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INSECTICIDE RESISTANCE IN THE COTTON APHID, *Aphis gossypii* GLOVER IN EGYPT

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ABSTRACT

The cotton aphid, *Aphis gossypii* Glover (Hemiptera - Aphididae), is one of the most important sap sucking pests in many cotton-growing areas world-wide. In this study, the efficacies of seven insecticides [organophosphate (Fenitrothion & Pirimiphos-methyl), carbamate (Carbosulfan & Aldicarb), pyrethroid (Lambda-Cyhalothrin & Deltamethrin) and imidaclopride (Confidor)] were determined against four strains of *Aphis gossypii* (Glover) collected from four Governorates in Egypt [Damytta (DAM), Dakahlia (DAK), Qaliobia (QAL) and Giza (GIZ)]. Collected strains were bioassayed and compared with a reference susceptible strain. QAL and DAM strains demonstrated 8.64 and 6.11-fold resistance, respectively to fenitrothion and also demonstrated 14.4 and 8.84-fold resistance, respectively to pirimiphos-methyl. QAL and DAM strains recorded 14.6 and 3.11-fold resistance, respectively to lambda-cyhalothrin while DAK and DAM strains recorded 11.49 and 5.71-fold resistance, respectively to deltamethrin. QAL and DAK strains demonstrating 27.7 and 10.05-fold resistance, respectively to carbosulfan and also demonstrated 18.3 and 8.57-fold resistance, respectively to aldicarb, while QAL and DAM strains recorded 32.55 and 1.82-fold resistance, respectively to confidor. These results are discussed in relation to the possible mechanisms of resistance present in the studied *A. gossypii* strains and underpin the resistance management strategy for aphids in Egypt.

Key words: cotton aphid - *Aphis gossypii* Glover – insecticides [organophosphate - carbamate - pyrethroid.

INTRODUCTION

Cotton aphid, *Aphis gossypii* Glover (Hemiptera - Aphididae) is the main aphid pest of cotton throughout the world causing significant problems due to honeydew contamination of the open boll lint (Schepers, 1989). The importance of *A. gossypii* as a cotton pest is increasing throughout the cotton-producing regions of the world (Leclant and Deguine, 1994). In Egypt, *A. gossypii* has recently emerged as one of the most serious pests. *A. gossypii* damage affects the yield of cotton seeds as well as the fiber quality, also these aphids can transmit viral diseases. There has been a general evolution of resistance in *A. gossypii* to most insecticides. First reported insecticide resistance was by Melander (1914). Resistance to insecticides has been found in at least 20 aphid species (Georghiou, 1981). In regards to *A. gossypii*, resistance to organophosphorious products was first reported in 1964 (Kung *et al.*, 1964). Subsequently, resistance to carbamates (Furk *et al.*, 1980) and pyrethroids (Zil'bermints & Zhuravleva, 1984) was reported.

The aim of the present investigation is to determine whether *A. gossypii* collected from Egypt is resistant to some insecticides intensively used in cotton field.

MATERIAL AND METHODS

Aphid strains

The laboratory standard clones (the susceptible reference strain; SUS) maintained in culture throughout the study was obtained from Plant Protection Research Institute., where it had been maintained in the absence of insecticides since 1998.

Four field strains were collected during 2005, DAM from Damytta governorate, DAK from Dakahlia governorate, QAL from Qaliobia governorate and GIZ from Giza governorate. All strains were reared parthenogenetically in the laboratory without prior cloning or exposure to insecticides. Each strain was reared on whole plants of cotton, *Gossypium barbadense* cv. Giza 81, in cages (50x50x50 cm) covered with an muslin at 26ºC. Plants were grown in a standardized soil mixture in plastic containers, plants were changed regularly and new ones infested to avoid host plant deterioration and excessive crowding of aphids.

Insecticides used

Formulations of the 7 tested insecticides were used for bioassays: organophosphates, Sumithion (Fenitrothion, 500 g/l- EC) and Actellic (Pirimiphos-methyl, 250 g/l-EC);carbamate Marshal (Carbosulfan, 10G 10% w/w) and Temik (Aldicarb, 10G 10% w/w); pyrethroid Hallmark (Lambda-cyhalothrin, 50 g/l- EC) and Decis (Deltamethrin, 25 g/l-EC) and Imidaclopride (Confidor, 200 g/l-SL)

Leaf-dip bioassay

Discs (35 mm diameter each) were cut from cotton leaves and dipped in insecticide solution for 20 s, placed abaxial surface uppermost on an agar bed (25 mm in depth) in disposable plastic containers (30mm high), and allowed to air-dry. Adults of each strain (10 per container) were gently placed on the treated leaf surface. Leaf discs dipped in distilled water were used as controls. Bioassay containers were covered with a fine mesh lid and maintained at 25 ±1ºC and 65% RH under ambient daylight conditions. All bioassays were scored at 24 h intervals up to 72 h following initial exposure to insecticide. Insects were considered alive if they showed any sign of movement, each bioassay test used three replicates of five concentrations each.

