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# Insect Predators and Control of *Aphis gossypii* Comparing to Certain Insecticides under Caged-cotton Plants Conditions

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**Abstract:** Numerous beneficial arthropods prey on aphid populations in cotton fields. Field experiments were conducted at Kafr El-Sheikh Governorate, Egypt in seasons of 2010 and 2011 to examine the impact of naturally occurring insect predators on cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) comparing to the impact of three insecticides; i.e., diafenthiuron, imidacloprid and thiamethoxam at their recommended rates using caged-plants technique. The toxicity of these insecticides to insect predators was determined likewise. Cotton aphid population on uncaged plants, where insect predators and aphids were allowed to develop undisturbed, declined gradually and consequently showed the lowest population density of aphids per cotton leaf at the last inspection. On the contrary, severe decrease in cotton aphid numbers occurred on caged plants that treated with insecticides and this decrease continued up to 15 days after spray, then increases in aphid numbers happened and significantly indicated the highest aphid population density at the last inspection. Density of aphid populations increased rapidly on caged-untreated plants, where insect predators were excluded and no insecticides were applied and declined only after exceeding the carrying capacity of cotton plants. Diafenthiuron was the most toxic to the insect predators. Imidacloprid and thiamethoxam significantly proved to be the least toxic to insect predators. Further studies are needed to establish the integration effect between selective insecticides and beneficial arthropods to control cotton aphids and other pests.

**Key words:** Insect predators, *Aphis gossypii*, caged-cotton plants, diafenthiuron, imidacloprid, thimaethoxam

## INTRODUCTION

Cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), is one of the most injurious insect pests which suck the cell sap and considered one of the cotton yield limiting factors (Fondren *et al*., 2004). Aphids damage is due not only to its direct feeding, but also to honeydew production during boll set resulting in sticky cotton that can decrease cotton lint quality (Carter, 1992). Chemical control of cotton aphid is primarily depend on the application of insecticides (Herron *et al*., 2001) such as organo-phosphates, carbamates and pyrethroids which have led to development of *A. gossypii* resistance (Cao *et al*., 2007; Pan *et al*., 2009). However, insecticides resistance and growing concerns on environmental hazard due to frequent use of insecticides prompted development of biological control of aphids. Novel compounds including neonicotinoids, the newest major class of insecticides, have the potential for crop protection against sucking pests and predators with low toxicity to environment components (Foster *et al*., 2003).

Biological control of aphids is being increasingly applied in the greenhouse crops (Parrella *et al*., 1999). *A. gossypii* is attacked by numerous predators and parasitoids (Zerpas *et al*., 2007). The polyphagous predator, *Orius* spp., is important predator of soybean aphid (Rutledge *et al*., 2004), resides in several Mediterranean crops throughout the growing season (Riudavents and Castane, 1998) and effectively preys on several pests (Tommasini *et al*., 2004). Coccinellid beetles are important group of predatory insects with considerable biocontrol potential against aphids and other pests (Michaud, 2012). Also, Kim *et al*. (2008) reported that cotton aphid populations were decreased due to the attraction of lady beetles to infested plants. Our goal in this study was to examine the capability of naturally occurring insect predators in suppression of cotton aphids population comparing to chemical insecticides using field caged-plants technique. Also, the toxicity of tested insecticides to selected insect predators was evaluated.

## MATERIALS AND METHODS

**Tested insecticides:** Insecticides were selected based on recommendation of Egyptian Ministry of Agriculture and

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all of the concentrations are within the recommendation (on cotton aphids) for field application use. Three insecticides tested, their trade names, formulations and field recommended concentrations applied were as follows:

- Thiamethoxam (Actara 250 WG), neonicotinoid insecticide, obtained from Syngenta Agro AG Co., applied at rate of 20 g/100 L
- Imidacloprid (Imidor 200 SL), neonicotinoid insecticide, obtained from Astrachem Agri. Co., applied at rate of 50 mL/100 L
- Diafenthiuron (Polo 500 SC), Thiourea derivative insecticide, obtained from Syngenta Agro AG Co., applied at rate of 100 mL/100 L

Irrigation water was used in diluting the tested insecticides at their mentioned rates. The final volumes of spray solutions were equal to 200 L per 4200 $m^2$. A knapsack sprayer ($CP_3$) equipped with one nozzle was used to give complete coverage of caged or uncaged plants.

