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Field efficiency and selectivity effects of selected insecticides on cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididea) and its predators

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Abstract

Cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) is a key pest of cotton plants in Egypt. A two-year field study was conducted at Faculty of Agriculture, Assiut University, Egypt, during 2013 and 2014 growing seasons to determined the efficiency of acetamiprid, imidacloprid, thiamethoxam, dinotefuran, pirimicarb and malathion on cotton aphid and selectivity effects of these insecticides on *Coccinella undecimpunctata* L. and *Chrysoperla carnea* (Stephens). The results indicated that thiamethoxam, dinotefuran, acetamiprid and imidacloprid proved to be the most effective insecticides in reducing cotton aphid population up to 21 days after treatment throughout both seasons and caused an average reduction percentage ranged from 73.58 to 96.42%%, whereas pirimicarb and malathion showed the lowest reduction with an average ranged 38.08 to 66.68 % at different exposure dates during 2013 and 2014 seasons. In addition, the selectivity effects of acetamiprid, imidacloprid, pirimicarb and malathion reduced the population of *C. undecimpunctata* with an average ranged from 78.05 to 96.43% and were classified as harmful. Thiamethoxam reduced the population with an average ranged from 68.72 to 69.20% and was classified as moderately harmful. Dinotefuran showed a slightly harmful effect to *C. undecimpunctata* with an average reduction 44.3 and 41.81% during 2013 and 2014 seasons. On the other hand, acetamiprid and dinotefuran caused a significant reduction in the population of *C. carnea* with an average ranged from 28.28 to 56.52% and were classified as harmless. Thiamethoxam and imidacloprid reduced the population with an average ranged from 55.53 and 64.39% and were classified as moderately harmful. By contrast, malathion and pirimicarb showed the highest reduction in the population with an average ranged from 67.15 to 96.57% and were classified as harmful during both seasons. These results suggested that, the selection of a suitable insecticide in an IPM program to control the cotton aphid not only depends on its efficiency against the aphid but also its toxicity to natural enemies (predators and parasitoids) and its persistence.

Key words: Aphididae , cotton, insect predators, pesticides, selectivity

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Introduction

The cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) is a polyphagous sap sucking aphid pest of cotton throughout the world causing a significant problem due to the honeydew contamination of the open boll lint (Schepers, 1989; Sarwar et al., 2013). Its importance as a cotton pest has increased throughout the cotton producing regions of the world (Leclant & Deguine, 1994). In Egypt, *A. gossypii* considered as one of the most serious pests and its damage affects the yield of cotton seeds as well as the fiber quality, beside the transmission of the viral diseases (Abou-Elhagag 1998a, b; El-Kady, 2007). The use of chemical control is the most common choice of farmers to eliminate not only the cotton aphid but many other arthropod pests as well. Some commonly used insecticides may only worsen an aphid outbreak by removing aphid predator species and allowing the population to dramatically increase. The intensive use of insecticides to control this pest over many years has led to populations that are now resistant to several classes of insecticides (Tabacian et al., 2011**)**. In recent years, selective insecticides (e.g. neonicotinoids) were introduced into the market instead of traditional insecticides because of insect pests (such as aphids) became more resistant to the most conventional insecticides and subsequently replacing the organophosphates and methyl-carbamates (Tomizawa et al., 2007). Acetamiprid, imidacloprid, thiamethoxam and dinotefuran are new type of necotinoid insecticides which act by binding to nicotionic acetylcholine receptors and provide an excellent control as seed and foliar treatments against a broad range of commercially important sucking insect pests, such as aphids, whiteflies, thrips, jassids and others (Prasanna et al., 2004; Abd-Ella, 2014). The selectivity, low rate of use and safety to beneficial insects especially when used as seed dressings make neonicotinoids an ideal component in any IPM program. The use of these neonicotinoid insecticides is more compatible with aphid predators, which used as a bio-control agent to limit aphid dissemination. Indeed, most contact insecticides from different chemical classes have a broad spectrum of effects on both prey and predator (Talebi et al., 2008). The objectives of the present work are to investigate the efficiency and selectivity of foliar treatment of four neonicotinoid insecticides acetamiprid, imidacloprid, thiamethoxam and dinotefuran in comparison with the commonly used malathion (organophosphate) and pirimicarb (carbamate) on cotton aphid, *A. gosypii*, and the most common insect predators, *Coccinella undecimpunctata* L. (Coleoptera: Coccenillidae) and *Chrysoperla carnea* (Stephens) (Neuroptera: Crysopidae) under cotton field conditions.

Materials and methods

Insecticides: Tested pesticide trade names, formulation types, percentage of active ingredients, and application rate are listed in Table 1 and their structures are illustrated in Figure 1. The pesticide concentrations used in this study were based on the labeled recommendation rate.

