CHANGES IN SUSCEPTIBILITY OF THE LARVAE OF PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* (SAUND.) TO SYNTHETIC PYRETHROIDS

ABO SHOLOA, M.K.A, M.A. NASSEF AND W.M. WATSON

Plant Protection Research Institute, Agricultural Research Centre, Dokki, Giza Egypt.

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Abstract

Field experiments were conducted during 1997 and 1998 cotton seasons to study the effect of individual synthetic pyrethroids sprayed three times at 15 days interval on the population density of the pink bollworm larvae infesting cotton bolls. Data shown that λ-cyhalothrin and cyhalothrin proved to be the most effective in reducing pink bollworm incidence on cotton among the tested compounds. They caused 79.29 and 77.45% reduction of pink bollworm larval population in 1997 and 74.97% and 71.97% in 1998, respectively. On the other hand, deltamethrin ad cyfluthrin were the least effective insecticides, giving 59.44 and 54.95% in 1997 and 50.00 and 46.94% reduction in 1998, respectively.

Also, the response of the field strain larvae to the same insecticides at the end of the rotational chemical control programme was evaluated in laboratory. Data indicate that the larvae of 1998 showed more tolerance compared to that of 1997 season. The tolerance ratio ranged between 1.01 and 1.32 at LC_{50} level, where it ranged between 1.08 and 1.69 at LC_{90}.

INTRODUCTION

At the beginning of the Seventy, Ministry of Agriculture of Egypt began to use synthetic pyrethroids as a one of the fourth generation of insecticides to control leafworm and bollworms in cotton fields. The repeated application of insecticides lead to the development of resistance of leafworm to such novel group of chemicals. The high levels of resistance to insecticides acquired by the pest had been reported by several investigators (El-Guindy *et al.*, 1982 and El-Dahan, 1991). Accordingly, the use of pyrethroids at the Eighty was limited for bollworms control at one spray only during the sequential pest control programme.

Aim of the present investigation was to evaluate the efficiency of synthetic pyrethroids in reducing the larval population of pink bollworm when sprayed in sequence for three times. Also, a laboratory test was conducted to evaluate the susceptibility of the field strain larvae to some pyrethroids at the end of the season.

MATERIALS AND METHODS

Chemicals used: The following synthetic pyrethroids were used:

-Cypermethrin (Polytrin), EC, 20%, at 60 ga.i./fed.(RS)-α-cyano-3-phenoxybenzyl -3-(2,2-dichlorovinyl)-2,2- = dimethylcyclopropane carboxylate.

-Alphamethrin (Fastac), EC, 25% at 25 g a.i./fed. a 1:1reaction mixture of (S) - α - cyano-3-phenoxybenzyl (IR)-cis-3-(2,2- dichlorovinyl) -2, 2-dimethylcyclopropanecarboxylate and (R)- α - cyano-3-phenoxybenzyl (IS)-cis-3-(2,2- (dichlorovinyl) -2,2 dimethylcyclopropanecarboxylate.

-Deltamethrin (Decis), EC,2.5%, at 18.75 ga.i/fed. (S)-α-cyano-3-phenoxybenzyl (IR,3R)-3-(2, 2-dibromovinyl)-2,2 dimethylcyclopropanecarboxylate.

-Cyfluthrin (Baythroid), EC, 5%, at 37.5 ga.i./fed.(RS)-α-cyano-4- fluoro-3-phenoxybenzyl (1RS, 3RS; 1RS, 3 SR)-3-(2, 2- dichlorovinyl)-2,2- dimethylcyclopropanecarboxylate.

-Fenpropathrin(Danitol), EC, 20%,at 150 g a.i/fed. (RS)-α-cyano-3-phenoxybenzyl -2,2,3,3-tetramethylcyclopropanecarboxylate.

-Esfenvalerate (Sumialpha), EC,5%, at 30 g.a.i./fed. (S)-α-cyano-3-phenoxybenzyl (S)-2-(4-chlorophenyl)-3-methtylbutylate.

-Cyhalathrin (Cypha), EC, 10%, at 30 g a.i/fed. (RS)-α-cyano-3-phenoxybenzyl (Z)-(1RS,3RS)-(2-chloro-3,3,3-trifluoropropenyl)-2,2= dimethylcyclopropanecarboxylate.

