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Monitoring Heliothis armiger (Hübner) strains from Queensland for insecticide resistance

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Summary

During the period 1975 to 1980, insecticide resistance testing of *Heliothis armiger* from areas of Queensland was conducted to monitor changes in the resistance status of strains from the major cotton growing areas, to determine base-line LD_{50} values for new insecticides, and to test for suspected resistance in strains from other areas. In the cotton growing areas levels of resistance to DDT + camphechlor (1:2) and parathion-methyl remained fairly steady, while endosulfan resistance levels fell at St George and Emerald. No evidence of resistance to the synthetic pyrethroids was detected. Data for several insecticides on strains from Mareeba, Biloela and Kingaroy are reported.

1. INTRODUCTION

Resistance to DDT in *Heliothis armiger* (Hübner) was detected in Queensland in 1972-73 (Twine and Kay 1973). Kay (1977) tested *H. armiger* strains collected from a number of areas in 1973-74 and 1974-75 and found widespread resistance to DDT, and resistance to endosulfan in the strain from St George.

From 1975 to 1980 further insecticide resistance testing of strains of *H. armiger* was carried out. This work had three aims. Firstly, to determine changes in resistance to the insecticides most frequently used for *Heliothis* spp. control in the main cotton growing areas (St George Irrigation Area, Emerald Irrigation Area and the Brookstead-Cecil Plains district). Secondly, to provide base-line data for future reference as new insecticides (for example, the synthetic pyrethroids) became available and were used. Finally, occasionally to test *H. armiger* strains from other areas to check for suspected resistance. The data recorded for these areas would provide reference points should resistance develop to the insecticides tested in the future.

2. MATERIALS AND METHODS

Between 50 and 100 larvae were collected in the field usually from one site within each area, allowed to pupate and then were sent to Tamworth, NSW as pupae. Larvae of the first or second laboratory generation were used for testing. They were reared on the diet of Shorey and Hale (1965) modified by the use of soybeans instead of pinto beans, and with wheatgerm added at 1 g per 10 g of beans. Larvae were held at 23°C before testing and at 25°C after testing with a 14 h photophase. They weighed 28 to 42 mg and were in the third or fourth instar when tested. Larvae which were about to moult or had just moulted were not used.

A topical application method was used. A 1 μL drop of an acetone solution of technical grade insecticide was applied to the dorsal surface of each larva using a Drummond micropipette. Ten larvae were treated at each of five or six doses and a control (acetone only) per replicate, with a minimum of three replicates. Mortality was recorded at 48 h for all insecticides except DDT + camphechlor (1:2) and endosulfan, which were assessed at 72 h. Dead larvae and those that could not walk when prodded were recorded as dead. The results were analysed by the probit method of Finney (1971).

3. RESULTS

LD_{50} values, 95% fiducial limits, slope values of the probit lines and resistance factors at the LD_{50} level are given in Table 1. Resistance factors were calculated as LD_{50} of the test strain divided by LD_{50} of the susceptible strain. Susceptible LD_{50} values for DDT, DDT + camphechlor (1:2) and parathion-methyl were those reported by Goodyer and Greenup (1980), while an LD_{50} of 0.35 μg per larva recorded for a susceptible strain from Bathurst, New South Wales (Goodyer, unpublished data) was used for endosulfan.

Table 1. LD_{50}, 95% fiducial limits, slope value, and resistance factor for strains of H. armiger

Location, host, and date of collection	Insecticide	LD_{50} (μg a.i. per larva)	95% fiducial limit		Slope value	Resistance factor
			Lower	Upper		
1975–76						
St George, cotton, February, 1976	DDT + camphechlor (1:2)	17.0	12.1	23.4	1.69	28
	endosulfan	11.3	8.22	15.6	1.46	32
	parathion-methyl	0.605	0.498	0.736	3.29	12
Emerald, sorghum, March, 1976	DDT	34.3	11.7	100	0.647	>100
	DDT + camphechlor (1:2)	6.38	0.523	12.8	0.722	11
	parathion-methyl	0.472	0.365	0.611	2.56	9
Brookstead–Cecil Plains, sorghum, February, 1976	DDT	9.91	4.90	20.0	0.685	29
	DDT + camphechlor (1:2)	13.8	9.18	19.3	1.48	23
	parathion-methyl	0.390	0.320	0.473	3.15	8
Mareeba, tobacco, February, 1976	DDT	78.9	47.6	>100	1.76	>100
	endosulfan	3.67	1.73	7.82	1.48	10
	parathion-methyl	0.474	0.394	0.571	3.29	9
	methomyl	0.965	0.757	1.22	2.21	..
1976–77						
Emerald, cotton, February, 1977	DDT	5.40	0.024	12.4	0.646	16
	DDT + camphechlor (1:2)	7.69	2.96	13.4	1.02	13
	parathion-methyl	0.280	0.202	0.396	3.57	6
Biloela, cotton, January, 1977	DDT	12.9	8.97	18.5	1.37	38
	DDT + camphechlor (1:2)	13.5	7.92	24.5	1.32	22
	endosulfan	9.08	7.03	11.7	1.94	26
	parathion-methyl	0.299	0.254	0.354	3.91	6
	carbaryl	28.4	16.8	48.1	1.12	..
Kingaroy, soybeans, April, 1977	endosulfan	1.82	1.39	2.39	1.91	5.2

