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RESPONSE OF SINGLE PAIRS OF PY-R STRAIN OF TOBACCO BUDWORM TO CYPERMETHRIN AND PROFENOFOS

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Abstract

LD50s of cypermethrin were determined for 14 single pairs of PY-R strain of the tobacco budworm, *Heliothis virescens* (F). LD50s of profenofos were determined for 25 single pairs of PY-R strain of the tobacco budworm, *H. virescens* (F). The range of LD50s was 937 and 195, respectively. Differences indicate polygenic factors for resistance. All significant and non-significant regressions of single pairs were resistant to cypermethrin and 36% were resistant to profenofos. Multiple resistance was evident in 18% of the single pairs.

Introduction

A selection experiment was conducted for 14 generations with multiple pairs of the PY-R strain of the tobacco budworm to cyclopropane and non-cyclopropane insecticides and organophosphorus (OP) insecticides (Wolfenbarger 2004). In this experiment single pairs were established in generation 10 and toxicity of cypermethrin and profenofos were determined.

Single pairs are the most effective way to elucidate resistance or susceptibility in any strain. Larvae of single pairs of the PY-R strain were treated with cypermethrin and profenofos to determine their resistance or susceptibility. A resistance threshold was used for each insecticide. No information has been found using single pairs of this pyrethroid resistant strain.

Materials and Methods

Technical cypermethrin and profenofos were obtained from their manufacturers. They were diluted with and maintained in nanograde acetone.

In generation 10 pupae from larvae of generation nine were sexed, paired and placed in 0.47L cardboard containers. Following moth emergence sugar water was changed every 3-4 d (Wolfenbarger 2004). Cloth covers and hangers provided oviposition sites in each container. They were changed every other d and placed in 12 oz plastic cups sealed with plastic lids. Upon eclosion neonate larvae were placed singly on artificial diet in cups and held for treating.

Third-instar larvae were treated after three to seven d when they weighed 22 ± 6 d (16 to 28) mg. Larvae of each single pair were treated with cypermethrin at 1.56 to 800 μg/larva and profenofos at 0.195 to 25 μg/larva. Mortalities were determined after 48h. The resistance thresholds of 0.2 μg/larva for cypermethrin [Martinez-Carrillo and Wolfenbarger 2004a) and 20.0 μg/larva for profenofos (Martinez-Carrillo and Wolfenbarger 2004b) respectively, were used to separate resistance from susceptibility.

Calculations of LD50s, slope ± SE, and 95% confidence intervals were determined for significant regressions by probit analysis of SAS (1988). When confidence intervals overlapped LD50s were statistically equal. Non-significant regressions were determined when the ratio of the slope/SE values were <1.96. Results of non-significant regressions are useful in determining resistance and susceptibility (Wolfenbarger 2004).

Results and Discussion

LD50s of cypermethrin and profenofos are shown for 14 and 25 single pairs, respectively [Table 1]. LD_{50}s of cypermethrin and profenofos were determined for 35% and 64% of the 40 and 39 single pairs tested, respectively: 15 of the single pairs established did not produce progeny. One half of the larvae of the 40 single pairs were treated with cypermethrin and the other half were treated with profenofos. One of the single pairs did not produce enough larvae to treat with profenofos.

LD50s for cypermethrin ranged from 10.06 to 9,424.0 9 μg/larva, a 937 fold difference. All the single pairs were resistant.

LD50s of profenofos for the single pairs ranged from 0.47 to 91.73 μg/larva, a 195 fold difference. The LD50s indicated both resistance and susceptibility to profenofos.

Multiple resistance to cypermethrin and profenofos was determined in 18% of the single pairs. The results confirm polygenic factors for resistance by this strain to both insecticides.

