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CROSS RESISTANCE OF DELTAMETHRIN RESISTANT STRAIN OF PINK BOLLWORM *PECTINOPHORA GOSSYPIELLA* (SAUND.) TO SOME INSECTICIDES

[40]

Mona F. Rofail[1]; M.S. El-Zemaity[2]; A.E. Bayoumi[2] and Hemat Z. Moustafa[1]

1- Plant Protection Research Institute, Agric. Research Center, Dokki, Giza, Egypt
2- Plant Protection Dept., Fac. Agric. Ain Shams Univ. Shoubra El-Kheima, Cairo, Egypt

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ABSTRACT

Selection pressure under laboratory conditions of the field strain of pink bollworm *Pectinophora gossypiella* (Saund.) collected from Sharkeya Governorate, Egypt was carried out using the pyrethroid insecticide deltamethrin. The obtained results indicated that the resistance ratio attained a level of 215.11-fold comparing with the susceptible strain after 14 generations of selection. In addition, the response of the obtained deltamethrin resistant strain to some insecticides indicated the cross-resistance to esfenvalerate whereas no cross-resistance occurred to thiodicarb (carbamate), chlorpyrifos (organophosphorus) and/or the bioinsecticides, Dipel 2X and Agerin (derived from *Bacillus thuringiensis*, subspecies *kurstaki*). These data may emphasize the possibility of rotation of deltamethrin with these insecticides in pest control program of pink bollworm.

INTRODUCTION

Pink bollworm *Pectinophora gossypiella* (Saund.) is one of the most serious pests attacking cotton crop in Egypt and the most cotton producing countries which cause a great damage in the quality and quantity of cotton yield (**El-Naggar, 2003**). In the early of 1980's, pyrethroid insecticides were rapidly substituted for organophosphorus and organochlorine insecticides for control of the pink bollworm due to their wide spectrum, low dosage, high killing efficiency, low residue and low toxicity to humans and animals (**Kranthi *et al* 2001**). Unfortunately, resistance by the bollworm to such insecticides became more and serious because of indiscriminate applications (**Wang, 1992**). Since the resistance of such pests are expected, the aim of the present work is to investigate the development of resistance of *P. gossypiella* to a pyrethroid insecticide, deltamethrin. Also, cross-resistance to other insecticides was studied.

MATERIALS AND METHODS

1. Bioassay and selection pressure procedures for resistance

Newly hatched larvae of a susceptible strain of *P. gossypiella* (Saund.) were obtained from the Bollworm Research Division, Plant Protection Research Institute, ARC, Dokki, Giza, Egypt. Larvae were reared on semi-artificial diet under laboratory conditions for several generations away from exposure to any insecticidal pressure according to the method described by **Rashad and Ammar (1984)**. Field strain (parent) was collected from Ebrahemia region, Sharkeya Governorate,

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Egypt during 2002-2003 cotton season and reared under laboratory conditions as the same with susceptible strain.

Serial concentrations (0.1-500 ppm) of deltamethrin were sprayed into petri dishes (9 cm diameter) using a hand atomizer in a three replicates for each concentration. The treated surfaces were left to dry. Thirty newly hatched larvae were transferred with a clean brush to each treated dish. The dishes were covered with toilet paper then further covered with their covers and kept in an incubator adjusted at 27 ± 2°C and 70-85% R.H. After an hour of exposure, the treated and untreated (check) insects were transferred individually on semi artificial diet poured into glass tubes (2 x 7.5 cm) covered with cotton piece and kept under the previous constant conditions.

The mortality percent was determined and corrected after 24 hours using the **Abbott's formula (1925)**. From the corrected mortality percent and the concentrations used, the toxicity regression lines of the tested compound was plotted and represented in Log/probit relation according to the method of **Finney, (1972)** using the computer program, Sigma Plot for Windows, Version 2.0. LC_{30} and LC_{50} values were estimated from the plotted toxicity lines. Selection for resistance was carried out on the newly-hatched larvae at the LC_{30} levels. (0.078 ppm) of deltamethrin was applied on artificial diet in glass tubes of (2x7.5cm), each tube was infested by neonatal larvae and capped with cotton piece. Higher concentrations of deltamethrin were used in subsequent generations with the increase of resistance levels. LC_{50} values were estimated for 1st, 3rd, 5th, 6th, 7th, 10th and 14th generations. Development of resistance ratio as well as relative resistibility for each generation were calculated as follows:

Resistant ratio = LC_{50} of the selected strain / LC_{50} of susceptible strain.