Table 1: Descriptions of the insecticides used against the cotton aphid and its predators.

Active ingredient (a.i.)	Trade name	(a.i.) % and formulation*	Manufacturer	Recommended rate
Acetamiprid	Mospilan®	20% SP	Nippon Soda Ltd.	25mg L^{-1}
Imidacloprid	Confidor®	20% SC	Bayer CropScience	0.5ml L^{-1}
Thiamethoxam	Actara®	25% WP	Syngenta Agro	50mg L^{-1}
Dinotefuran	Ochin®	20% SG	Mitsui Chemicals	50mg L^{-1}
Malathion	Malathon®	57% EC	Sinochem Ningbo Chemicals	5ml L^{-1}
Pirimicarb	Aphox®	50% DG	Syngenta Agro	31.2mg L^{-1}

*SP: Soluble powder, SC: Suspension concentrate, WP: Wettable powder, SG: Soluble granules, EC: mulsifiable concentrate, DG: Dispersible granules.

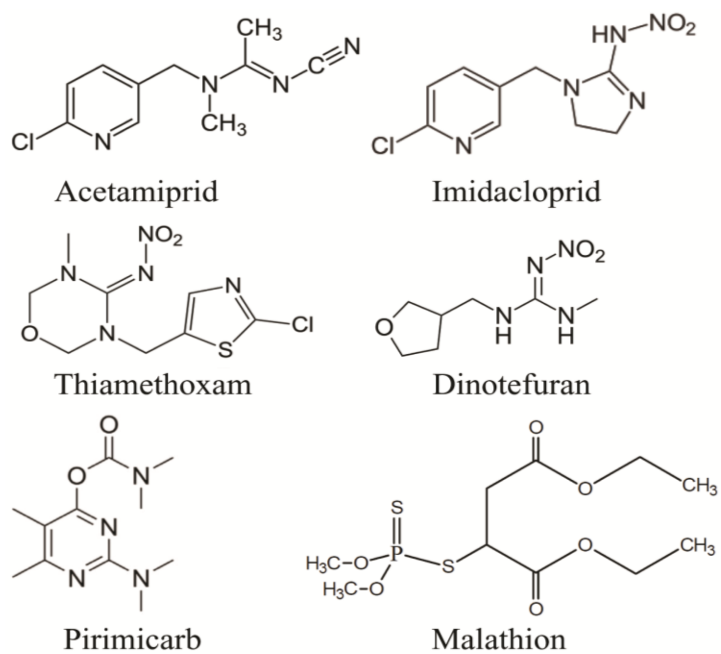

Fig 1. Structure of selected neonicotinoid (acetamiprid, imidacloprid, thiamethoxam and dinotefuran), carbamate (pirimicarb) and organophosphate (malathion) insecticides used against cotton aphid, *A. gossypii* under cotton field conditions.

Field trial, sampling method, experimental design and pest inspection: The field studies were conducted in cotton field (Egyptian cultivar Giza 90) at Assiut University Experimental Farm (Assiut, Egypt), during 2013 and 2014 seasons. The experimental area was divided into plots, 3 ×3.5 meters and planted on March 15, 2013 and on March 21, 2014. Sampling of aphid and its predators was commenced on April 7, 2013 and retained weekly till the aphid disappearance. Tested neonicotinoid (acetamiprid, imidacloprid, thiamethoxam and dinotefuran), carbamate (pirimicarb) and organophosphate (malathion) insecticides were distributed in a randomized complete block design

(RCBD) in three treated replications and untreated control. A knapsack sprayer with one nozzle covering 200 liter per feddan (1 feddan= 0.42 hectare) was used in the application. Insecticides were applied twice a year on April 7 and 28, 2013 and on April 15 and May 6, 2014. Ten plants were randomly selected from each replicate before and after treatment at periods of 1, 7, 15 and 21 days of treatment for evaluating the efficiency and the residual activity of these insecticides on aphid populations and its predators.

Impact and selectivity effects of different insecticides on *A. gossypii* and its predators: The percentages of aphids and predators reduction were calculated according to Henderson & Tilton's equation (1955) to determine the field efficiency and selectivity effect of the tested insecticides (after 1, 7, 15 and 21 days of spraying).

$$\text{Reduction \%} = \left(1 - \frac{\text{n in Co before treatment} * \text{n in T after treatment}}{\text{n in Co after treatment} * \text{n in T before treatment}}\right) * 100$$

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

Pesticides used in this study were categorized according to the International Organization of Biological Control (IOBC) classification to three categories (Hassan, 1994; Boller et al., 2005) as following: N=harmless or slightly harmful (reduction semi field 0–50%, laboratory <30%), M=moderately harmful (reduction semi field 51–75%, laboratory 30–79%), and T=harmful (reduction semi field >75%, laboratory ≥ 80%).