Location, host, and date of collection	Insecticide	LD_{50} (µg a.i. per larva)	95% fiducial limit		Slope value	Resistance factor
			Lower	Upper		
1977–78						
St George, cotton, March, 1978	DDT + camphechlor (1:2)	22.6	17.1	30.6	2.06	38
	endosulfan	34.9	21.3	57.3	1.76	100
	permethrin	0.0449	0.0164	0.123	2.80	..
Emerald, cotton, March, 1978	DDT + camphechlor (1:2)	23.2	5.76	>100	1.40	39
	endosulfan	25.7	15.6	42.3	1.17	73
	permethrin	0.0600	0.0247	0.146	4.60	..
Brookstead–Cecil Plains, maize, February 1978	endosulfan	1.54	1.30	1.82	3.61	4
1978–79						
St George, cotton, March 1979	DDT + camphechlor (1:2)	7.36	5.47	9.91	1.67	12
	endosulfan	3.62	2.59	5.08	1.47	10
	parathion-methyl	0.235	0.194	0.284	3.23	5
Emerald, cotton, February 1979	DDT + camphechlor (1:2)	8.45	6.41	11.1	1.77	14
	endosulfan	2.74	2.15	3.50	2.38	8
	parathion-methyl	0.236	0.197	0.282	3.54	5
Brookstead–Cecil Plains, maize, February 1979	DDT + camphechlor (1:2)	8.67	6.28	12.0	1.34	14
	endosulfan	0.94	..	..	1.32	3
	parathion-methyl	0.271	0.220	0.333	3.63	5
1979–80						
St George, cotton, February 1980	DDT + camphechlor (1:2)	6.87	4.41	10.7	1.05	11
	endosulfan	1.49	1.16	1.92	2.51	4
	parathion-methyl	0.258	0.211	0.316	4.16	5
	fenvalerate	0.0287	0.0244	0.0346	3.31	..
Emerald, cotton, February 1980	DDT + camphechlor (1:2)	7.94	5.79	10.9	1.44	13
	endosulfan	2.87	2.33	3.53	3.75	8
	parathion-methyl	0.430	0.357	0.519	3.24	9
	fenvalerate	0.0203	0.0162	0.0254	2.59	..
Brookstead–Cecil Plains, maize, January 1980	DDT + camphechlor (1:2)	4.81	3.36	6.90	1.33	8
	endosulfan	1.92	1.57	2.35	3.17	5
	parathion-methyl	0.180	0.151	0.215	4.27	4
	fenvalerate	0.0260	0.0218	0.0310	3.52	..
	deltamethrin	0.0132	0.0103	0.0169	3.04	..
	profenofos	0.197	0.169	0.231	5.67	..

4. DISCUSSION

The widespread occurrence of DDT resistance reported in New South Wales by Goodyer and Greenup (1980) and in Queensland by Kay (1977) is further confirmed by resistance in strains from Emerald and Biloela.

DDT + camphechlor (1:2) and endosulfan were the insecticides most commonly used for *Heliothis* control in cotton during the five seasons of this programme. Parathion-methyl was used occasionally. The synthetic pyrethroids were introduced during the 1977–78 season and have been used extensively since then.

Resistance to DDT + camphechlor (1:2) is recorded in strains from each of the main cotton growing areas (Cecil Plains–Brookstead, St George Irrigation Area, Emerald Irrigation Area). Despite repeated use of this insecticide against *H. armiger* each season, the levels of resistance have remained fairly steady. Field control with this insecticide remains satisfactory.

Parathion-methyl LD_{50} values indicate a low level of resistance in strains from all areas. Values have not altered appreciably during the testing period.

Kay (1977) reported resistance to endosulfan in the St George *H. armiger* strain, and the LD_{50} values for 1975–76 and 1977–78 support that conclusion. In 1977–78 the Emerald strain also showed resistance to endosulfan. However, in the 1978–79 season there was a large decrease in the LD_{50} values for strains from both areas, and the lower values were repeated in 1979–80. These drops in resistance level were surprising and are difficult to explain as endosulfan is still used frequently in both areas. Differences in sampling sites with different insecticidal control regimes within a district from year to year could account for small changes in LD_{50} values, but are unlikely to be responsible for the large drop recorded here. More extensive testing to investigate the factors causing these results was beyond the scope of the monitoring programme.

The synthetic pyrethroids have been used for three seasons in the cotton areas during which time the LD_{50} values have remained low, with no indication of development of resistance. The LD_{50} values recorded for permethrin in 1977–78, and for fenvalerate, deltamethrin and the organophosphate profenofos in 1979–80, establish base-line values against which the results of future testing can be compared.

The results reported for several insecticides for strains from Mareeba, Biloela and Kingaroy give historical points of reference for future comparison.

5. ACKNOWLEDGEMENT

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References

Finney, D. J. (1971), *Probit Analysis,* Third Edition, University Press, Cambridge, UK 333 pp.

Goodyer, G. J., and Greenup, L. R. (1980), 'A survey of insecticide resistance in the cotton bollworm, *Heliothis armigera* (Hübner) (Lepidoptera:Noctuidae) in New South Wales'. *General and Applied Entomology* **12,** 37-39.

Kay, I. R. (1977), 'Insecticide resistance in *Heliothis armigera* (Hübner) (Lepidoptera:Noctuidae) in areas of Queensland, Australia'. *Journal of the Australian Entomological Society* **16,** 43–45.

Shorey, H. H., and Hale, R. L. (1965), 'Mass-rearing of the larvae of nine noctuid species on a simple artificial medium'. *Journal of Economic Entomology* **58,** 522-24.

Twine, P. H., and Kay, I. R. (1973), '*Heliothis* species and DDT resistance'. *Queensland Agricultural Journal* **99,** 520–22.

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