-λcyhalothrin (Krate), EC, 5%, at 18.75 g a.i/fed. a 1:1reaction mixture of (S)-α cyano-3-phenoxybenzyl (Z)-(1R,3R)-3- (2-chloro-3,3,3 -trifluoropropenyl) -2,2-= dimethylcyclopropanecarboxylate. and (R)-α-cyano-3-phenoxybenzyl (Z)-(1S,3S)-3-(2-chloro-3,3,3-trifluoropropenyl)- 2,2-= dimethylcyclopropanecarboxylate.

Field experiments: The experiments were conducted during the cotton growing seasons of 1997 and 1998 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The experimental area was divided into plots of 1/24 of a feddan each and cultivated with Giza 77 cotton variety. The treatments were arranged in complete randomized blocks with 4 replicates each.The tested insecticides were sprayed three times using a low volume sprayer (model CP_3)in water dilutions at the rate of 300 litre/feddan. The spray programme was started on July 24 th, 1997 and July 18th,1998 and continued regularly every two weeks. Representative samples of 25 green cotton bolls were collected at random from both diagonals of each plot just before spray and then at weekly intervals till September 4th, 1997 and August 29 th, 1998. The number of pink bollworm larvae in each sample was recorded. Percent reduction in larval population was estimated using Henderson and Tilton (1995) equation.

Laboratory tests: The larvae required for the laboratory tests were collected from infested cotton bolls obtained at the end of season from the different insecticidal treatments. The residual film technique adopted by Guriguis and Watson (1981) was used to determine the LC_{50} and LC_{90} values of the tested synthetic pyrethroids. One milliliter of acetone solution of each of the tested insecticides was uniformly distributed on the surface of a Peti-dish (10 cm diameter). After complete dryness, five full grown larvae were confined and left to dose themselves by crawling on the deposited film. The Petri-dish was covered and kept in dark at 26±1 ^{o}C and 65±5% RH. Mortality counts were recorded 24 hours after exposure. Five replicates of 5 larvae were used for each concentration. Dosage-mortaliy curves were plotted and the LC_{50} and LC_{90} and slope values were calculated according to Litchfield and Wilcoxon statisical method (1949).

RESULTS AND DISCUSSION

The effect of tested synthetic pyrethroids sprayed three times at 15 days interval on the population density of pink bollworm larvae infesting cotton during 1997 and 1998 seasons is shown in Table 1. Data indicate that the percent reduction in popultion density of pink bollworm in 1997 ranged between 79.29 and 54.95%.In this respect, λ -cyhalothrin and cyhalothrin were the most effective compounds as they caused 79.29 and 77.45% reduction, respectively. Fenpropathrin, cypermethrin, esfenvalerate and alphamethrin followed closely the aforementioned insecticides, causing 68.47 to 61.28% reduction, whereas deltamethrin and cyfluthrin were the least effective (59.44 and 54.95%, respectively).

In 1998, the percentage of reduction in pink bollworm larval population was lesser than in 1997 season and could be arranged descendingly by as follows: λ-cyhalothrin (74.97%), cyhalothrin (71.97),fenpropathrin (61.94), esfenvalerate

(59.96), cypermethrin (60.92), alphamethrin (55.04), deltamethrin (50.00) and cyfluthrin (46.94% reduction).

Table 1. Percentage of reduction in larval population of *P. gossypiella infesting* green cotton bolls during 1997 and 1998 seasons.

Treatments	1997		1998	
	Mean number of larvae/25 bolls*	% reduction	Mean number of larvae/25 bolls*	% reduction
1. λ-cyhalothrin	0.96 e	79.29	1.04 e	74.97
2. Cyhalothrin	1.04 e	77.45	1.17 e	71.97
3. Fenpropathrin	1.46 d	68.47	1.59 d	61.94
4. Cypermethrin	1.46 d	68.47	1.67 d	59.96
5. Esfenvalerate	1.67 cd	63.93	1.63 d	60.92
6. Alphamethrin	1.79 bcd	61.28	1.87 cd	55.04
7. Deltamethrin	1.88 bc	59.44	2.08 bc	50.00
8. Cyfluthrin	2.08 b	54.95	2.21 b	46.94
9. Control	4.62 a	-	4.17 a	-

*Mean of 6 post-treatment inspections.

By Duncan's multiple range test, means followed by the same letter are not significantly different at 5% level.

Data in Table 2 show the response of the field strain pink bollworm larvae, collected from the treated fields, to the same insecticides used in each treatmen at the end of the chemical control programme. Results in 1997 revealed that λ-cyhalothrin was the most effective insecticide, while cyfluthrin was the least potent, recording LC50 of 0.773 and 1.776 µg/cm2, respectively, The other compounds could be arranged descendingly as follows: cyhalothrin (0.885), fenpropathrin (0.996), cypermethrin (1.103), esfenvalerate (1.224), alphamethrin (1.381) and deltamethrin (1.525 µg/cm2). The order of potency in the second season (1998) was the same as mentioned before, except a switch in position between cyhalothrin and fenpropathrin; alphamethrin and deltamethrin.