Relative resistibility = LC_{50} of selected generation / LC_{50} of anterior generation.

2. Cross-resistance of deltamethrin resistant strain to the tested insecticides

Both of the obtained resistant strain to deltamethrin and the susceptible strain were exposed to various insecticides, i.e. esfenvalerate (a pyrethroid compound), chlorpyrifos (an organophosphorous), thiodicarb (a carbamate), Ecotech and Agerin (an bioinsecticides derived from *Bacillus thuringiensis*, subspecies *kurstaki*). The newly hatched larvae of each strain was exposed to serial dilutions of the tested insecticides as mentioned before. The corrected mortality percentages were estimated and the LC_{50} values were evaluated according to **Finney, (1972)**. The resistance ratio of the tested insecticides (LC_{50} value of R-strain / LC_{50} value of S-strain) was calculated and the differences of 5-fold or more were considered as indicating positive correlation while those between 1 : 4-fold were considered as indicating to no correlation. Differences less than 1-fold represented a probable negative correlation.

3. Statistical Analysis

All of the toxicity values (LC_{50}'s) which estimated from the plotted toxicity regression lines and their corresponding slope values were calculated using the Probit Analysis Program designed by Dr. Nabil AM. Abd EL-Salam, Plant Protection Institute, Dokki, Giza, Egypt. The significant differences between the mentioned values were statistically analyzed using the Computer program Statitica for Windows, version 4.5.

RESULTS AND DISCUSSION

1. Development of resistance of pink bollworm to deltamethrin

The estimated LC_{50} values of deltamethrin to the different strains of pink bollworm *P. gossypiella* (Saund.) during fourteen generations of selection are shown in **Table (1)**, while the plotted toxicity regression lines are illustrated in **Figure (1).** The results clearly indicate that LC_{50} values increased gradually during the first five generations. At G3 the resistance ratio attained a level of 11.49-folds then increased in generations 5 and 6 to be 20.82 and 69.69-folds, respectively. With further selection pressure, the resistance ratio increased again during generations 7 and 10 to be 99.80 and 165.84-folds and reached 215.11-folds in generation fourteen.

In addition, the toxicity regression lines were characterized by slight fluctuations in the slope values, which were comparatively low and were nearly close to each other. In this respect **Hoskins and Gordon (1956)** pointed out that the development of true resistance was characterized by regression line becoming shallower as it moves to the right direction, finally it becomes steeper again as resistance genotypes comes to characterize the

Table 1. Rate of development of resistance to deltamethrin in *P. gossypiella* (Saund.) during selection for 14 generations

Selection generations	LC_{50} (ppm) (5%fiducial limits)	Slope	Resistance Ratio (Fold)	Relative Resistibility
Susceptible	0.55 (0.28-1.06)	0.69	-	-
Parent	1.03 (0.58-1.84)	0.63	1.87	-
G1	2.93 (1.82-4.71)	1.31	5.32	2.84
G3	6.32* (3.48-11.51)	0.73	11.49	2.16
G5	11.45** (7.98-16.42)	1.30	20.82	1.81
G6	38.33*** (23.46-62.62)	0.85	69.69	3.35
G7	54.90*** (31.66-95.20)	0.85	99.80	1.43
G10	91.21*** (61.60-135.06)	1.14	165.84	1.66
G14	118.31*** (82.89-168.87)	1.31	215.11	1.30

Comparing to the parent generation, (***) highly significant $p \leq 0.001$, (**) moderately significant $p \leq 0.01$ and (*) significant $p \leq 0.05$ (student *t*-test).