Statistical analysis: Data were analysed using one-way ANOVA and presented as mean ± S.E.M (Standard Error of Mean). Means were separated by Duncan's Multiple Range Test (DMRT). Figures and statistical analysis were done using Graph Pad Prism 5™ software (San Diego, CA).

Results

Impact of insecticides on the population of cotton aphid, *A. gossypii*: The growing of the cotton aphid, *A. gossypii* population started at the beginning of April and have increased until the end of the first week of June during 2013 and 2014 seasons (Fig. 2A, B). Aphid reached a peak of 11.35 and 3.12 insects per plant in the second week of May during 2013 season and in the third week of May during 2014 season, respectively. The results presented in Figure 2A, B reveal that the population of cotton aphid was reduced by insecticide treatments which caused a significant reduction compared to the control in both years. The aphid populations were lower in the plots treated with thiamethoxam, dinotefuran, acetamiprid and imidacloprid in the second weeks of May and in the third week of May during 2013 and 2014 seasons than the untreated plots. These results show that, thiamethoxam, dinotefuran, acetamiprid and imidacloprid caused an average reduction percentage of cotton aphid which was 96.42, 95.94, 84.71 and 73.58 %, whereas pirimicarb and malathion showed an average reduction about 66.68 and 38.08% at different exposure dates during 2013 season, respectively (Table 2). During 2014 season, acetamiprid, imidacloprid, pirimicarb, thiamethoxam exhibit a maximum reduction to aphid population as 100, 87.83, 80.83 and 74.74% respectively. In contrast to dinotefuran and malathion, which showed an average reduction of 66.83 and 32.11% respectively (Table 3).