In both seasons, the LC90/LC 50 ratio simply represented the steepness of the LC lines in a reversal to the slope values. Thus, the higher the slope value or the lower the LC_{90}/LC_{50} ratio, the steeper the toxicity line is .

Considering the toxicity index at LC50, Table 2 shows that cyhalothrin and fenpropathrin were 87.34 and 77.61% as toxic as λ–cyhalothrin in 1997 season, while the rest insecticides were 70.08 to 43.52% as λ-cyhalothrin. In 1998, fenpropathrin and cyhalothrin were 84.42 and 75.86% as toxic as λ–cyhalothrin, while cypermethrin, esfenvalerate, deltamethrin, alphamethrin and cyfluthrin were 69.2, 61.88, 57.6, 53.58 and 40.41 as toxic as λ–cyhalothrin, respectively.

The various insignificant low levels of resistance detected to the tested synthetic pyrethroids depend upon the active chemical groups in each pyrethroid, nature and ratio of optical and geometric isomers which allow a certain degree of effectiveness, the physical properties which determine the degree of penetration and volatility which can increase or decrease the efficiency. In this respect, the toxicity of the different pyrethroids on the field strain of pink bollworm could be demonstrated according to the differences in their chemical structure. As λ–cyhalothrin includes a 1:1 reaction mixture of (S)-α-cyano-3-phenoxy benzyl (Z) - (1R, 3R)-3-(2-chloro-3, 3,3-trifluoropropenyl)-2,2-= dimethylcyclopropane-carboxylate and (R)-α-cyano-3-phenoxybenzyl (Z)-(1S, 3S)-3-(2-chloro-3,3,3-trifluoropropenyl)-2, 2-=dimethylcyclopropanecarboxylate, this specific configuration produced the maximum degree of toxicity. Meanwhile, cyfluthrin which contain (RS)-α-cyano-4-fluoro-3-phenoxybenzyl (1RS, 3RS, 1RS, 3SR)-3-(2,2-dichlorovinyl)-2,2-= dimethylcyclopropane carboxylate induced the least toxicity.

As regards the tolerance ratio (TR) at LC50 and LC90, the larvae of 1998 were more tolerant than of 1997. The values of TR ranged between 1.01 and 1.32 at LC50. Also, it could be seen that at LC90 level which is important from economic point of view, λ–cyhalothrin was superior (TR = 1.08) and cyfluthrin was inferior (TR = 1.69), while the other insecticides lie in between.

Discussing the foregoing results, it could be seen that the response of pink bollworm larvae to the tested synthetic pyrethroids was decreased when assayed at the end of the season. The decreasing in toxicity depends upon the chemical structure of such insecticides and its type in both field and laboratory tests.

Our findings agree to great extent with those obtained by Watson *et al.* (1981 a), Watson *et al.* (1981 b), Watson *et al.* (1986), Ayad *et al.* (1993) and Khidr *et al.* (1996).

Watson et al. (1981a) found that synthetic pyrethroids sprayed three times reduced significantly the population of the pink bollworm. Fenvalerate proved to be superior to all other tested pyrethroids, resulting in 78.33% reduction in bollworm infestation followed by cypermethrin (73.33%), deltamethrin (72.5%) and cyfloxylate (61.67%).

Meanwhile, cypermethrin, fenvalerate and deltamethrin reduced significantly the

Table 2. Insecticidal activity of certain synthetic pyrethroids against the full grown larvae *P. gossypiella* during

Insecticides	LC_{50} ($\mu g/cm^2$)		LC_{90} ($\mu g/cm^2$)		Slope		LC_{90}/LC_{50}		Toxicity index at LC_{50}		Tolerance ratio (TR)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	LC_{50}	LC_{90}
λ-cyhalothrin	0.773	0.883	7.398	7.991	1.35	1.28	9.57	9.05	100	100	1.14	1.08
Cyhalothrin	0.885	1.164	8.319	11.407	1.36	1.26	9.40	9.80	87.34	75.86	1.32	1.37
Fenpropathrin	0.996	1.046	10.418	12.008	1.32	1.06	10.46	11.48	77.61	84.42	1.05	1.15
Cypermethrin	1.103	1.276	8.261	13.870	1.64	1.16	7.49	10.87	70.08	69.20	1.15	1.68
Esfenvalerate	1.224	1.427	10.233	15.326	1.48	1.18	8.36	10.74	63.15	61.88	1.17	1.50
Alphamethrin	1.381	1.648	10.882	17.386	1.52	1.22	7.88	10.55	55.97	53.58	1.19	1.60
Deltamethrin	1.525	1.533	16.013	17.078	1.27	1.16	10.50	11.14	50.69	57.60	1.01	1.07
Cyfluthrin	1.776	2.185	13.498	22.746	1.58	1.24	7.60	10.41	43.52	40.41	1.23	1.69