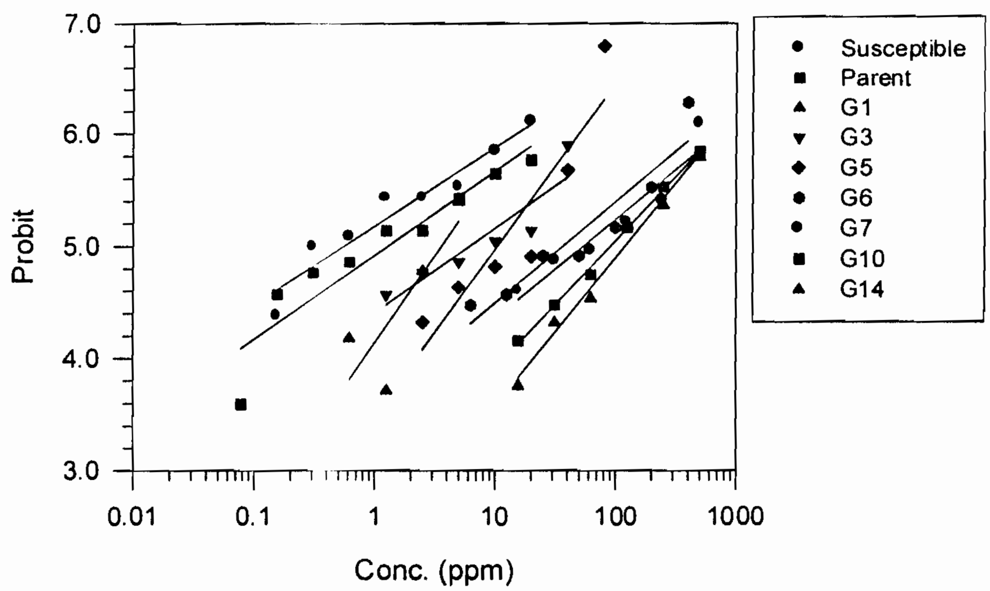

Fig. 1. Toxicity lines of deltamethrin to the tested generations of *P. gossypiella*

new population. Moreover, **Osman *et al* (1991)** reported that sixteen generations of larval selection of a field strain of pink bollworm *P. gossypiella* exposed to permethrin produced 9.7-folds resistance in adults. Higher slope values obtained in F12 through F16 generations indicated an increasing of homogeneity in later generations. On the other hand, the estimated slope values indicated that a population that was apparently heterogeneous at the beginning of the study tended to become relatively more homozygous as selection progressed. However, similar finding was obtained by **Aldosari *et al* (1996)** who found that selection of field populations of beet armyworm *Spodoptera exigua* for resistance to cyfluthrin for eight generations resulted in a 54.1-folds increase in the estimated LD_{50} values. The regression lines of all strains, including the susceptible strain yielded relatively low slope values of 1.09 to 2.13 indicating that high degree of genetic heterogeneity exists among these strains.

Generally, various investigators reported that the selection pressure of tobacco budworm *Heliothis virescens* with pyrethroids produced an increase in levels of resistance compared to the susceptible strain. In such studies, it was found that the selection pressure of larvae of the diamond-back moth *Plutella xylostella* with permethrin increased resistance. After twenty generations of continuous selection pressure resistance to permethrin reached to be over than 600-folds in this strain compared with the unselected parent strain. Strain differences as well as the degree of homozygosity of resistance may account for the discrepancy (**Jensen *et al* 1984; Ibrahim *et al* 1996; Zhao *et al* 1996 & Yu and Nguyen 1996).**

2. Cross-resistance to certain insecticides

The determined LC_{50} values of the tested insecticides on susceptible and deltamethrin resistant strains after the selection pressure of *P. gossypiella* for fourteen generations were listed in **Table (2)** and the corresponding plotted toxicity regression lines are illustrated in **Figures (2-6)**. The selected strain was apparently resistant to esfenvalerate, i.e. 25.57-folds, conferred low resistance to chlorpyrifos, i.e. 4.20-folds and low tolerant to thiodicarb, i.e. 3.18-folds. On the contrary, the impact of deltamethrin resistance as the potency of the biopesticides, Agerin and Ecotech, were negligible.

Table 2. Response of deltamethrin resistant strain of *P. gossypiella* (Saund.) to the tested compounds

Tested insecticide	Susceptible strain		Deltamethrin resistance strain		
	LC_{50} (ppm) (Fiducial limits)	Slope	LC_{50} (ppm) (Fiducial limits)	Slope	Resistance ratio
Esfenvalerate	0.14 (0.09-0.20)	1.19	3.58**(2.35-5.47)	1.19	25.57
Chlorpyrifos	0.05 (0.04-0.07)	1.47	0.21*(0.14-0.31)	1.19	4.20
Thiodicarb	70.80 (53.22-94.18)	1.88	225.02***(159.34-317.77)	1.44	3.18
Ecotech	380 (280-500)	1.41	350 (270-450)	1.59	0.92
Agerin	350 (240-510)	1.12	340 (230-510)	1.02	0.97

Comparing between deltamethrin resistant strain and susceptible strain, (***) highly significant $p \leq 0.001$, (**) moderately significant $p \leq 0.01$ and (*) significant $p \leq 0.05$ (student t-test).