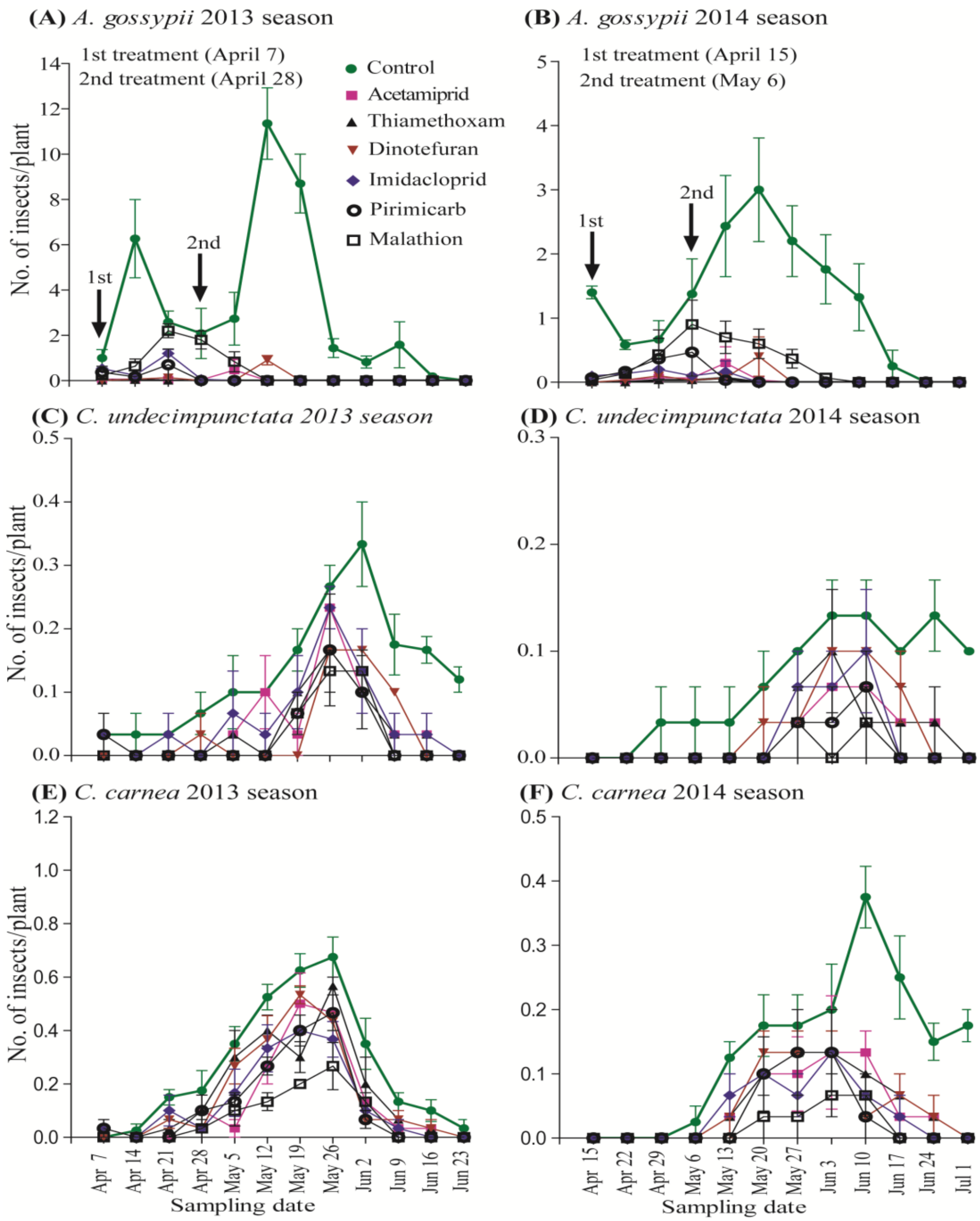

Fig 2. Abundance of cotton aphid, *A. gossypii* (A, B), *C. undecimpunctata* (D, E) and *C. carnea* (E, F) on cotton plant after two treatments of different insecticides under field conditions during 2013 and 2014 seasons.

Table 2: Efficacy of selected insecticides for control of cotton aphid, *A.gossypii* at 1, 7, 15 and 21 DAT during 2013 season under field conditions.

		Reduction (%) of cotton aphid population ± SE				
Insecticides	Recommended rate	1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	96.54±0.3[a]	91.12 ±2.2[a]	99.50±2.4[a]	51.66±1.8[d]	84.71±11.15[b]
Thiamethoxam 25% WP	0.5 ml L^{-1}	100.00±0.0[a]	85.67±3.2[b]	100.00±0.0[a]	100.00±0.0[a]	96.42±3.58[a]
Dinotefuran 20% SC	50 mg L^{-1}	100.00±0.0[a]	86.97±1.9[b]	96.80±2.1[a]	100.00±1.7[a]	95.94±3.08[a]
Imidacloprid 20% SC	50 mg L^{-1}	65.98±2.1[c]	62.11±1.2[c]	75.61±1.1[c]	90.65±2.1[b]	73.58±6.35[c]
Pirimicarb 50% DG	31.2 mg L^{-1}	58.62±2.3[d]	51.27±2.1[d]	90.15±1.3[b]	66.68±2.1[c]	66.68±8.43[d]
Malathion 57%EC	5 ml L^{-1}	74.31±1.4[b]	36.13±1.2[e]	28.73±2.4[d]	13.15±1.6[e]	38.08±12.99[e]

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test (DMRT).

Table 3: Efficacy of selected insecticides for control of cotton aphid, *A.gossypii* at 1, 7, 15 and 21 DAT during 2014 season under field conditions.

		Reduction (%) of cotton aphid population ± SE				
Insecticides	Recommended rate	1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	100.00±0.0[a]	100.00±0.0[a]	100.00±0.0[a]	100.00±0.0[a]	100.00 ±0.0[a]
Thiamethoxam 25% WP	0.5 ml L^{-1}	43.52±2.8[b]	55.42±1.9[b]	100.00±0.0[b]	100.00±0.0[a]	74.74±14.78[d]
Dinotefuran 20% SC	50 mg L^{-1}	22.66 ±3.2[d]	40.67±4.3[c]	100.00±0.0[a]	100.00±0.0[a]	66.83±20.06[e]
Imidacloprid 20% SC	50 mg L^{-1}	100.00±0.0[a]	100.00±0.0[a]	100.00±0.0[a]	51.30±2.4[c]	87.83±12.17[b]
Pirimicarb 50% DG	31.2 mg L^{-1}	45.75±1.8[b]	100.00±0.0[a]	93.41±1.6[b]	84.14±1.9[b]	80.83±12.14[c]
Malathion 57%EC	5 ml L^{-1}	32.85±2.8[c]	25.22±4.6[d]	32.87±3.5[c]	37.55±2.6[d]	32.11±2.55[f]

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to DMRT.

