Impact of Synthetic Insecticides Against Aphis *Gossypii* Glover, *Bemisia Tabaci* (Genn.) and Their Associated Predators on Cotton Plants

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ABSTRACT

Pyridinecarboxamide and neonicotinoids insecticides are used in small quantity and economically effective for control sucking pests in cotton fields. Therefore, the current study was conducted to evaluate the efficiency of flonicamid, imidacloprid and dinotefuran and its compared with abamectin, carbosulfan, malathion and cholorpyrifos against cotton aphids, *Aphis gossypii* Glover and whitefly, *Bemisia tabaci* (Genn.) and its associated predators, *Chrysoperle carnea* (larvae and adults) and spiders in cotton fields at Sakha Agricultural Research Station, Kafr El- Sheikh Governorate, Egypt during 2017 and 2018 cotton seasons. Seven insecticides were applied at their field recommended rates. The obtained results 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. Carbosulfan and chlorpyrifos caused moderate effective against *Aphis gossypii*, while the least effective compound was malathion. Concerning the whitefly, imidacloprid, flonicamid and dinotefuran statistically exhibited reduction in populations of adults' stage ranged from 67.54-78.46% in 2017 and 2018 seasons and 71.04-87.26% reduction in immature stages in both seasons, while carbosulfan was the least effective compound against *Bemisia tabaci* (adult and immature stages). It is important to note that flonicamid, imidacloprid and dinotefuran were less harmful effect on populations of tested predators than the tested organophosphates and cabosulfan. Accordingly, flonicamid, imidacloprid and dinotefuran are useful choice for use in IPM programs to control these pests in cotton fields.

Keywords: flonicamid, neonicotinoid, sucking pests, associated predators.

INTRODUCTION

Cotton, *Gossypium hirsutum* L. is one of the most commercially important fiber crops in the world. Many phytophagous pests are encountered on cotton plants from germination to harvesting. Among of which are aphids cotton, *Aphis gossypii* Glover and whitefly, Bemisia *tabaci* (Genn.) causing serious damage to plants. In case of heavy infestation, these pests decreased in fiber quality because of stickiness and development of black sooty mold fungi associated with honeydew dropped on the open bolls (Blackman and Eastop, 1984; Forlow and Henneberry,2001). The mold fungi reduce photosynthesis and lessens the market value of the yields it unmarketable (Berlinger,1986). Furthermore, *B. tabaci* biotypes can transmit more than 90 types of plant virus (Jorge and Mendoza,1995; Hunter & Polston, 2001).

In many agricultural systems worldwide, it is well recognized that *A. gossypii* and *B. tabaci* populations are resistant to organophosphates, carbamates and pyrethroids insecticides (Horowitz *et al.,* 1998; Li *et al*.,2001). Therefore, it is imperative to search out some alternatives of highly toxic insecticides and safe to humans and nontoxic to the natural enemies. In this view, there is a field of utilizing the newer chemistry molecules such as pyridinecarboxamide and neonicotinoid which are required in small quantity and economically effective for control of sucking pests in cotton ecosystem (Gourkhede *et al*., 2015).

Flonicamid is a novel systemic insecticide that belongs to pyridinecarboxamide group and acts as irreversible inhibitor of aphid feeding (Roditakis *et al*., 2014). This compound was discovered by Ishihara Sangyo Kaisha, Ltd., Japan and launched in many parts of the world such as USA, Brazil, France and Korea Since 2005 (Morita *et al*., 2007). Dinotefuran and imidacloprid are belonging to neonicotinoid chemical group and interfere with the nicotinic acetylcholine receptors; therefore, they have specific activity against the insects' nervous system (Maienfisch *et al*., 2001). Therefore, the present study aimed to detect the efficacy of flonicamid, dinotefuran and imidacloprid against cotton aphids, *A. gossypii*, whitefly *B. tabaci* and their associated predators on cotton plants under field conditions.

MATERIALS AND METHODS

Insecticides:

The commercial formulations of the tested insecticides were used:

***Pyridinecarboxamide**

Flonicamid (Teppeki 50% WG), *N*-cyanomethyl-4-(trifluoromethyl) nicotinamide, obtained from ISK Biosciences Europe N.V, Belgium and rate of 45 g/100L.