**Field experimental design:** Field experiments were conducted at Kafr El-Sheikh Governorate, Egypt in seasons of 2010 and 2011. In both seasons, an area of 4200 $m^2$ was sown on 25 April with cotton seeds cv. Giza 86 and divided into plots each of 81 $m^2$. Unplanted belts with 1 and 2 m width were left as barriers between every two adjacent plots. The recommended agricultural practices were followed throughout the two growing seasons without using any insecticidal treatments. The complete randomized blocks design with four replications was adopted in all experiments of this study. In caged plants treatment wooden cages (1.2 m length by 1.0 m width by 1.8 m height) and covered with 40 mesh mosquitoes netting was used to prevent insect entry or escape. The inspections started immediately before spray as zero time on (20 July 2010 and 25 July 2011) and continued on 5 days basis through 29 August 2010 and 3 Sep. 2011.

**Efficiency of tested insecticides on cotton aphids:** To evaluate the efficiency of tested insecticides against cotton aphids, four plots were randomly selected and within each one of them four groups of cotton plants were chosen. Each group contained four cotton plants growing in two adjacent hills in the same row. Plant selection was based on the total number of aphids on the entire plant. Adjacent plants were removed one meter on all sides of each selected group, each group of caged plants was considered as one replication. Four caged-untreated replications represented the control-C1. In each replication, the total number of aphids on 10 randomly selected full-sized leaves was counted using lens and the mean number of aphids/leaf was estimated at every inspection.

**Impact of insect predators on cotton aphids:** The predacious stages of the most abundant naturally occurring insect predators in cotton fields and effectively prey on cotton aphids were studied. The selected insect predators included; *Coccinella* spp., larvae and adults; *Chrysoperla carnea*, larvae; *Scymnus* spp., larvae and adults; *Orius* spp., nymphs and adults.

To determine the impact of insect predators on cotton aphids, all arthropods other than cotton aphids were removed from the selected plants prior to positioning the cages. Four plots were randomly selected free from any insecticidal treatments, where cotton aphids and insect predators were allowed to develop undisturbed. In each plot, 50 cotton leaves infested with aphids were chosen and labeled. The numbers of aphids on labeled leaves were counted using lens and the mean number per leaf was estimated at every inspection. The population density of cotton aphid in this experiment was compared to aphid population densities on caged-untreated plants (Control-C1) and other caged-treated plants. In this experiment, 10 cotton plants were randomly chosen from each plot and the numbers of selected insect predators on the entire plant were directly counted using lens at the same dates of inspection of aphids population. The mean numbers of selected insect predators per cotton plant were estimated at every inspection.

**Side effects of tested insecticides to selected insect predators:** In this experiment additional 12 plots were randomly chosen (uncaged plants). Each four plots were made for each tested insecticide. The three tested insecticides were applied as described previously. From each plot, 10 cotton plants were randomly selected and inspected as shown in pervious paragraph to monitor the numbers of mentioned insect predators. The population densities of selected predators/cotton plant were estimated. The population densities of selected predators in uncaged-untreated plots (predators impact) were taken as control.

**Statistical analysis:** The data were subjected to one-way analysis of variance (ANOVA). Duncan's multiple range test and Least Significant Difference test (LSD) were used to determine significant differences between treatments ($p<0.05$) by CoStat system for Windows, Version 6.311, Berkeley, CA, USA (CoStat, 2006).

## RESULTS AND DISCUSSION

**Efficiency of tested insecticides on *A. gossypii* population comparing to impact of selected insect predators:** Cotton aphid populations development on caged-insecticides treated, caged-untreated (Control-C1) and uncaged-untreated cotton plants of 2010 season were presented in Table 1. Initial counts were taken directly before spray, where population densities of cotton aphid averaged from 28.3 to 32.4 aphids per leaf at different treatments. Mean aphid populations on all caged insecticides-treated plants were severely decreased after 5 days of spray, recording less than 5.8 aphids per leaf. Caged imidacloprid-treated plants significantly recorded the lowest (2.6) mean aphids per leaf after 5 days and gradually increased to level of 36.4 aphids per leaf after 40 days. Caged-diafenthiuron and caged-thiamethoxam treated plants significantly showed the same effect on aphid populations throughout the first 25 days, where the lowest means of aphids per leaf were 1.9 and 2.9 after 15 days of spray and gradually increased to 6.3 and 11.1 aphids per leaf after 25 days for the two treatments, respectively. The aphid population increase continued and recorded 26.2 and 39.9 aphids per leaf after 40 days for the two treatments, respectively.