Impact and selectivity effects of different insecticides on *C. undecimpunctata*: The population density of *C. undecimpunctata* was very low in the early season and reached its peak in the first week of June (0.33 and 0.14 insect/plant) during 2013 and 2014 seasons (Fig. 2C, D). The foliar application of thiamethoxam, dinotefuran, acetamiprid, imidacloprid, pirimicarb and malathion showed a significant reduction on the population of *C. undecimpunctata* compared to untreated plots at different exposure dates during the two seasons. During 2013 season (Table 4), acetamiprid, imidacloprid, pirimicarb and malathion reduced the population of *C. undecimpunctata* with an average ranged from 78.05 to 96.43% and were classified as harmful (T= reduction> 75%). Thiamethoxam reduced the population with an average 69.20% and was classified as moderately harmful (M= reduction from 51 to 75%). Dinotefuran showed a slightly harmful (harmless) effect to *C. undecimpunctata* with an average reduction 44.3% (N= reduction from 0 to 50%) (Fig. 3A, B). For 2014 season, results in Table 5 show that, acetamiprid, imidacloprid and malathion caused a significant reduction in the population of *C. undecimpunctata* with an average ranged from 77.87 to 86.53% and were classified as harmful. Thiamethoxam and pirimicarb reduced the population with an average 68.72 and 59.00% and were classified as moderately harmful. Dinotefuran was a slightly harmful and reduced the population with an average 41.18% (Fig. 3A, B).

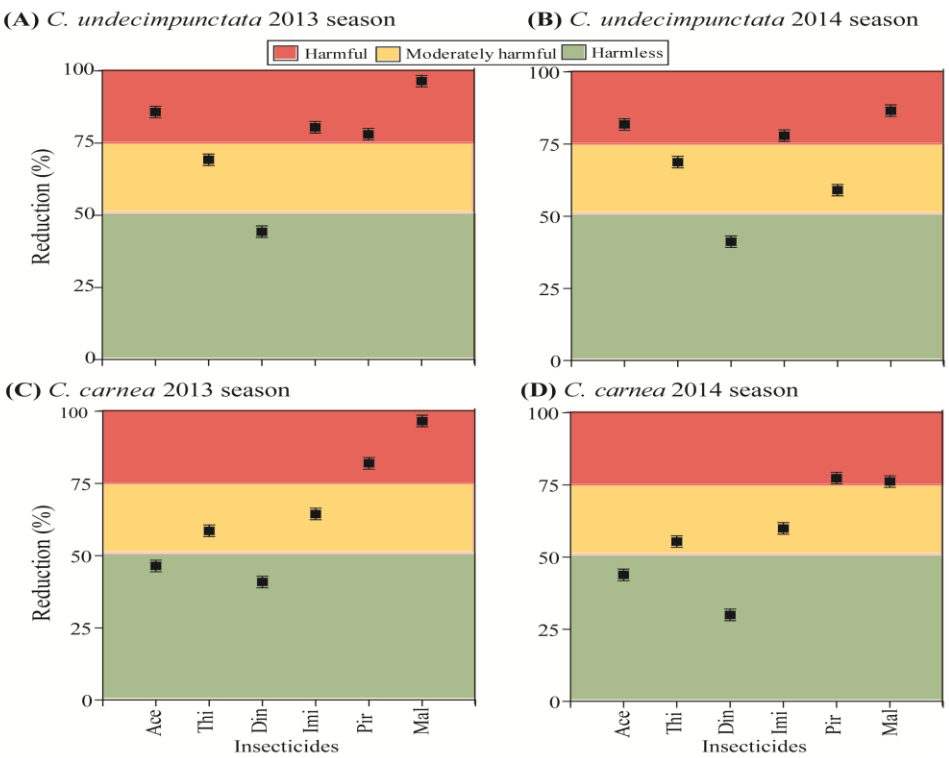

Fig 3. Impact and selectivity effects of different insecticides on *C. undecimpunctata* (A, B) and *C. carnea* (C, D) on cotton plant under field conditions during 2013 and 2014 seasons. IOBC toxicity classification (field test): N= harmless or slightly harmful (reduction ranged from 0 to 50%), M= moderately harmful (reduction ranged from 51 to 75%) and T= harmful (reduction>75%). Ace: acetamiprid, Thi: thiamethoxam, Din: dinotefuran, Imi: imidacloprid, Pir: pirimicarb and Mal: malathion.

Table 4: Reduction percentage and selectivity effects of insecticides on *C. undecimpunctata* at 1, 7, 15 and 21 DAT during 2013 season under cotton field conditions.

		Reduction (%) of *C. undecimpunctata* population ± SE				
Insecticides	Recommended rate	1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	100.00±0.0[a]	100.00±0.0[a]	84.22±0.0[b]	58.62±2.2[c]	85.71[b]T
Thiamethoxam 25% WP	0.5 ml L^{-1}	59.25±1.6[b]	66.82±2.4[d]	72.28±3.1[c]	78.46±0.6[b]	69.20[d]M
Dinotefuran 20% SC	50 mg L^{-1}	31.62±1.3[e]	62.69±0.9[e]	33.62±2.1[f]	49.28±2.5[d]	44.30[e]N
Imidacloprid 20% SC	50 mg L^{-1}	82.06±2.6[c]	96.82±1.7[b]	64.23±1.9[e]	78.56±3.8[b]	80.42[c]T
Pirimicarb 50% DG	31.2 mg L^{-1}	86.24±2.3[b]	79.82±1.8[c]	68.28±3.5[d]	77.84±2.4[b]	78.05[c]T
Malathion 57%EC	5 ml L^{-1}	100.00±0.0[a]	100.00±0.0[a]	96.42±2.5[a]	89.28 ±1.8[a]	96.43[a]T

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. IOBC toxicity classification (field test): N= harmless or slightly harmful (0-50%), M= moderately harmful (51-75%) and T= harmful (reduction>75%). Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to DMRT.