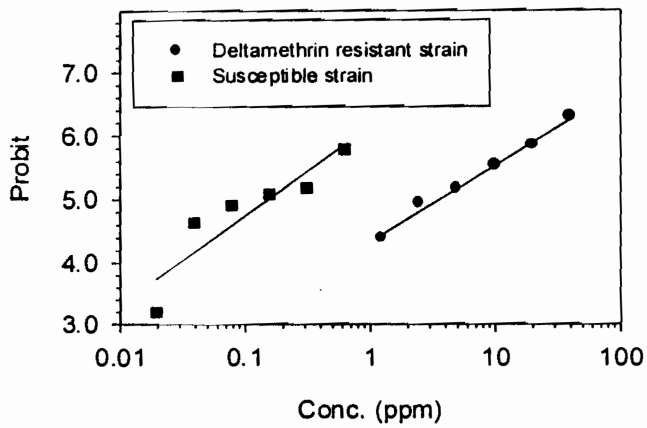

Fig. 2. Toxicity regression lines of esfenvalerate against susceptible and deltamethrin resistant strains of *P. gossypiella*

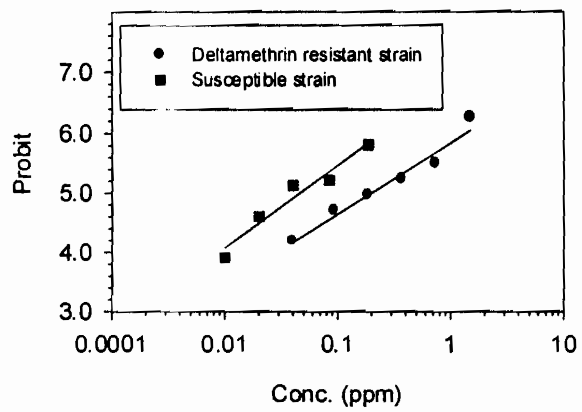

Fig. 3. Toxicity regression lines of chlorpyrifos against susceptible and deltamethrin resistant strains of *P. gossypiella*

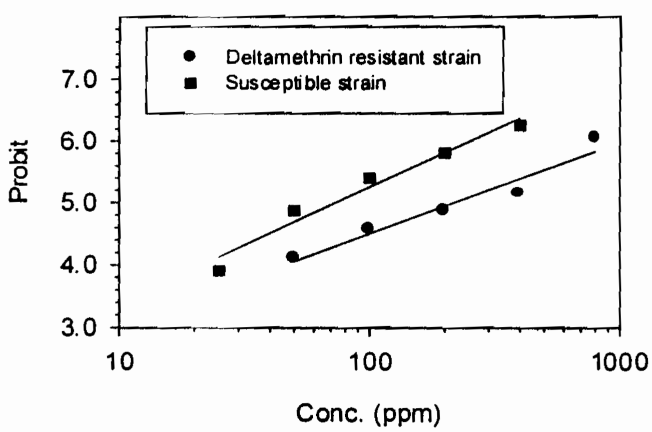

Fig. 4. Toxicity regression lines of thiocarb against susceptible and deltamethrin resistant strains of *P. gossypiella*.

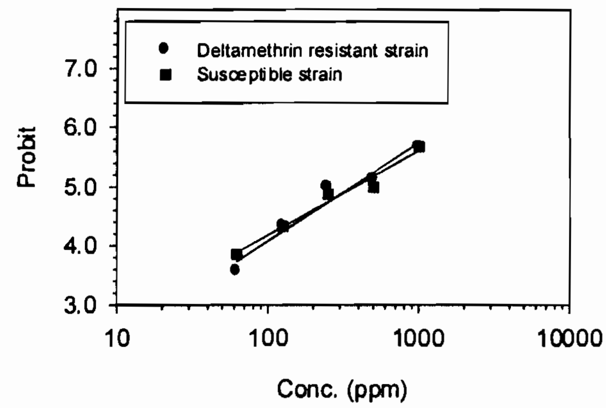

Fig. 5. Toxicity regression lines of Ecotech against susceptible and deltamethrin resistant strains of *P. gossypiella*