Systemic bioassay

Because imidacloprid, aldicarb and carbosulfan are highly systemic insecticides, it was considered important to establish a systemic bioassay test to mimic as a far as possible the typical means of exposure to these insecticides.

Fully expanded leaves were cut from cotton plants and the petiole was immediately immersed into the required concentration of insecticide, for 24 h. Leaves immersed in distilled water were used as control. Leaf discs were cut from these treated leaves and placed onto agar in disposable plastic containers. 10 adults from each strain were placed on the treated leaf surface, containers were covered with a fine mesh lid and stored as described with leaf-dip bioassay.

Analysis of bioassays

Dose-response bioassay against standard strain and field strains were conducted using three batches of 10 aphids (i.e. 30 insects) at a minimum of five insecticide concentrations per bioassay. Each assay was repeated at least three times and results pooled for analysis, probit analysis of the concentration dependent mortality data were carried out using the software program POLO-PC (Anon., 1987). Resistance factors (RFs) were calculated by dividing the LC50 of the resistant strain by the LC50 of the susceptible strain. All LC50 values were calculated in ppm.

RESULTS

Leaf-dip bioassay, organophosphates

Data in Table (1) showed that DAM strain displayed little resistance to fenitrothion (6.11 fold resistance), DAK and GIZ strains exhibited similarly resistance to fenitrothion (7.71 and 7.58 fold resistance), but QAL strain was more resistant to fenitrothion (8.64 fold resistance).

In comparison, DAM and GIZ strains exhibited 8.84 to 9.41 fold resistance to pirimiphos-methyl, but QAL and DAK strains were more resistance to primiphos-methyl (14.4 to 12.03 fold). Generally all strains consider more resistant to primiphos-methyl than fenitrothion.

Leaf-dip bioassay, pyrethroids

Data in Table (2) indicate that DAM strain exhibited unacceptible resistance to lambda cyhalothrin (3.11 fold), while DAK and GIZ strains showed some tolerance to lambda cyhalothrin (7.39 to 8.56 fold). While the slight resistance to lambda cyhalothrin (14.6 fold) was recorded from QAL aphids.

The slight resistance was observed in both DAK and QAL strains to deltamethrin (11.49 and 10.79 fold), but DAM strain was the least resistant (low tolerance) to deltamethrin (5.71 fold) followed by GIZ strain (7.97 fold).

Systemic bioassay, carbamates

Data in Table (3) indicate that QAL strain was, relatively, the highest resistant to carbosulfan (27.7 fold), followed by DAM strain (20.9 fold), while in GIZ and DAK strains, resistance factors varied from 12.56 to 10.05 fold for carbosulfan. In comparison, all strains displayed little variation in resistance to aldicarb, QAL strain showed highest resistance (18.3 fold), while DAK strain was vigor tolerant (8.57 fold). Resistance factors for DAM and GIZ strains were 10.56 and 12.38 respectively. Generally all strains showed more resistance to carbosulfan than aldicarb.

Table (1): Comparative responses of *Aphis gossypii* strains tested against fenitrothion & primiphos-methyl (organophosphates)

Strains	Fenitrothion					Pirimiphos-methyl				
	N.	LC50 (ppm)	95% CLs	slope (b)	RF	N.	LC50 (ppm)	95% CLs	slope (b)	RF
SUS	365	11.29	9.07-13.95	2.99	-	370	11.32	7.15-17.08	0.755	-
DAM	298	69.02	55.04-80.83	3.20	6.11	348	100.08	83.43-116.06	2.61	8.84
DAK	305	87.10	72.79-100.5	3.07	7.71	339	136.23	109.2-164.6	2.74	12.03
QAL	258	97.49	83.09-111.7	3.26	8.64	325	163.02	127.56-203.6	2.86	14.4
GIZ	307	85.62	71.24-98.93	3.15	7.58	330	106.56	84.61-127.55	2.52	9.41

Table (2): Comparative responses of *Aphis gossypii* strains tested against lambda cyhalothrin & deltamethrin (pyrethroids)