Table 5: Reduction percentage and selectivity effects of insecticides on *C. undecimpunctata* at 1, 7, 15 and 21 DAT during 2014 season under cotton field conditions.

		Reduction (%) of *C. undecimpunctata* population ± SE				
Insecticides	Recommended rate	1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	50.20±2.3[c]	100.00±2.1[a]	100.00±1.9[a]	76.92±1.2[b]	81.78[b]T
Thiamethoxam 25% WP	0.5 ml L^{-1}	50.00±1.4[c]	76.92±2.1[b]	70.00±2.6[b]	76.92±2.8[b]	68.72[d]M
Dinotefuran 20% SC	50 mg L^{-1}	23.53±0.9[e]	58.82±2.9[d]	23.53±3.2[d]	58.82±1.5[d]	41.18[f]N
Imidacloprid 20% SC	50 mg L^{-1}	80.50±2.4[b]	100.00±0.0[a]	61.00±1.8[c]	70.00±2.3[c]	77.87[c]T
Pirimicarb 50% DG	31.2 mg L^{-1}	35.00±1.8[d]	70.00±2.5[c]	61.00±2.9[c]	70.00±2.6[c]	59.00[e]M
Malathion 57%EC	5 ml L^{-1}	100.00±0.0[a]	46.15±2.3[e]	100.00±0.0[a]	100.00±0.0[a]	86.53[a]T

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. IOBC toxicity classification (field test): N= harmless or slightly harmful (0-50%), M= moderately harmful (51-75%) and T= harmful (reduction>75%). Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to DMRT.

Impact and selectivity effects of different insecticides on *C. carnea*: The common green lacewing, *C. carnea,* is considered an important aphid predator in cotton plants in Egypt. The population of *C. carnea* was very low in the early season and reached its peak in the fourth week of May (0.68 insect/plant) during 2013 and in the second week of June (0.36 insect/plant) during 2014 season (Fig. 2E, F). The impact of foliar application of thiamethoxam, dinotefuran, acetamiprid, imidacloprid, pirimicarb and malathion showed a significant reduction on the population of *C. carnea* compared to untreated plots at different exposure dates during the two seasons. Results in Table 6 showthe reduction percentage and selective effects of different insecticides on *C. carnea* at 1, 7, 15 and 21 DAT during 2013 season. Acetamiprid and dinotefuran caused a significant reduction in the population of *C. carnea* with an average ranged from 28.28 to 56.52% and were classified as slightly harmful (harmless). Thiamethoxam and imidacloprid reduced the population with an average 58.61 and 64.39% and were classified as moderately harmful. By contrast, malathion and pirimicarb showed a highest reduction in the population with an average 96.57 and 81.95% and were classified as harmful (Fig. 3C, D). During 2014 season, results in Table 7 show that acetamiprid and dinotefuran caused a significant reduction in the population of *C. carnea* with an average 43.84 and 29.94% and were classified as slightly harmful (harmless). Thiamethoxam and imidacloprid reduced the population with an average 55.35 and 59.92% and were classified as moderately harmful. Malathion and and pirimicarb caused the highest reduction in the population with an average 67.15 and 77.33% and were still classified as harmful (Fig. 3C, D).

Table 6: Reduction percentage and selectivity effects of insecticides on *C. carnea* at 1, 7, 15 and 21 DAT during 2013 season under cotton field conditions.

