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Resistance to Lambada-Cyhalothrin in Laboratory Strain of Whitefly *Bemisia tabaci* (Genn.) and Cross Resistance to Several Insecticides

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Abstract: A lab-strain of whitefly *Bemisia tabaci* (Genn.) was selected for lambda-cyhalothrin and build-up resistance in the laboratory. Resistance was 18.52 fold after 13 generations. These strain showed cross-resistance to the neonicotinoid dinotefuran (8.98-fold) in the 6^{th} generation increased to 14.46-fold in the 13^{th} generation, but the neonicotinoid acetamiprid (39.70-fold) in the 6^{th} generation decreased to 13.96-fold in the 13^{th} generation. Also, it became tolerance to the neonicotinoid imidacloprid, the IGR buprofezin, the OP profenofos, the carbamates methomyl and carbosulfan in the 6^{th} generation, but these insecticides were high susceptibility in the 13^{th} generation. The resistant strain was susceptible to deltamethrin and alpha-cypermethrin (Pyrethroids) and KZ-oil (meneral oil) in the 6^{th} and 13^{th} generation.

Key words: Whitefly *Bemisia tabaci* · Cross-resistance · Lambda-cyhalothrin

INTRODUCTION

Recently, the cotton whitefly *Bemisia tabaci* (Genn.) has become an important pest of cotton and vegetables in Egypt and also all over the world; this may be attributed for many reasons including the random use of insecticides and the subsequent selection of insecticides resistance [1], changes in agronomic practices [2] and the immigration of previously unknown whitefly biotypes [3, 4]. Last thirty years, *Bemisia tabaci* almost exclusively controlled by use conventional insecticides such as organophosphates, pyrethroids and carbamets. It is clear that since 1980s, at least some of these broad-spectrum insecticides were failing in some times. For example the use of pyrethroid cypermethrin, once useful whitefly control agent lost its efficacy [5]. The most challenges in management this pest is the ability to develop insecticide resistance to virtually every chemical that has never been used against it [1].

Rotating insecticides with different modes of action is one of the most commonly recommended approaches to delay insecticide resistance. However, successful implementation of this technique hinges on a good understanding of resistance and cross-resistance patterns in population of target pests [6]. Resistance to insecticides can be considered as a major obstacle to effective whitefly control. The response of increasing dosage and frequency of application of insecticides to combat resistance is not only prohibitive and ecologically unsound but also counter productive. To prevent new global resistance problems, an efficient resistance management program should be established, based on the rotation of compounds with different modes of action. The aim of this study was to evaluate Lambda-cyhalothrin as potential components of resistant management program for *Bemisia tabaci.*

MATERIALS AND METHODS

1.1-Insecticide used

I - Pyrethroids:

1 - Lambda-cyhalothrin (Karate, 20% EC)
2 - Deltamethrin (Decis, 2.5% EC)
3 - Alpha-cypermethrin (Fastac, 15% EC)

II - Neonicotinoids

1 - Dinotefuran (MTI, 446, 4% SG)
2 - Imidacloprid (Confidor, 20% SL)
3 - Acetamiprid (Mospilan, 20% SP)

III - Organophosphorus

1 - Profenofos (Selecron, 72% EC)

IV - Carbamates:

1 - Methomyl (Lannate, 90% WP)
2 - Carbosulfan (Marshal, 25% WP)

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V - Insect Growth Regulator IGR:

1 - Buprofezin (Applaud, 25% SC)

VI - Meneral oil:

1 - Meneral oil (Kz oil, 95% EC)

Bemsia Tabaci (Genn.) Strain: Field strain of *Bemsia tabaci* (Genn.) was collected from Behera Governorate in the year 2000 and maintained without insecticide selection pressure for more than 8 years in Central Agricultural pesticides Laboratory, Department of rearing standard insects. Resistant-strain derived from the Lab-strain was selected with lambda-cyhalothrin for 13 generations.

Bioassay: Bioassay method for obtaining concentration-response lines was described by Dittrich *et al.* [7, 8] and Prabhaker *et al.* [9] with some modification. Cotton leaves were dipped for 5 sec. in 100 ml of the desired concentration of each insecticide and allowed to dry. Treated leaves were laid on a thin layer of 2% agar in small cage and then twenty adults were transferred into the cage by an aspirator. Mortality of adults was recorded 24 and 48 hr after treatment. At least six concentrations were tested for each insecticide; and five replicates were done for each test. Results were expressed as percentage mortalities correcting for untreated (check) mortality using Abbott's formula [10]. Data were analyzed on the computer by probit according to Finney [11].