Aphid population density on caged-untreated plants (Control-C1) significantly showed the highest levels in all dates following zero time inspection comparing to all other treatments, recording 84.8 aphids per leaf after 5 days of spray and quickly increased to 490.9 aphids per leaf after 15 days. Aphid population density in this treatment peaked at 840.7 individuals per leaf after 25 days, then declined and appeared to level off at 408.1 aphids per leaf after 40 days when inspections were terminated. This decline appeared to be a consequence of cotton aphid population exceeding the carrying capacity of cotton plants.

The impact of selected insect predators on cotton aphids was monitored in uncaged-untreated (predators impact) plants. In this treatment, cotton aphid populations increased initially to 32.1 insects per leaf after 5 days of spray then declined piecemeal to give significantly the lowest mean of aphids per leaf (8.5) after 40 days of spray when inspections were terminated. Data presented in Table 2, 2011 season, indicated that cotton plants were infested with aphids at levels lower than that of 2010 season, where aphid population density averaged from 22.7 to 26.1 aphids per leaf at zero time. In 2011 season, the studied treatments approximately showed the same direction of effect on aphid populations as obtained in 2010 season.

The impact of naturally occurring predators in cotton fields on development of cotton aphid populations is not well defined even present time. Leser *et al.* (1992) stated that the average of predators population was less than 1% of aphids population and the impact of this low predators density in preventing cotton aphid development was unknown. Our results indicated that in uncaged-untreated plants, when aphids and predators populations were allowed to develop undisturbed, aphids population increased for short duration (5 days) at the beginning of the experiments, then gradually declined by the act of

Table 1: Mean number of *Aphis gossypii* per cotton leaf on caged and uncaged cotton plants exposed to various treatments under field conditions of 2010 season

| | | Mean No. of *A. gossypii*/cotton leaf at indicated dates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | After spray at days | | | | | | | |
| Treatments | Rate of application per 100 L | Before spray (20 July) | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Caged diafenthiuron-treated | 100 mL | 28.3$^{a}$ | 5.20$^{c}$ | 1.900$^{c}$ | 1.900$^{c}$ | 3.20$^{d}$ | 6.300$^{c}$ | 11.200$^{c}$ | 16.800$^{c}$ | 26.200$^{c}$ |
| Caged imidacloprid-treated | 50 mL | 30.5$^{a}$ | 2.60$^{d}$ | 2.500$^{c}$ | 4.000$^{c}$ | 10.50$^{c}$ | 16.400$^{b}$ | 20.100$^{b}$ | 27.300$^{b}$ | 36.400$^{b}$ |
| Caged thiamethoxam-treated | 20 g | 32.4$^{a}$ | 5.80$^{c}$ | 3.400$^{c}$ | 2.900$^{c}$ | 6.70$^{cd}$ | 11.100$^{c}$ | 18.200$^{b}$ | 25.400$^{b}$ | 39.900$^{b}$ |
| Caged untreated (Control-C1) | - | 31.7$^{a}$ | 84.80$^{a}$ | 210.100$^{a}$ | 490.900$^{a}$ | 650.30$^{a}$ | 840.700$^{a}$ | 713.900$^{a}$ | 512.300$^{a}$ | 408.100$^{a}$ |
| Uncaged untreated (predators impact) | - | 30.9$^{a}$ | 32.10$^{b}$ | 29.200$^{b}$ | 27.100$^{b}$ | 24.20$^{b}$ | 20.600$^{b}$ | 15.400$^{bc}$ | 12.900$^{c}$ | 8.500$^{d}$ |
| LSD 5% | - | ns | 2.401 | 5.552 | 6.206 | 5.881 | 4.965 | 5.087 | 5.637 | 4.058 |

Within the same column, means followed by the same letter are not significantly different using Duncan's test ($p<0.05$). ns: Not significant

Table 2: Mean number of *Aphis gossypii* per cotton leaf on caged and uncaged cotton plants exposed to various treatments under field conditions of 2011 season