		Reduction (%) of *C. carnea* population ± SE				
Insecticides	Recommended rate	1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	31.12±1.6^{e}	56.52±1.8^{d}	48.21±2.6^{d}	49.88±1.5^{e}	46.43^{c}N
Thiamethoxam 25% WP	0.5 ml L^{-1}	22.62±1.4^{f}	58.44±2.3^{d}	74.82±2.4^{c}	78.56±1.3^{b}	58.61^{b}M
Dinotefuran 20% SC	50 mg L^{-1}	45.46±1.8^{d}	28.28±2.6^{e}	33.58±1.8^{e}	56.12±2.6^{d}	40.86^{d}N
Imidacloprid 20% SC	50 mg L^{-1}	48.35±0.9^{c}	71.86±1.5^{c}	76.08±3.1^{c}	61.26±1.2^{c}	64.39^{b}M
Pirimicarb 50% DG	31.2 mg L^{-1}	78.42±2.4^{b}	82.28±1.8^{b}	88.06±2.6^{b}	79.02±2.1^{b}	81.95^{a}T
Malathion 57%EC	5 ml L^{-1}	100.00±0.0^{a}	100.00±0.0^{a}	100.00±0.0^{a}	86.26±2.2^{a}	96.57^{a}T

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. IOBC toxicity classification (field test): N= harmless or slightly harmful (0-50%), M= moderately harmful (51-75%) and T= harmful (reduction>75%). Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to DMRT.

Table 7: Reduction percentage and selectivity effects of insecticides on *C. carnea* at 1, 7, 15 and 21 DAT during 2014 season under cotton field conditions.

Insecticides	Recommended rate	Reduction (%) of *C. carnea* population ± SE				
		1 DAT	7 DAT	15 DAT	21 DAT	Average
Acetamiprid 20% SP	25 mg L^{-1}	23.51 ± 3.3^{d}	54.95 ± 2.1^{d}	44.36 ± 1.4^{c}	52.52 ± 2.5^{d}	43.84^{c}N
Thiamethoxam 25% WP	0.5 ml L^{-1}	15.86 ± 2.8^{e}	54.95 ± 1.5^{d}	76.15 ± 1.2^{a}	74.43 ± 2.3^{b}	55.35^{b}M
Dinotefuran 20% SC	50 mg L^{-1}	5.66 ± 2.4^{f}	27.78 ± 3.1^{e}	31.37 ± 1.2^{d}	54.95 ± 1.9^{d}	29.94^{d}N
Imidacloprid 20% SC	50 mg L^{-1}	42.82 ± 1.6^{c}	64.65 ± 1.1^{c}	73.26 ± 2.8^{a}	59.05 ± 2.7^{c}	59.92^{b}M
Pirimicarb 50% DG	31.2 mg L^{-1}	65.66 ± 1.5^{b}	78.47 ± 2.6^{b}	76.15 ± 1.4^{a}	89.04 ± 3.5^{a}	77.33^{a}T
Malathion 57%EC	5 ml L^{-1}	100.00 ± 0.0^{a}	100.00 ± 0.0^{a}	48.53 ± 2.5^{b}	56.08 ± 1.9^{d}	76.15^{a}T

Notes: Data are expressed as means ± stander error (SE) of three replicates at each insecticide. DAT: Day after treatment. IOBC toxicity classification (field test): N= harmless or slightly harmful (0-50%), M= moderately harmful (51-75%) and T= harmful (reduction>75%). Means followed by the same superscript letter(s), within the same column are insignificantly different ($P \leq 0.05$) according to DMRT.

Discussion

In this study, we found that the foliar application of neonicotinoid insecticides acetamiprid, thiamethoxam, dinotefuran and imidacloprid caused a high significant reduction in the cotton aphid population in the cotton fields during 2013 and 2014 seasons (Fig. 2A, B). In addition, the efficiency and residual effects of these insecticides persisted up to 21 DAT against *A. gossypii* in both years (Table 2, 3). By contrast, carbamate (pirimicarb) and organo-phosphate (malathion) caused a lower reduction in the cotton aphid population than the neonicotinoid insecticides. That was because of the cotton aphid having developed a resistance to malathion and pirimicarb compared to the neonicotinoid insecticides due to the intensive use of these insecticides by farmers to control this pest over many years (Ahmed et al., 2003). Similar results indicated that neonicotinoid insecticides were highly effective against cotton aphid and reduced the population of this pest (up to 14 days) under field conditions (Shi et al., 2011; El-Naggar & Zidan, 2013). In addition, when outbreaks occur in cotton aphid populations, insecticides application is the only effective tactic to suppress this pest and consequently insect predators often got killed which resurge the pest again and thus more sprays are needed. That will lead us to use selective insecticides to spare the natural enemies (Preetha et al., 2009).

