of the susceptibility of the pea aphid, *Acyrthosiphon pisum*, to a selection of novel biorational insecticides using an artificial diet. J Insect Sci. 9: 1-8.

Sarwar, MK, Azam I, Iram N, Iqbal W, Rashda A, Anwer F, Atta K, Ali R (2014). Cotton aphid *Aphis gossypii* L. (Homoptera: Aphididae); a challenging pest; biology and control strategies: A review. International Journal of Applied Biology and Pharmaceutical Technology 5: 288-294.

Sathyan, T, Murugesan N, Elanchezhyan K, Arockia Stephen Raj J, Ravi G (2016). Efficacy of synthetic insecticides against sucking insect pests in cotton, *Gossypium hirsutum* L. International Journal of Entomology Research 1: 16-21.

Tomizawa, M, Maltby D, Medzihradszky KF, Zhang N, Durkin KA, Presly J, Talley TT, Taylor P, Burlingame AL, Casida JE (2007). Defining nicotinic agonist binding surfaces through photo affinity labeling. Biochemistry 46: 8798-8806.

Tosi, S, Burgio G, Nieh JC (2017). A common neonicotinoid pesticide, thiamethoxam, impairs honey bee flight ability. Scientific Reports 7: 1201.

Uchida, M, Asai T, Sugimoto T (1985). Inhibition of cuticle deposition and chitin biosynthesis by a new insect growth regulator, buprofezin, in *Nilaparvata lugens* Stal. J. Agric. Biol. Chem. 49: 1233–1334.

Wang, KY, Liu TX, Yu CH, Jiang XY, Yi MQ (2002). Resistance of *Aphis gossypii* (Homoptera: Aphididae) to fenvalerate and imidacloprid and activities of detoxification enzymes on cotton and cucumber. J. Econ. Entomol. 95: 407-413.

فعالية بعض المبيدات الحشرية ضد منّ القطن وآثارها الضارة على أثنين من الأعداء الطبيعية

سحر السيد الدسوقي

معهد بحوث وقاية النبات ، مركز البحوث الزراعية ، الصبحية – الإسكندرية

الملخص العربي

تم إجراء هذا البحث لدراسة تأثير كلا من الفلونيكاميد ، البيريبروكسيفين و البيروفيزين معمليا وحقليا على سلالة حقلية لمنّ القطن. تحت الظروف المعمليه وجد أن أكثر المبيدات المختبرة سميه الفلونيكاميد يليه البيريبروكسيفين ثم البيروفيزين حيث كانت التركيزات اللازمه لقتل ٥٠٪ من الأفراد المعاملة ٠,٥٨ ، ٣,٤٢ ، ٤,٢٦ ملجم/ لتر، على التوالي. وعند خلط المبيدات المختبرة وجد ان أكثر الخلطات فاعلية فى زيادة السمية هى الخلط بين الفلونيكاميد بالتركيزاللازم لقتل ٢٥٪ من الأفراد المعاملة مع البيريبروكسيفين أو البيروفيزين بمعامل سميه يتراوح بين ٢٣,٠٨ و٣٧,٥٢ بعد ٢٤ ساعة من المعاملة. وقد أجريت تجربتين حقليتين خلال الموسمين ٢٠١٧ و ٢٠١٨ بمنطقة أبيس بالإسكندرية. فأوضحت النتائج أن المعاملة فلونيكاميد/ بيريبروكسيفين تليها فلونيكاميد/ ببروفيزين كلا بنصف المعدل الحقلي ثم الفلونيكاميد بمفردة بالمعدل الحقلى حققت أعلى خفض فى تعداد منّ القطن بنسب خفض ٩٠,٤٥ ، ٨٧,٤٧ ، ٨٤,٣١ ٪ لموسم ٢٠١٧ و ٨٧,١٥ ، ٨١,٣٤ ، ٧٧,٨٩ ٪ لموسم ٢٠١٨ ، على التوالى. كما سجلت النتائج أن جميع المعاملات المختبرة حقليا تراوحت ما بين غير ضارة لقليلة الضرر على الأعداء الطبيعية المصاحبه كحشرات أسد المنّ و أبوالعيد فى كلا الموسمين. ومن هذه الدراسة يتضح فعالية كلا من الفلونيكاميد بمفرده او عند خلطه مع البيريبروكسيفين أو البيروفيزين فى التحكم فى تعداد منّ القطن إلى جانب انها معاملات آمنه على الأعداء الطبيعية المصاحبه. وبهذا يمكن إستخدام تلك المعاملات في برامج المكافحة المتكاملة على منّ القطن تحت الظروف الحقلية.