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***Neonicotinoids**

Dinotefuran (Oshin 20% WG), (*RS*)-1-methyl-2-nitro-3-(tetrahydro-3-furylmethyl) guanidine, proved by Mitsui Chemicals Agro., Inc., Japan and rate of 125g/100l.

Imidacloprid (Rodex 35% SC), 1-(6-chloro-3-pyridylmethyl)-*N*-nitroimidazolidin-2-ylideneamine, obtained from Jiangsu Yangnong Chemical group Co, Ltd, China and rate of 75ml/100L.

***Avermectin**

Abamectin (Vertimec 1.8 % EC), 5-*O*-demethylavermectin A_{1a} (i) mixture with 5-*O*-demethyl-25-de(1-methylpropyl)-25-(1-methylethyl) avermectin A_{1a} (ii), supplied from Syngenta Agro and rate of 40ml/100L.

***Carbamates**

Carbosulfan (Marshal 20% EC), 2,3-dihydro-2,2-dimethylbenzofuran-7-yl (dibutylaminothio) methylcarbamate, obtained from FMC Corporation – USA and rate of 27ml/100L.

***Organophosphates**

Malathion (Malatox 57% EC), diethyl (dimethoxythiophosphorylthio) succinate; *S*-1,2-bis(ethoxycarbonyl)ethyl *O*, *O*-dimethyl phosphorodithioate, obtained from Chemenova Denmark Co. and rate of 50ml/100L.

Chlorpyrifos, Dursban 48% EC, *O*, *O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate, obtained from Dow Agro Sciences and rate of 333.3ml/ 100L.

Field study and sampling:

The experiment of field was carried out at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt during the cotton growing seasons of 2017 and 2018. An area of 3000m^2 and was divided into plot (84m^2 each) and sown with cotton seeds (*Gossypium barbadens* Var, Giza 94). All recommended agricultural practices were followed throughout the season without any insecticidal treatments. Eight treatments including control were arranged in this area under a randomized complete block design with four replicates (plots). The insecticides were sprayed once on August 10, 2017 and August 13, 2018 by a knapsack sprayer (CP3), the final volume of spray solution demonstrated 300 L/ feddan. Samples of 25 cotton leaves were selected randomly in the early morning from each replicate to count the number of cotton aphid (nymphs and adults) and whitefly (adults) in the field using lens (8x) immediately before the spray and 2, 5, 8, 11 and 14 days' post spray. The chosen leaves were picked up and taken to the laboratory to count immature stages of *B. tabaci* using binocular microscope. At the same time the common associated predators, *Chrysoperle carnea* (larvae and adults) and spiders were counted on 5 cotton plants from each replicate and examined carefully on whole plant. The reduction percentages of each insect and predator were estimated using the equation of Henderson and Tilton (1955).

Statistical analysis

The mean numbers of each insect per cotton leaf for all treatments were calculated and subjected to one-way analysis of variance (ANOVA) and compared for significantly by Duncan's multiple range test (Duncan, 1955) at 0.05 probability level between treatments using CoStat system for Windows, Version 6.311, (2005).

RESULTS AND DISCUSSION

Field efficacy of flonicamid, dinotefuran, imidacloprid, abamectin, carbosulfan, malathion and chlorpyrifos against cotton aphids, *Aphis gossypii* Glover and whitefly, *Bemisia tabaci* (Genn.) as well as their associated predators were evaluated during 2017 and 2018 cotton seasons. The data were registered in Table (1-6) and Figure (1).

Efficacy of tested insecticides against *Aphis gossypii* Glover:

The present investigation in Table (1&2) revealed that the pre-treatment populations of aphids per cotton leaf was in the range of 9.16-16.08 insects in 2017 season, while it ranged from 15.48 to 33.28 insects in 2018.Tested insecticides exhibited a significantly reduction in cotton aphids' populations in all days (2, 5, 8, 11, 14 days) after treatment. According to the general mean of reduction in aphids' populations throughout the experiment periods, imidacloprid proved to be the most effective compound recording 92.95% reduction in 2017 season followed by flonicamid (86.36%). Next effective treatments were dinotefuran (76.16%), carbosulfan (77.47%), chlorpyrifos (77.05%) and malathion (75.34%) without significantly differences between them, while abamectin was the least effective compound (71.68%). In 2018 season, the results recorded the same trend as in 2017 season (Table2), where imidacloprid was the best insecticide in reduction of *A. gossypii* (90.95%), followed by flonicamid, dinotefuran and abamectin giving 82.48, 78.44 and 79.14%, respectively without significant difference. Malathion was the least compound causing 61.78% reduction in populations. The present findings are in conformity with Abd-Ella, 2013 and Ghelani *et al*., 2014) who observed effectiveness of flonicamid, acetamiprid, imidacloprid and dinotefuran against cotton aphids. Also, Sathyan *et al*., 2016 and Nemade *et al*.,2017) found that neonicotinoid compounds and flonicamid were effective against *A. gossypii*

Table 1. Efficacy of different insecticides against *Aphis gossypii* on cotton plants under field condition during season 2017 at Kafr El- Sheikh Governorate

Insecticide	Rate /100 L	Pre-spray	Reduction of *A. gossypii* during season 2017					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45g	10.72	96.76	93.32	91.13	78.73	71.88	86.36[b]
Dinotefuran	125g	10.04	91.73	82.28	75.44	69.72	61.65	76.16[cd]
Imidacloprid	75ml	11.28	98.8	99.79	97.86	85.31	83.03	92.95[a]
Abamectin	40ml	16.96	79.04	76.94	68.04	68.0	66.0	71.68[d]
Carbosulfan	27ml	9.16	86.89	80.16	79.52	75.11	65.66	77.47[c]
Malathion	50ml	9.84	84.69	79.03	72.76	70.65	69.59	75.34[cd]
Chlorpyrifos	333.3ml	10.12	88.93	87.67	71.66	70.26	66.74	77.05[c]
control	-	16.08	33.28*	20.84*	12.04*	10.56*	7.28*	-

* No. of *A. gossypii* /cotton leaf during the experiment in control

In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Table 2. Efficacy of different insecticides against *Aphis gossypii* on cotton plants under field condition during season 2018 at Kafr El- Sheikh Governorate

Insecticide	Rate/100 L)	Pre-spray	Reduction of *A. gossypii* during season 2018					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45 g	15.48	91.89	89.86	88.93	71.42	70.28	82.48[b]
Dinotefuran	125 g	16.72	91.5	81.3	79.87	72.26	67.26	78.44[b]
Imidacloprid	75 ml	18.96	96.03	97.49	89.91	89.15	82.17	90.95[a]
Abamectin	40 ml	21.92	88.77	83.52	79.9	72.27	71.25	79.14[b]
Carbosulfan	27 ml	15.72	88.9	76.28	71.58	67.52	64.74	73.8[bc]
Malathion	50 ml	16.32	78.07	66.45	57.72	56.03	50.67	61.79[d]
Chlorpyrifos	333.3 ml	22.76	90.78	79.02	61.01	58.45	54.42	68.74[c]
Control	-	35	57.96*	28.24*	21.72*	17.84*	11.8*	-

* No. of *A. gossypii* /cotton leaf during the experiment in control .

In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955)

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Efficacy of tested insecticides against *Bemisia tabaci* (Genn.):

Reduction percentages of the tested insecticides against adults and immature stages of *B. tabaci* were registered in Table (3-6). The data in Table (3 and 4) noticed that all the tested insecticides exhibited significantly depression in populations of *B. tabaci* adults compared to control in 2017 and 2018 cotton seasons. Imidacloprid proved to be the most effective one giving 78.46% and 75.85% in 2017 and 2018 seasons, respectively. Next effective treatments were dinotefuran, flonicamid and malathion producing reduction ranged from 64.92-68.03% in 2017, while in 2018, dinotefuran, abamectin and flonicamid exhibited significant reduction ranged from 69.47 to 73.99%. It is important to note that carbosulfan was the least effective producing 49.69 and 59.45% reduction in 2017 and 2018 seasons, respectively.