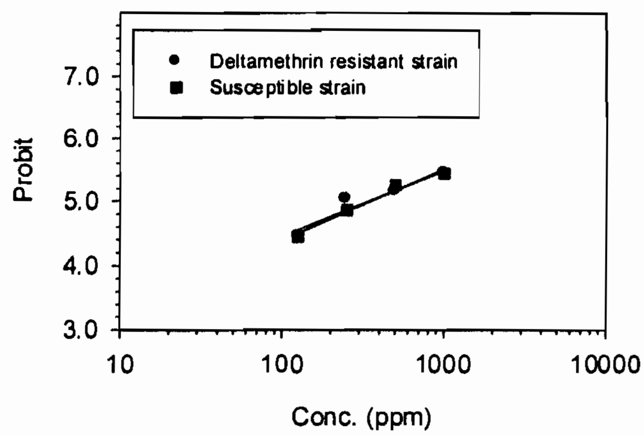

Fig. 6. Toxicity regression lines of Agerin against susceptible and deltamethrin resistant strains of *P. gossypiella*

Similar finding was reported by **Riskallah *et al* (1983)** who showed that the selection pressure of a field strain of Egyptian cotton leafworm *Spodoptera littoralis* with fenvalerate or deltamethrin resulted in the development of resistance to all pyrethroids, DDT and aminocarb but showed no cross resistance to the organophosphate, methyl parathion. Several investigators reported that there is no cross resistance between pyrethroids and organophosphorus, carbamate and microbial insecticides, (**Yu and Nguyen 1996; Liu and Jiang 1995; Wu *et al* 1994 and Ayad and Phillabaum 1990**). Also, **Jensen *et al* (1984)** found that a permethrin resistant strain of tobacco budworm *H. virescens* had developed cross resistance to cypermethrin which was evaluated by 7.9-folds. **Tabashnik *et al* 1987** suggests that cross-resistance between conventional insecticides and *B.thuringiensis* is unlikely in diamondback moth. In contrary, **Elzen (1995) and Zhao *et al* (1996)** found that the tobacco budworm *H. virescens* resistance strain to cypermethrin proved cross resistance to organophosphates, i.e. profenofos and azinophos methyl and carbamates, i.e. thiodicarb and methomyl but the data did not indicate any resistance to *B. thuringiensis*. Also, **Aldosari *et al* (1996)** reported that cyfluthrin selected strain of beet armyworm *S. exigua* (Hubner) showed cross resistance to methomyl whereas it was only weakly cross-resistant to profenofos.

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حوليات العلوم الزراعية
جامعة عين شمس، القاهرة
مجلد(٥١)، عدد (٢)، ٥٥١-٥٥٨، ٢٠٠٦

عبور صفة مقاومة سلالة دودة اللوز القرنفلية المقاومة للدلتامثرين لبعض المبيدات الحشرية

[٤٠]

مونا فكرى روفائيل[١]- محمد السعيد صالح الزميتي[٢]- علاء الدين بيومي[٢]- همت زكريا محمد مصطفى[١]

١- معهد بحوث وقاية النباتات - مركز البحوث الزراعية - الدقي - الجيزة - مصر
٢- قسم وقاية النبات - كلية الزراعة - جامعة عين شمس - شبرا الخيمة - القاهرة - مصر

تم إجراء الضغط الإنتخابى تحت ظروف معملية لسلالة حقلية من دودة اللوز القرنفلية جمعت من محافظة الشرقية باستخدام المبيد البيرثرويدى دلتامثرين. ودلت النتائج المتحصل عليها على أن مستوى المقاومة قد وصل إلى ٢١٥,٧٥ ضعفا وذلك مقارنة بالسلالة الحساسة بعد ١٤ جيلا. وأظهرت دراسة إستجابة سلالة دودة اللوز القرنفلية المقاومة للدلتامثرين أنه يوجد عبور لصفة المقاومة بين الدلتامثرين و اس فنفاليرات بينما لا يوجد عبور لصفة المقاومة بين المبيدات الحشرية المعتادة كلوربيريفوس، ثيوديكارب أو المبيدات الحيوية إكوتيك و أجرين في هذه السلالة. و تؤكد هذه النتائج علي إمكانية مناوبة الدلتامثرين لهذه المبيدات في برنامج مكافحة دودة اللوز القرنفلية.

تحكيم: أ.د عبد الحميد عبد الحميد زيدان
أ.د العيداروس أحمد جمعه