Selection Procedures: The resistant-strain was subjected to laboratory selection pressure with insecticide, at a level producing 30% mortality to the adult stage. The level of developing resistance was determined in generations 3, 6, 9 and 13. Resistance ratio (RR) was determined by dividing the LC_{50} of the R-strain by the LC_{50} of lab-strain.

RESULTS AND DISCUSSION

Development of Resistance: Data presented in Table 1 show changes in the response of *Bemisia tabaci* adult towards selection pressure of lambda-cyhalothrin. The LC_{50} value increased steadily till 127.08 ppm in the 13^{th} generation. The slopes of regression lines increased, this indicates the heterogenesis of individuals toward resistance to lambda-cyhalothrin. The rate of reduction in the potency of lambda-cyhalothrin increased by continuous stress generationaly until it reached the maximum reduction in the 13^{th} generation (18.52-fold). From these results, it is clear that selection pressure of laboratory population of whitefly with the pyrethroid lambada-cyhalothrin resulted in the development of resistance to this insecticide, although it was collected from the cotton field in 2000 cotton season and maintained in our laboratory under complete absence of any insecticide contamination till time of study. This may be explained by the fact that genes responsible for resistance to pyrethroids still exist within the population and the whitefly would be expected to have a head start in developing resistance to pyrethroids. With history of pyrethroids, they have been only used on cotton for control both cotton leafworm and cotton bollworm during mid growing season in Egypt since 1978. Fortunately the whitefly in cotton was exposed to these insecticides when used against cotton leafworm and cotton bollworm. The resistance levels to several pyrethroids in field population of whitefly were reported by Cem Erdogan *et al.* [12] who showed that significant resistance to pyrethroids, bifenthrin ranged from (190 to 360-fold) and those for fenpropathrin ranged from (57 to 290-fold) to four strains of whitefly *Bemisia tabaci* greater than in an insecticide-susceptible strain.

Table 1: Rate of development of resistance to Lambda-cyhalothrin in whitefly *B.tabaci* (Genn.) during selection for 13 generations

	Karate selected 13 generations strain		
Strain	Slope±SE	LC_{50}ppm (95%FL)	RR*
Susc. strain	1.39±0.43	6.86 (3.43-11.39)	--
Parent	1.12±0.44	5.36 (1.77-13.53)	0.78
G_3	2.86±0.82	21.10	3.10
G_6	1.63±0.24	30.63 (23.78-41.28)	4.46
G_9	1.12±0.37	98.94 (27.02-215.42)	14.42
G_{13}	1.45±0.19	127.08 (97.02-175.51)	18.52

RR* (Resistance ratio) = LC_{50} of the resistant strain / LC_{50} of the Susceptible strain

Table 2: Cross- resistance of several insecticides in white fly Lambda-cyhalothrin resistant strain

		Germination 6			Germination 13		
Insecticide	Strain	Slope ± SE	LC_{50} ppm (95%FL)	RR*	Slope ± SE	LC_{50} ppm (95%FL)	RR*
Lambda-cyhalothrin	Susc. strain	1.39 ± 0.43	6.86(3.43- 11.39)	--	1.39 ± 0.43	6.86(3.43-11.39)	--
Karate 20 % EC	Resist. strain	1.63 ± 0.24	30.65(23.8 - 41.3)	4.47	0.99 ± 0.19	127.08 (97.02-175. 5)	18.52
Deltamethrin	Susc. strain	0.43 ± 0.57	16.10	--	0.43 ± 0.57	16.10	--
Decis 2.5% EC	Resist. strain	1.38 ± 0.22	9.33(5.53-12.94)	0.58	0.69 ±0.18	3.13(0.42- 8.17)	0.19
Alpha- cypermethrin	Susc. strain	0.35 ± 0.06	63.05(30.57-72.81)	--	0.35 ± 0.06	63.05(30.57-172.81)	--
Fastac 15 % EC	Resist. strain	1.01 ± 0.29	139.27(69.13- 35.1)	2.21	0.68± 0.15	99.12(38.37-264.92)	1.57
Imidacloprid	Susc. strain	0.85 ± 0.16	1.19(0.79-1.87)	--	0.85 ± 0.16	1.19(0.79-1.87)	--
Confidor 20 % SL	Resist. strain	1.51 ± 1.19	10.69(8.07-15.49)	8.98	0.79 ± 0.17	17.21(7.26 -39.78)	14.46
Acetamiprid	Susc. strain	0.57± 0.7	8.94	-	0.57 ±0.7	8.94	--
Mospilan 20 % SP	Resist. strain	1.60±0.23	54.19 (42.17- 69.40)	6.06	0.74± 0.21	6.14(1.62-14.37)	0.69
Buprofezin	Susc. strain	0.45± 0.10	1.41(0.59-2.68)	-	0.45± 0.10	1.41(0.59 - 2.68)	--
Applaud 25 % SC	Resist. strain	1.34 ± 1.79	55.98	39.7	1.19± 0.29	19.68(4.59 -38.74)	13.96
Profenofos	Susc. strain	0.76± 0.08	24.92(17. 37- 36.73)	--	0.76 ± 0.08	24.92(17.37- 36.73)	--
Selecron72% EC	Resist. strain	1.98 ± 0.40	237.35(151.57-317.6)	9.52	0.50 ± 0.16	39.46(0.42-8.17)	1.58
Methomyl	Susc. strain	0.98 ± 0.32	105.87(46.51-68.66)	--	0.98 ± 0.32	105.87(46.51-268.66)	--
Lannate 90% WP	Resist. strain	1.71± 0.23	592.16(414.9-793.6)	5.59	1.13 ± 0.20	252.94(128.3-458.2)	2.41
Carbosulfan	Susc. strain	1.26 ± 0.31	101.53(44.43-170.09)	--	1.26 ± 0.31	101.53(44.43-170.1)	--
Marshal 25 % WP	Resist. strain	0.85 ± 0.13	463.17(273.1-759.6)	4.56	0.93 ± 0.18	292.70(117.7-607.9)	2.88
Meneral oil	Susc. Strain	1.24± 0.29	27.35(15.58-49.49)	--	1.24± 0.29	27.35(15.58-49.49)	--
Kz oil 95 % EC	Resist. strain	1.29 ± 0.40	213.78(74.3- 1.00000E+38)	7.82	0.54± 0.14	62.77(13.90-210.96)	2.29