The effect of the tested insecticides against immature stages of *B. tabaci*, were summarized in Tables (5and 6). The data revealed that imidacloprid, flonicamid and chlorpyrifos were the most effective without significantly differences causing 81.61, 78.21 and 78.06% reduction, respectively in 2017 season, while abamectin recorded the least effect (63.76%) against immature stages. The same trend was also observed in 2018 season. On the other hand, the tested insecticides were more effective against immature stages than adults *B. tabaci*, our study proved that imidacloprid, flonicamid and dinotefuran were higher significant in suppressing populations of *B. tabaci*. These results are consistent with data reported by that (Kalyan *et al*.,2012; Gourkhede *et al*., 2015 and Ghelani *et al*.,2014) who reported that flonicamid and imidacloprid were effective against *B. tabaci* in cotton fields. Also, Roditakis *et al*., 2014; Sathyan *et al.,* 2016 and Nemade *et al.,* 2017 found that flonicamid at rate 75 g a.i./ha and flonicamid at 100 g a.i./ha and imidacloprid managed *B. tabaci* populations.

Table 3. Efficacy of different insecticides against adult stage of *Bemisia tabaci* (Genn.) on cotton plants under field condition during season 2017 at Kafr El- Sheikh Governorate

Insecticide	Rate/100L	Pre-spray	percent reduction of *B.tabaci* during season 2017					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45g	11.04	61.65	62.43	75.89	70.74	67.0	67.54^{bc}
Dinotefuran	125g	13.92	61.21	66.7	73.49	75.09	63.65	68.03^{b}
Imidacloprid	75 ml	10.12	62	78.75	84.31	87.23	80.0	78.46^{a}
Abamectin	4o ml	16.4	68.13	68.47	64.15	58.12	54.27	62.63^{cd}
Carbosulfan	27 ml	15.04	39.68	53.02	57.78	51.17	46.84	49. 69^{e}
Malathion	50 ml	12.16	53.11	67.58	69.9	69.9	64.21	64.92^{bcd}
Chlorpyrifos	333.3 ml	15.2	49.33	64.46	71.09	66.18	59.35	62.08^{cd}
Control	-	15.2	14.04*	11.8*	10.36*	8.9*	6*	-

* No. of *B.tabaci* adults /cotton leaf during the experiment in control.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Table 4. Efficacy of different insecticides against adult stage of *Bemisia tabaci*(Genn). on cotton plants under field condition during season 2018 at Kafr El- Sheikh Governorate

Insecticide	Rate /100 L	Pre-spray	Reduction of *B.tabaci* during season 2018					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45 g	10.72	74.4	60.35	67.96	73.37	71.36	69.47^{bc}
Dinotefuran	125 g	14.88	71.28	69.95	77.56	78.07	73.08	73.99 ^{a}
Imidacloprid	75 ml	7.0	69.2	80.29	79.57	77.26	72.92	75.85^{a}
Abamectin	40 ml	14.52	76.51	77.57	70.1	69.87	69.8	72.71^{ab}
Carbosulfan	27 ml	13.4	47.05	58.81	63.22	65.84	62.34	59.45^{d}
Malathion	50 ml	10.52	58.92	65.89	73.1	68.22	63.2	65.87^{c}
Chlorpyrifos	333.3 ml	13.96	51.7	60.49	60.14	66.92	57.92	59.43^{d}
Control	-	13.12	13.28*	9.52*	8.24*	6.58*	4.92*	-

* No. of *B.tabaci* adults /cotton leaf during the experiment in control.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Table 5. Efficacy of different insecticides against immature stages of *Bemisia tabaci*(Genn.) on cotton plants under field condition during season 2017 at Kafr El- Sheikh Governorate

Insecticide	Rate /100 L	Pre-spray	Reduction immature stages of *B.tabaci* during season 2017					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45 g	7.68	78.33	86.13	80.35	78.23	67.99	78.21^{ab}
Dinotefuran	125 g	6.24	67.18	71.38	73.06	72.6	70.97	71.04^{c}
Imidacloprid	75 ml	9.84	74.09	88.44	83.7	86.83	75.01	81.61^{a}
Abamectin	40 ml	11.36	35.1	74.39	77.63	71.23	60.13	63.76^{d}
Carbosulfan	27 ml	7.4	55.72	67.31	77.8	68.16	62.4	66.28^{d}
Malathion	50 ml	10.84	71.42	83.79	89.43	76.86	64.69	77.26^{b}
Chlorpyrifos	333.3 ml	13.76	72.47	83.05	85.56	82.6	66.62	78.06^{ab}
Control	-	15.52	12.12*	10.8*	8.12*	4.08*	2.48*	-