The foliar application of the above insecticides reduced significantly the population of the predators, i.e., *C. undecimpunctata* and *C. carnea* as compared with the untreated plots during 2013 and 2014 seasons (Table 4-7). This might be due to the direct toxicity of these insecticides to the predators in foliar application along with the possibility of intake of poisonous hosts (prey). The results of our study revealed that under field conditions, malathion, pirimicarb, acetamiprid and imidacloprid were harmful to *C. undecimpunctata* (96.43, 78.05, 85.71 and 80.42%, respectively) during 2013 season (Table 4, 5). While thiamethoxam was moderately harmful (69.20%) and dinotefuran proved to be the least toxic one to this predator and classified as slightly harmful (44.30%). During 2014 season, malathion, acetamiprid and imidacloprid were harmful to *C. undecimpunctata* (86.5, 81.78, 77.87%, respectively), thiamethoxam and pirimicarb were moderately harmful (68.72 and 59.00%) and dinotefuran was still the lowest toxic one and classified as harmless (41.18%) (Fig. 3A, B). These results manifested that the reduction percentage of aphid population during 2014 season was less than 2013 season and *C. undecimpunctata* predator may be more tolerant to these insecticides. Thus, the decrease of aphid populations in the second season probably resulted in a coincidence with the decrease in the population of *C. undecimpunctata.* Our results are contrary to the results obtained by El-Zahi and Arif (2011) who found that imidacloprid and thiamethoxam were harmless to insect predators. They also found that, organophosphates (chlorpyrifos, profe-nophos) and carbamate (methomyl) were the most toxic ones to the predators on cotton plants under field conditions. Previous studies indicated that pirimicarb is harmless to several natural enemies, for example ladybirds and lacewings under laboratory and field conditions (Jansen, 2000; Cabral et al., 2008; Jansen et al., 2011; Bacci et al., 2012).

The common green lacewing, *C. carnea,* is the main natural enemy that has been effectively used to control various insect pests in different agro-ecosystems (Athan et al., 2004; Tsaganou et al., 2004). In addition to selectivity effect, our study found that malathion and pirimicarb have the highest toxic effects to *C. carnea* with a significant reduction of its population and classified as harmful (96.57, 81.95% and 76.15, 77.33%) (Table 6, 7). Moreever, the results here indicated that malathion and pirimicarb are a highly persistent up to 21 DAT and reduced the population of *C. carnea* on cotton plants. Our results are contrary to the results obtained by Cabral et al., (2008) how found that pirimicarb was harmless to several natural enemies, for example ladybirds and lacewings under laboratory and field conditions. However imidacloprid and thiamethoxam were classified as moderately harmful (64.39, 58.61% and 59.92, 55.35%). By contrast, acetamiprid and dinotefuran were the least toxic ones on *C. carnea* among the tested insecticides and classified as harmless (46.43, 40.86% and 43.84, 29.94%) during 2013 and 2014 seasons respectively (Fig. 3C, D). Arnaouty et al. (2007) observed a shorter residual toxicity of imidacloprid (Confidor 20% SL) against the second instar larvae of *C. carnea* than to target pests (up to 4 days). Elbert et al. (1998) reported that exposure of *C. carnea* larvae to imidacloprid resulted in a 40% reduction in the population under field conditions. Imidacloprid was determined to be extremely harmful to *C. carnea* third instar larvae, and inhibited adult emergence as well as killing a high proportion of newly emerged adults (Huerta et al., 2003). However, thiamethoxam caused 86.7% mortality of the *C. carnea* larvae and found to be a moderately harmful after 24 hours and harmful after 48 hours exposure for semifield and field tests (Nasreen et al., 2005). Earlier studies have shown that an organophosphate phosalone was moderately harmful to syrphid larvae (*Syrphus vitripiennis* Meigen), harmless for lacewings larvae, *C. carnea*, under laboratory trials and reduced the population of these predators under field conditions (Jansen, 2000).

Generally, it could be concluded that the neonicotinoid insecticides acetamiprid, thiamethoxam, dinotefuran and imidacloprid can be used to control cotton aphid, *A. gossypii*, followed by carbamate (pirimicarb) and organophosphorus (malathion) in cotton fields. Regarding the residual effect of these insecticides which they were highly persistent up to 21 DAT. These insecticides can be ascending order as follows: thiamethoxam > acetamiprid > imidacloprid > dinotefuran > pirimicarb > malathion for controlling the cotton aphid. Thus, the neonicotionid insecticides still provide a good efficiency against cotton aphid under field conditions but, the problem is that this pest can develop resistance very quickly for these insecticides. Therefore, we must use these insecticides in an orderly manner and place them in a controlling program which makes this pest unable to develop a resistance to them. In addition to the selectivity effects of these insecticides between aphid and its predators under cotton field conditions, which classified by IOBC classification to be either harmful or slightly harmful to *C. undecimpunctata* and *C. carnea* and their orders based on which were malathion > pirimicarb > thiamethoxam > acetamiprid > imidacloprid > dinotefuran. Therefore, *C. undecimpunctata* and *C. carnea* were more sensitive to the organophosphorus (malathion) and carbamate (pirimicarb) than the nionicotinoid insecticides. These results could be useful for the selection of suitable insecticides for use in IPM program in cotton plants to control the cotton aphid under field conditions.

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