RR* (Resistance ratio) = LC50 of the resistant strain / LC50 of the Susceptible strain

Cross resistance: The toxicity of ten insecticides to adult stage of lambda-cyhalothrin resistant strain was presented in Table 2. These results indicate that the resistant strain showed resistance to acetamiprid (39.70-fold) in the 6^{th} generation, but with development of resistance lambda-cyhalothrin became 13.96-fold in the 13^{th} generation; also became tolerance to dinotefuran, imidacloprid, buprofezin, profenofos, methomyl and carbosulfan. The resistance ratios (RR) were 8.98, 6.06, 9.52, 5.59, 4.56 and 7.82-fold, respectively. In the 13^{th} generation with development of resistance, resistant strain acquired susceptibility to these insecticides except for dinotefuran which recorded high resistance (14.46-fold). Also, resistant strain was susceptible to deltamethrin, alpha-cypermethrin and Kz-oil in the 6^{th} and 13^{th} generation.

Summarized results showed that there is no cross-resistance was found between lambda-cyhalothrin and the two pyrethroid insecticides (deltamethrin and alpha-cypermethrin). These results may be due to the differences in chemical structure of each pyrethroid insecticide in the ester-bonded. In contrast, Yang *et al.* [13] reported that, cross-resistance data indicated that resistance to flucythrinate, fenvalerate and esfenvalerate was higher than that to permethrin, deltamethrin, bifenthrin and cypermethrin against pyrethroid-resistant strain (fenvalerate and phoxim) and they suggested that the acid moiety of pyrethroid structure could be the key to selectivity in the esterase-mediated pyrethroid resistance of *Helicoverpa armigera*.

As for neonicotinoid, Lambda-cyhalothrin - resistant strain exhibited cross-resistance to dinotefuran and acetamprid. From this result, it is suggested that, pyrethroid insecticides should be applied in alternation with neonicotinoid insecticides for control of whitefly. Wang *et al.* [14] found that resistant strain of imidacloprid exhibited cross-resistance to fenvalerate, with a resistance ratio of 108.9 fold on cotton and 33.5 fold on cucumber. The present findings agree with Kayser *et al.* [15] who found two classes of neonicotinoids with distinct modes of interference with imidacloprid, described as direct competitive inhibition and non-competitive inhibition respectively, where the direct competitive share the binding site with imidaclopride or in a different mode. Also, these results are inharmony with Farghaly [16] who found that the resistant strain of thiamethoxam showed cross-resistance only with imidacloprid, diafenthiuron and lambda-cyhalothrin with 22.41, 17.28 and 1540.8 fold, respectively and she suggested that treatment of whitefly *Bemsia tabaci* with neonicotinoid followed by pyrethroids caused resistance to thiamethoxam and lambda-cyhalothrin.

The use of pesticides of different modes and sites of action in rotation, alternation or sequence to control the same pest has been studied and accepted to avoid resistance [17]. It assumes that number of generations or length or time between uses of any one material is sufficient to allow resistance to decline, below a critical frequency. Also, factors determining the selection of resistance to insecticides can for convenience be classified genetically or ecological ones relating to the intrinsic properties of pests and resistance mechanisms and operational one relating to the chemical itself and how applied [17].

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