* No. of *B.tabaci* immature stages /cotton leaf during the experiment in control.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955)

Table 6. Efficacy of different insecticides against immature stages of *Bemisia tabaci* (Genn.) on cotton plants under field condition during season 2018 at Kafr El- Sheikh Governorate

Insecticide	Rate /100 L	Pre-spray	Reduction immature stages of *B.tabaci* during season 2018					Mean %
			Post spray at indicated days					
			2	5	8	11	14	
Flonicamid	45 g	10.48	87.43	93.19	92.11	80.53	73.26	85.3[a]
Dinotefuran	125 g	8.32	72.08	80.12	77.02	74.04	72.5	75.15[b]
Imidacloprid	75 ml	10.16	88.09	94.89	90.59	92.03	70.72	87.26[a]
Abamectin	40 ml	10.84	48.15	61.04	75.49	77.86	53.04	63.12[d]
Carbosulfan	27 ml	9.0	73.75	86.56	90.64	80.33	60.6	78.38[b]
Malathion	50 ml	8.0	61.4	64.09	73.68	70.75	59.96	65.98[d]
Chlorpyrifos	333.3 ml	9.36	69.02	66.63	68.15	79.81	70.67	70.84[c]
Control	-	8.92	9.96*	8.24*	6.16*	2.93*	1.56*	-

* No. of *B.tabaci* immature stages /cotton leaf during the experiment in control.

In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Efficacy of tested insecticides against associated predators:

Reduction percentages of associated predators, *chrysoperla carnea* (adults and larvae) and spiders was recorded in figure (1). The data showed that flonicamid, imidacloprid and abamectin have little effect on the predators compared the other tested insecticides, where they reduced populations ranged from 11.87 to 19.73% in 2017 season and from 19.16 to 25.25% reduction in 2018 season. Dinotefuran and carbosulfan exhibited moderate harmful to predators producing 26.21% and 31.71% reduction in 2017 season and 31.7 and 44.32% reduction in 2018 season, respectively. It is important to note that tested predators under field conditions was reduced by chlorpyrifos recoding 58.59 and 68.43% in 2017 and 2018 seasons, respectively. These results decided that flonicamid, imidacloprid and dinotefuran were low toxic effect than the tested organophosphates and carbosulfan to the tested predators. The current results are in harmony with Hautier *et al*., (2006) who observed that flonicamid was less harmful than organophosphates, pyrethroids and neonicotinoids to the beneficial arthropods in the open field. In addition, Colomer *et al*., 2011; Ghelani *et al.*, 2014 and El-Zahi *et al.*, 2017 found that flonicamid was safer than imidacloprid and thiamethoxam to coccinellids and chrysopids under field conditions.

On the basis of the current investigation, it can be concluded that flonicamid, imidacloprid and dinotefuran have high activity against *Aphis gossypii* Glover and *Bemisia tabaci* (Genn.). 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.