| | | Mean No. of *A. gossypii*/cotton leaf at indicated dates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | After spray at days | | | | | | | |
| Treatments | Rate of application per 100 L | Before spray (25 July) | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Caged diafenthiuron-treated | 100 mL | 22.9$^{a}$ | 4.500$^{c}$ | 1.500$^{c}$ | 1.200$^{c}$ | 2.900$^{d}$ | 5.800$^{c}$ | 10.200$^{c}$ | 14.900$^{c}$ | 21.500$^{c}$ |
| Caged imidacloprid-treated | 50 mL | 25.1$^{a}$ | 2.200$^{d}$ | 2.500$^{c}$ | 3.100$^{c}$ | 8.700$^{c}$ | 14.200$^{b}$ | 18.600$^{b}$ | 24.500$^{b}$ | 32.600$^{b}$ |
| Caged thiamethoxam-treated | 20 g | 22.7$^{a}$ | 4.000$^{c}$ | 2.800$^{c}$ | 2.100$^{c}$ | 5.400$^{cd}$ | 10.100$^{bc}$ | 16.300$^{b}$ | 21.300$^{b}$ | 30.400$^{b}$ |
| Caged untreated (Control-C1) | - | 26.1$^{a}$ | 75.400$^{a}$ | 189.200$^{a}$ | 410.500$^{a}$ | 536.700$^{a}$ | 721.900$^{a}$ | 640.300$^{a}$ | 490.600$^{a}$ | 330.300$^{a}$ |
| Uncaged untreated (predators impact) | - | 23.5$^{a}$ | 26.200$^{b}$ | 22.700$^{b}$ | 19.300$^{b}$ | 15.400$^{b}$ | 11.800$^{b}$ | 8.600$^{c}$ | 5.700$^{d}$ | 4.200$^{d}$ |
| LSD 5% | - | ns | 1.716 | 4.880 | 4.262 | 4.551 | 5.625 | 5.132 | 5.892 | 6.015 |

Within the same column, means followed by the same letter are not significantly different using Duncan's test ($p<0.05$), ns: Not significant

insect predators. Hassell and May (1986) mentioned that, the response of predatory arthropods was unlikely to occur quickly enough to lead to pest outbreak suppression. This decline continued through the inspections was terminated. Unfortunately, aphids population density did not decrease to level off zero at any inspection of uncaged-untreated plants as a direct effect of predators, but anyhow aphids population density was lower than that in caged insecticides-treated plants at the end of experiment. Population density of selected insect predators was low at the first inspection and then increased after. Winder *et al.* (1994) reported that, the abundance peak of predators was generally delayed in comparison with that of the prey. The changes in predator's population density appeared to be a direct response to the increase and decline of aphid's populations. Predation of aphids by coccinellids is potentially important in maintaining cotton aphid densities below the treatment levels (Conway *et al.*, 2006). Severe decline in aphids population density was obtained (5 days post treatment) in caged-plants which treated with one of diafenthiuron, imidacloprid and thiamethoxam. This decline continued only up to 15 days post treatment and then aphid populations increased to their highest levels when inspections were stopped. On the contrary, aphid's population density showed the lowest average per cotton leaf in the last inspection of uncaged plants, where predators allowed to act undisturbed even the inspection termination. In case of caged-untreated plants, where predators were excluded and there were no insecticides application, rapid increases in cotton aphid population densities occurred and declined only after exceeding the carrying capacity of caged-plants.

**Side effects of tested insecticides to selected insect predators:** The selected insect predators were inspected and their population densities per cotton plant on uncaged-insecticides treated and uncaged-untreated plants (predators impact) as control in 2010 and 2011 seasons were presented in Fig. 1 and 2, respectively. All the tested insecticides affected significantly the survival of predators, the mean number of selected insect predators were significantly decreased (Duncan's test at $p<0.05$) than that obtained from the control in the two seasons. In 2010 season, Fig. 1, diafenthiuron was significantly decreased the mean number of selected insect predators 0.67 than that values obtained from the control groups 2.62 predators per plant. Diafenthiuron was the most harmful to selected insect predators during the experiment. On the other hand plots treated with thiamethoxam and imidacloprid was significantly decreased the mean number of selected insect predators compared with the control (LSD 5% = 0.402). Thiamethoxam and imidacloprid proved to be less harmful to selected insect predators without significant differences between them 1.93 and 1.66 predators per plant, respectively Population density of selected predators on uncaged-untreated plants (control) increased from 2.1 predators per plant on 20 July to 2.9 predators per plant on 25 July. According to the results we observed similar trends to side effects of tested insecticides in the mean number of selected insect predators with in 2011 season (Fig. 2). The mean numbers of selected insect predators for control, thiamethoxam, imidacloprid and diafenthiuron were 2.30, 1.60, 1.51 and 0.74 predators per plant, respectively (LSD 5% = 0.323).