Strains	Lambda cyhalothrin					Deltamethrin				
	N.	LC50 (ppm)	95% CLs	slope (b)	RF	N.	LC50 (ppm)	95% CLs	slope (b)	RF
SUS	370	5.67	4.43-6.76	2.44	-	380	4.63	2.57-6.43	2.05	-
DAM	385	17.63	5.72-27.86	1.06	3.11	387	26.45	15.7-36.3	0.97	5.71
DAK	351	41.9	30.9-51.55	2.2	7.39	391	53.19	39.5-64.6	2.73	11.49
QAL	381	82.86	61.5-102.2	2.16	14.6	367	49.94	30.2-66.33	2.19	10.79
GIZ	378	48.55	21.4-71.79	1.81	8.56	385	36.9	21.15-49.6	2.51	7.97

Table (3): Comparative responses of *Aphis gossypii* strains tested against carbosulfan & aldicarb (carbamates)

strains	Carbosulfan					Aldicarb				
	N.	LC50 (ppm)	95% CLs	slope (b)	RF	N.	LC50 (ppm)	95% CLs	slope (b)	RF
SUS	260	7.82	4.96-11.60	1.26	-	272	7.99	2.39-17.13	0.46	-
DAM	310	163.6	66.93-1202.6	0.49	20.9	305	84.34	47.19-213.34	0.64	10.56
DAK	273	78.60	37.06-334.9	0.51	10.05	302	68.45	31.85-305.35	0.46	8.57
QAL	304	216.75	84.27-1776.7	0.56	27.7	342	146.17	64.96-761.04	0.53	18.3
GIZ	308	98.23	41.17-691.54	0.46	12.56	296	98.9	48.36-379.33	0.55	12.38

Systemic bioassay, imidacloprid

From data in Table (4) all strains could be considered resistant to imidacloprid except DAM strain. LC50s for all strains to imidacloprid ranged from 0.089 to 1.595 ppm, DAM was highest susceptible strain (1.82 fold), while QAL was the most resistant strain (32.55 fold), followed by DAK and GIZ strains (25.39 and 12.76 fold, respectively).

Table (4): Comparative responses of *Aphis gossypii* strains tested against imidacloprid

Strains	Confidor				
	N.	LC50 (ppm)	95% CLs	slope (b)	RF
SUS	478	0.049	0.002-0.200	0.68	-
DAM	373	0.089	0.000-0.307	1.30	1.82
DAK	351	1.244	0.714-1.827	1.19	25.39
QAL	350	1.595	0.917-2.359	1.07	32.55
GIZ	362	0.625	0.285-1.015	1.26	12.76

DISCUSSION

The current study revealed that all strains showed varied degrees of resistance to the 7 insecticides studied. The highest resistance was recorded at LC50 of 216.75 ppm in QAL strain for carbosulfan, in contrast, the lowest resistant strain was DAM strain for confidor (LC50 0.089 ppm).

Pesticide bioassays are useful for detecting the trends in *A. gossypii* resistance to insecticides. The data indicated that resistance to carbamates is quite high and intensifying, suggesting that their application may be approaching an end. In contrast, resistances to organophosphates and pyrethroids occured, yet the level or frequency of resistance is fluctuating from year to year (Grafton-Cardwell and Goodell 1996).

Modification of synapse acetylcholinesterase, the target protein of carbamates and organophosphates, has been reported in *A. gossypii* (Susuki and Hama 1994) and *Myzus persicae* (Moores *et al.* 1994).

Increased detoxification by esterases is also a frequent mechanism of resistance in aphids. It has been reported in *A. gossypii* (Suzuki *et al.* 1993) and *Myzus persicae* and *Myzus nicotiana* (Field *et al.* 1994).

The obtained resistance values to lambda-cyhalothrin and deltamethrin (pyrethroids) may be attributed to increased detoxification, by the mutation of the Na+ voltage dependent channel, which is the target of pyrethroid insecticides.

Imidacloprid, on the other hand, was very effective against *A. gossypii*. Imidacloprid was found to be more toxic to *A.gossypii* (Kumar, 1998) and *Aphis craccivora* than methyl demeton (Ramesh babu and Santharam, 2000) and to apple aphids *Nasonovia ribisnigri* and *M.persicae* than lamda-cyhalothrin, deltamethrin, cypermethrin, dimethoate, methyl demeton, primicarb and heptanophos (Barber *et al*., 1999).

There is greater potential for maintaining susceptibility of aphids to these pesticides if their use is limited. There is a great need for new insecticides for aphid control to provide different chemistries to rotate with and so manage insecticide resistance. In addition, greater selectivity of new aphid insecticides is needed to allow the natural enemies of other pests to survive so that growers become less dependent on insecticides.

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