For cypermethrin, slope ± SE, percentage mortality of non-significant regressions or no regression and number of larvae tested at maximum dose against 26 single pairs were 0.53 ± 0.44 and 29% mortality of 101 larvae at 400 µg/larva, 0.19 ± 0.39 and 43% mortality of 139 larvae at 400 µg/larva, 0.68 ± 0.54 and 25% mortality of 75 larvae at 400 µg/larva, 0.58 ± 1.0 and 39% mortality of 75 larvae at 400 µg/larva, 0.48 ± 0.66 and 50% mortality of 92 larvae at 400 µg/larva, 0.72 ± 0.81 and 8 % mortality of 39 larvae at 200 µg/larva, 0.78 ± 2.38 and 77% mortality of 46 larvae at 400 µg/larva, 1.46 ± 0.81 and 24% mortality of 43 larvae at 12.5 µg/larva, 0.53 ± 0.46 and 33% mortality of 40 larvae at 200 µg/larva, 0.94 ± 1.15 and 69% mortality of 20 larvae at 25 µg/larva, 0.22 ± 0.45 and 60% mortality of 78 larvae at 25 µg/larva, no regression and 0% mortality of 12 larvae at 25 µg/larva, 1.39 ± 0.73 and 28% mortality of 39 larvae at 100 µg/larva, no regression and 20% mortality of 62 larvae at 100 µg/larva, 0.37 ± 0.38 and 14% mortality of 53 larvae at 100 µg/larva, 0.28 ± 0.67 and 11% mortality of 158 larvae at 200 µg/larva, 0.25 ± 0.29 and 4% mortality of 162 larvae at 200 µg/larva, 0.61 ± 0.4 and 5% mortality of 137 larvae at 200 µg/larva, 0.46 ± 0.26 and 47% mortality of 111 larvae at 200 µg/larva, -0.87 ± 0.71 and 63% mortality of 56 larvae at 12.5 µg/larva, 1.15 ± 0.99 and 17% mortality of 36 larvae at 100 µg/larva, 0.37 ± 0.3 and 60% mortality of 80 larvae at 200 µg/larva, -0.24 ± 0.23 and 67% mortality of 119 larvae at 200 µg/larva, -1.02 ± 1.02 and 60% mortality of 30 larvae at 200 µg/larva, 0.26 ± 0.23 and 65% mortality of 131 larvae at 200 µg/larva and -0.73 ± 0.53 and 31% mortality of 52 larvae at 50 µg/larva, respectively. All single pairs were resistant to cypermethrin. Doses tested either exceeded >0.2 µg/larva or <50% were killed. No regression or non-significant regressions were shown in 65% of the single pairs tested with cypermethrin.

For 38 single pairs treated with cypermethrin, regression for slopes <0.5 to 1.0, 1.1 to 1.5 and 1.6 to 3.0 and >3.0 were 42%, 42%, 11% and 5%, respectively (Table 1). Slopes (42%) were considered to be flat (<1.0). Single pairs one and 23 showed slopes >3.0, but there was no consistency of slopes and toxicity.

For profenofos, slope ± SE, percentage mortality of non-significant regression or no regression and number larvae tested at maximum dose against 14 single pairs were 1.23 ± 0.78 and 59% mortality of 72 larvae at 0.78 µg/larva, -0.5 ± 0.57 and 50% mortality of 40 larvae at 12.5 µg/larva, 1.11 ± 1.69 and 40% mortality of 28 larvae of 40 larvae at 3.125 µg/larva, 1.46 ± 0.8 and 24% mortality of 43 larvae at 12.5 µg/larva, 0.13 ± 1.93 and 0% mortality of 26 larvae at 25 µg/larva, 2.31 ± 1.67 and 57% mortality of 50 larvae at 0.78 µg/larva,-0.079 ± 0.98 and 86% mortality of 27 larvae at 3.125 µg/larva, no regression and 50% mortality of 12 larvae at 6.25 µg/larva, 2.63 ± 1.42 and 50% mortality of 73 larvae at 25 µg/larva, no regression and 0% mortality of 50 larvae at 12.5 µg/larva, -0.24 ± 0.99 and 13% mortality of 74 larvae at 12.5 µg/larva, 1.63 ± 1.36 and 52% mortality of 39 larvae at 6.25 µg/larva, 0.33 ± 0.36 and 93% mortality of 91 larvae at 0.39 µg/larva and 1.52 ± 0.87 and 80% mortality of 57 larvae at 0.39 µg/larva, respectively. With resistance threshold 36% of single pairs were resistant to profenofos because doses were >20 µg/larva or <50% were killed. No regression or non-significant regressions were shown in 36% of the single pairs tested against profenofos.

For 37 single pairs, treated with profenofos, regression for slopes <0.5, 0.51 to 1.0, 1.1 to 1.5, 1.51 to 2.0, 2.0 to 3.0 and >3.0 were 14%, 11%, 22%, 30%, 19% and 5%, respectively (Table 1). Slopes (25%) were considered to be flat (<1.0). Single pairs seven and 17 showed slopes >3.0 but neither was resistant; LD50s were <2.0. Slopes were generally steeper for profenofos than for cypermethrin.

In each of the 40 single pairs the number of larvae/female treated by both insecticides were 24, 47, 66, 74, 75, 79, 86, 105, 116, 119, 134, 145, 146, 150, 161, 163, 164, 165, 166, 167, 180, 181, 187, 188, 191, 195, 197, 198, 199, 199, 214, 238, 244, 249, 254, 254, 260, 327 and 369, respectively: a mean of 166 from a total of 6,640 larvae. These results are normal. It is impossible to predict the number of larvae from each female.