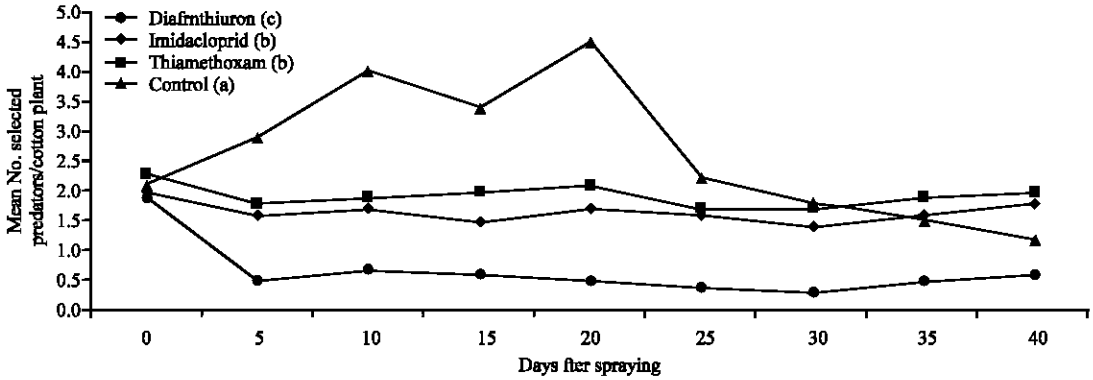


Fig. 1: Mean number of selected insect predators (*Coccinella* spp., larvae and adults; *Chrysoperla carnea*, larvae; *Scymnus* spp., larvae and adults; *Orius* spp., nymphs and adults) per uncaged cotton plant exposed to various treatments under field conditions of season 2010. Treatments followed by the same letter(s) are not significantly different at p = 0.05 (Duncan's test), LSD = 0.402 and F = 14.709

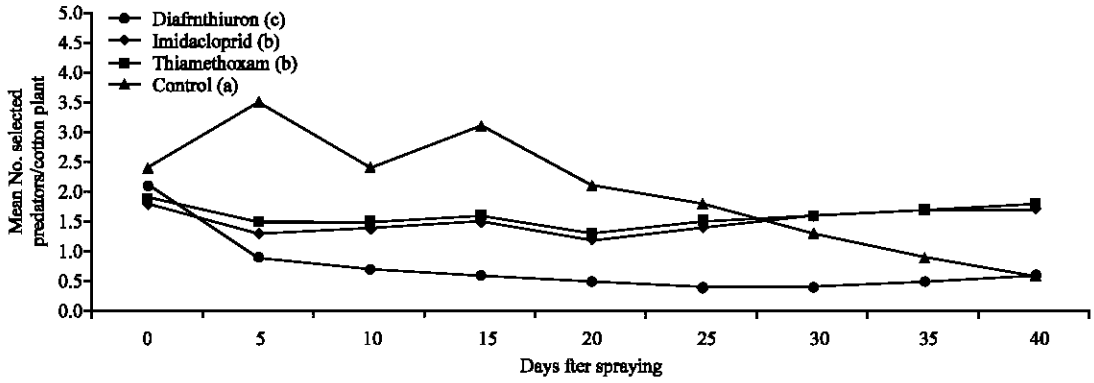


Fig. 2: Mean number of selected insect predators (*Coccinella* spp., larvae and adults; *Chrysoperla carnea*, larvae; *Scymnus* spp., larvae and adults; *Orius* spp., nymphs and adults) per uncaged cotton plant exposed to various treatments under field conditions of season 2011. Treatments followed by the same letter(s) are not significantly different at p = 0.05 (Duncan's test), LSD = 0.323 and F = 7.778

Insecticides application is unavailable tactic especially when outbreaks occur in aphid populations and many of these insecticides often kill natural enemies making the pest to resurge and thus more sprays are needed. Insecticides used in programs of pests control should be selective enough to spare the beneficials (Preetha *et al*., 2009). Results of our study revealed that, under field conditions, diafenthiuron was the most toxic to selected insect predators. Where, the population density of selected predators in treated plots averaged less than one predator per cotton plant after spray and remained at this level all through the experiment duration. Abdelgader (2000) found similar results and reported harmful effects of diafenthiuron on predators. The neonicotinoid insecticides, imidacloprid and thiamethoxam proved to be the least toxic to selected insect predators. In plots treated with either imidacloprid or thiamethoxam, the population densities of predators were higher than that in untreated control at the last inspection. This may be due to the harmless effect of the two neonicotinoids on predators and the increase of aphid's population in treated plots at the last inspection. While, the decrease of aphid populations in untreated plots at last inspection resulted in coincide decrease in population of predators. Varghese and Beevi (2004) stated that, chlorpyrifos was the most toxic to *Chrysoperla carnea* larvae followed by profenofos while the imidacloprid was the safest. El-Zahi and Arif (2011) found that, imidacloprid and thiamethoxam were harmless to insect predators on cotton plants under field conditions.

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