$$\text{Tolerance ratio (TR)} = \frac{LC_{50} \text{ or } LC_{90} \text{ (1998 season)}}{LC_{50} \text{ or } LC_{90} \text{ (1997 season)}}$$

infestation by both pink bollworm and spiny bollworm as it induced 88.2, 84.6 and 81.9% reduction, respectively (Watson *et al.*, 1981b).

Watson *et al.* (1986) mentioned that three sprays at 2 weeks interval with fenpropathrin, fenvalerate and deltamethrin induced the highest reduction in pink bollworm larval population (86.4, 81.3 and 79.1%, respectively). Also, larvae received three sprays with one of the tested pyrethroids acquired tolerance to the compound. The tolerance ratios at LC50 were 4.18, 4.42 and 6.42 fold for fenpropathrin, fenvalerate and deltamethrin, respectively.

Ayad *et al.* (1993) found that cyfluthrin was the most effective on pink bollworm larvae at Kafr El-Sheikh Governorate before heating process, followed by fenpropathrin, cypermethrin, deltamethrin, alphamethrin then esfenvalerte.

Khidr *et al.* (1996) mentioned that fenpropathrin revealed the highest activity followed by esfenvalerate, λ–cyhalothrin, cypermethrin and cyfluthrin which caused average seasonal reductions for pink bollworm larval population of 95.65,95.35,94.8,92.6 and 81.25%, respectively.

Generally, it could be concluded that the continuous use of such group of insecticides in the last fifteen years may induce higher level of resistance for pink bollworm larval population.

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التغيرات فى حساسية يرقات دودة اللوز القرنفلية لمبيدات البيرثرويدات المخلقة

محمد خيري عباس أبو شلوع -محمد عبد الفتاح ناصف -وطسن متى وطسن

معهد بحوث وقاية النبات - مركز البحوث الزراعية -محطة البحوث الزراعية بسخا

تم إجراء عدد من التجارب الحقلية والمعملية فى موسمى ١٩٩٧ , ١٩٩٨ لدراسة فعالية بعض المبيدات من البيرثرويدات المخلقة فى خفض تعداد يرقات دودة اللوز القرنفلية التى تصيب لوز القطن ومن جهة أخرى تتبع التغيرات التى تحدث فى درجه حساسية اليرقات لمثل هذه المجموعة من المبيدات .

أوضحت النتائج عندما تم رش كل مبيد من المبيدات الثمانية المختبرة ثلاث مرات على فترات كل ١٥ يوم أن مبيدى لامداسيها لوثرن (قراط) وسيهالوثرن (سيفا) قد حققا أفضل النتائج فى كلا الموسمين حيث كانت نسبة الخفض فى تعداد اليرقات ٧٩,٢٩٪ و ٧٧,٤٥٪ فى موسم ١٩٩٧ و ٧٤,٩٧٪ و ٧١,٩٧٪ في موسم ١٩٩٨ . من ناحية اخري كان لمبيدي دلتاميثرين (ديسز) وسيفلوثرن (بايثرويد) أقل تاثير فى خفض تعداد اليرقات حيث كانت نسبة الخفض ٥٩,٤٤٪ و ٥٤,٩٥٪ فى موسم ١٩٩٧ و ٥٠,٠٠٪ و٤٦,٩٤٪ فى موسم ١٩٩٨ على التوالى.

وعندما تم اختيار درجة حساسية يرقات دودة اللوز القرنفلية والتى جمعت من الحقول المعاملة بكل مبيد فى نهاية التجربة الحقلية لكل موسم فى المعمل لو حظ أن يرقات الموسم الثانى(١٩٩٨) كانت أكثر تحملا من يرقات الموسم الأول(١٩٩٧) حيث تراوحت نسبة التحمل على أساس LC_{50} بين (١,٠١ -١,٣٢) بينما كانت النسبة بين (١,٠٨ -١,٦٩) على أساس LC_{90}