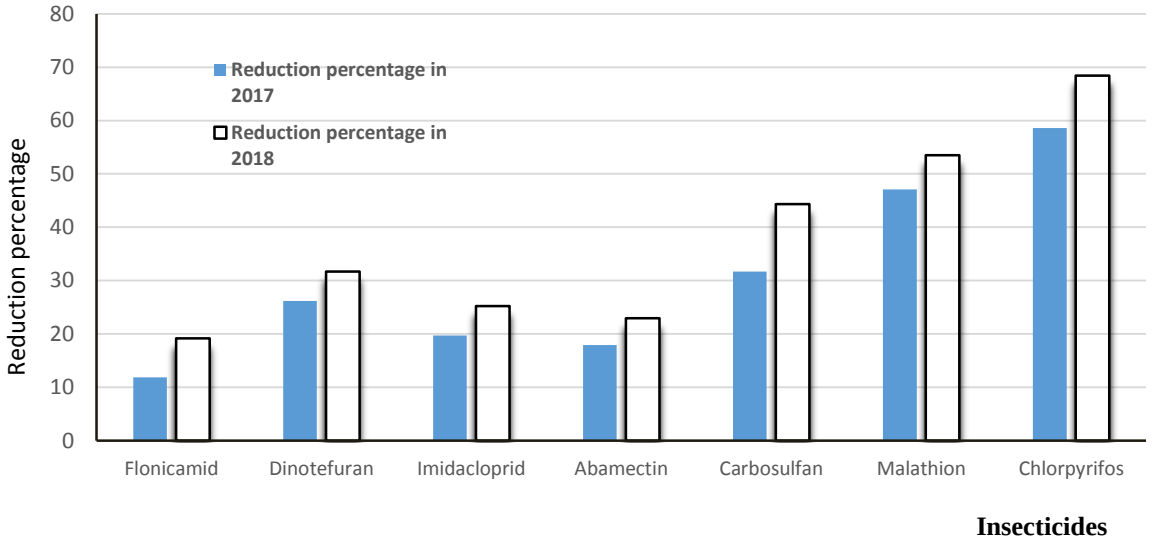

Figure 1. Efficacy of the tested insecticides against associated predators under field conditions at 2017 and 2018 cotton seasons

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الملخص العربي

فاعلية المبيدات المخلقة على من القطن والذبابة البيضاء وبعض المفترسات المرتبطة بهما على نباتات القطن

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مركبات مجموعتي بيرودانيكربكساميد و نيونيكوتينيد من المبيدات الكيميائية التى تستخدم بمعدلات صغيرة ولها أهمية اقتصادية فى مكافحة الأفات الثاقبة الماصة فى حقول القطن ، لذا تهدف هذه الدراسة تقييم فاعلية مبيد فلونيكاميد و اميداكلوبريد و داينيتفيوران ومقارنتهم فاعليتهم بمبيدات أخرى مثل أبامكتين ،كربوسلفان ،ملاثيون و كلوربيرفوس على من القطن والذبابة البيضاء ودراسة تأثيرهم على بعض المفترسات المرتبطة بهما مثل أسد المن (اليرقة والحشرة الكاملة) والعناكب الحقيقية .أجريت الدراسة بالمزرعة البحثية بسخا بمحافظة كفر الشيخ وذلك فى موسمى القطن ٢٠١٧،٢٠١٨ وكانت المبيدات السبعة المختبرة مستخدمة بالمعدلات الموصي بها .أوضحت النتائج أن مبيد اميداكلوبريد و فلونيكاميد و داينيتفيوران أكثر المبيدات فاعليةعلى من القطن وكانت نسبة الخفض فى التعداد (٧٦,١٦ ،٨٦,٣٦، ٩٢,٩٥%) وذلك فى موسم ٢٠١٧وكان ٧٨,٤٤،٨٢,٨٤،٩٠,٩٥%فى ٢٠١٨ ، وسجل مبيدى كربوسلفان و كلوربيرفوس تأثيرا متوسطا معنويا فى خفض تعداد المن ، بينما كان مبيد الملاثيون أقلها فاعلية على المن ، بالنسبة لتأثير المبيدات المختبرة على الذبابة البيضاء فقد سجلت المبيدات اميداكلوبريد و فلونيكاميد و داينيتفيوران أعلى تأثير على الطور الكامل للذبابة البيضاء وكانت نسبة الخفض فى التعداد تراوحت من(٦٧,٥٤-٧٨,٤٦%) فى موسمي القطن ٢٠١٧ ،٢٠١٨، وانخفض تعداد الطور الغير كامل للذبابة البيضاء من (٧١,٠٤-٨٧,٢٦%) بينما كان مبيد كربوسلفان أقلها تأثيرا على الطور الكامل والغير الكامل للذبابة البيضاء ،وأشارت النتائج أن مبيدات اميداكلوبريد و فلونيكاميد و داينيتفيوران أقل سمية على أكثر المفترسات المصاحبة انتشارا عن المبيدات الفوسفورية العضوية المختبرة وعن مبيد كربوسلفان .مما سبق يتضح أن مبيدات اميداكلوبريد و فلونيكاميد و داينيتفيوران يمكن اختيارهم للاستخدام ضمن برامج المكافحة المتكاملة لمن القطن والذبابة البيضاء فى حقول القطن.