In conclusion, LD50s of cypermethrin and profenofos were highly variable for this pyrethroid resistant strain. Results for LD50s of cypermethrin were more variable than for LD50s of profenofos. Factors for resistance among these single pairs are polygenic.

References

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Table 1. Toxicity of cypermethrin and profenofos to single pairs of PY-R strain of tobacco budworm in generation 10, April, 1990.

Insecticide	Number larvae treated	Slope ± SE	LD50 (μg/larva)	95% CI (low-high)
Single pair 1				
Cypermethrin	72	3.94 ± 1.15	31.68	20.6 - 41.54
Single pair 2				
Cypermethrin	74	0.74 ± 0.39	10.06	∞-∞
Profenofos	42	1.93 ± 0.89	1.6	0.69 - 7.04
Single pair 3				
Cypermethrin	94	0.66 ± 0.32	48.54	1.79×10^{-15} -121.92
Profenofos	71	1.6 ± 0.45	1.32	0.5 - 2.12
Single pair 4				
Cypermethrin	75	0.9 ± 0.36	59.46	4.78 -128.87
Profenofos	92	1.51 ± 0.69	0.95	∞-∞
Single pair 5				
Profenofos	97	1.39 ± 0.36	4.73	2.88- 14.03
Single pair 6				
Profenofos	105	1.74 ± 0.52	1.89	0.22 - 6.68
Single pair 7				
Cypermethrin	195	-0.68 ± 0.19	32.26	11.46 - 54.91
Profenofos	132	3.14 ± 0.54	1.29	1.01-1.6
Single pair 8				
Profenofos	139	0.81 ± 0.26	91.73	29.89 -8,580.0
Single pair 9				
Profenofos	89	1.58 ± 0.39	1.25	0.53 -1.97
Single pair 10				
Profenofos	95	2.72 ± 0.81	1.87	0.16 18.22
Single pair 15				
Cypermethrin	116	1.61 ± 0.34	36.45	20.22 -52.73
Single pair 17				
Profenofos	67	3.23 ± 0.81	1.07	0.65 - 1.42
Single pair 19				
Profenofos	66	2.22 ± 0.53	10.5	7.0 - 19.11
Single pair 20				
Profenofos	88	1.02 ± 0.39	10.6	∞-∞
Single pair 21				
Profenofos	114	2.33 ± 0.41	12.61	8.8 - 17.4
Single pair 22				
Profenofos	211	1.93 ± 0.22	8.78	6.74 - 11.79
Single pair 23				
Cypermethrin	73	3.19 ± 0.91	27.84	21.28 - 52.4
Single pair 24				
Cypermethrin	111	1.09 ± 0.33	360.22	157.49 -5,658.0
Single pair 25				
Profenofos	98	0.81 ± 0.27	7.79	3.66- 33.49
Single pair 26				
Profenofos	112	1.34 ± 0.42	7.39	2.29 -235.73
Single pair 27				
Cypermethrin	159	0.6 ± 0.23	1,407.0	273.05 - 2.36×10^{7}
Profenofos	95	1.12 ± 0.42	5.32	∞-∞

Table 1. continued.

Insecticide	Number larvae treated	Slope ± SE	LD50 (µg/larva)	95% CI (low-high)
Single pair 28				
Profenofos	127	1.81 ± 0.33	2.11	1.49 - 2.9
Single pair 29				
Cypermethrin	133	0.5 ± 0.25	9,424.0	537.38- 2.15 x 10^{97}
Profenofos	121	2.01 ± 0.53	2.95	0.83 -11.56
Single pair 30				
Cypermethrin	117	1.0 ± 0.28	127.39	58.79 -1,173.0
Single pair 31				
Profenofos	107	0.59 ± 0.25	56.91	21.88 -11,224.0
Single pair 33				
Cypermethrin	90	0.8 ± 0.27	32.82	10.86 -85.95
Profenofos	109	2.36 ± 0.74	1.51	0.32 - 5.86
Single pair 34				
Cypermethrin	110	0.91 ± 0.46	38.25	∞-∞
Profenofos	89	1.16 ± 0.38	1.45	0.13 2.84
Single pair 35				
Profenofos	84	2.21 ± 0.42	2.23	1.45 - 3.19
Single pair 37				
Profenofos	104	1.77 ± 0.34	0.47	0.27 - 0.68
Single pair 38				
Cypermethrin	90	0.85 ± 0.28	12.68	1.7 - 26.72
Single pair 40				
Profenofos	128	1.03 ± 0.28	0.9	0.12 - 2.54