INSECTICIDE RESISTANCE IN GREEN PEACH APHID FROM POTATOES IN SOUTH AUCKLAND

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SUMMARY

Green peach aphid (*Myzus persicae*) from a South Auckland population on potatoes were shown in laboratory bioassays (at the LC_{50}) to be resistant to demeton-s-methyl (223x), malathion (46x), dimethoate (39x), pirimicarb (20x) and deltamethrin (10.8x), tolerant to methomyl (2.7x) and methamidophos (2.0x), but susceptible to acephate and endosulfan. Diagnostic concentration tests showed that resistance to demeton-s-methyl was present at all seven sites examined in the area, whereas pirimicarb resistance was present at two of four sites. The high resistance factors, and biochemical assays of the esterase activity in individual aphids, indicated that highly resistant aphids are present at Pukekohe.

INTRODUCTION

Failures to control green peach aphid in potatoes have been recorded in field trials by Fellowes and Ferguson (1974). They concluded that insecticide resistance in the South Auckland area to six organophosphate (OP) insecticides, two carbamates and one organochlorine, was responsible for these failures. The level of this resistance has not been quantified and some of these insecticides are still commonly used. Current control of green peach aphid in South Auckland appears to be satisfactory either because part of the aphid population is still susceptible to most insecticides used, or because some insecticides are still potent against aphids which have developed resistance to others. Resistance in glasshouse populations of green peach aphid has been quantified using dose-response bioassays (Baker 1978) which showed a pattern of OP resistance similar to that obtained by Fellowes and Ferguson (1974), except for higher resistance factors which reflected the confined selection regime of glasshouse culture.

Insecticide resistance in green peach aphid is widespread overseas and can develop rapidly (McClanahan and Founk 1983). Some insecticides have remained effective, depending on the level and geographic distribution of resistance to them (Furk 1986). In Australia, resistance to OP's except methamidophos is widespread, but some OP resistant strains are susceptible to the carbamates pirimicarb and methomyl. In the UK, variation in OP and carbamate resistance between areas has been linked to the frequency of aphids with high esterase enzyme activity (Sawicki *et al* 1978). This has provided a simple rapid biochemical method of detecting very resistant aphids in a population.

The bioassays described here were undertaken to define insecticide resistance in green peach aphid from the Pukekohe area in South Auckland, by comparison with a susceptible strain. This provided baseline data from which changes in resistance could be detected. In addition, biochemical assays were used to examine the level of resistance.

METHODS

Aphids for bioassays against a range of insecticides were collected from a commercial potato crop in the Pukekohe area and compared with a susceptible strain obtained from dock at the Mount Albert Research Centre (MARC). These colonies were maintained separately and reared on seedling potatoes or Chinese cabbage (*Brassica pekinensis*). Comparisons of insecticide resistance between sites were carried out on aphids from six other commercial potato crops within 5 km of Pukekohe town,

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and separated by at least 1 km. The test insecticides were chosen to represent those in common usage for foliar application, and to allow comparison with the literature on resistance in green peach aphid.

Exposure to residues

The formulated insecticides were sprayed onto the lower surface of Chinese cabbage leaf segments placed on damp filter paper in a 85 mm diameter plastic Petri dish. Spraying was done with a Potter tower using 2 ml of the test liquid, with a pressure of 69 kPa and a settling time of 10 sec. The leaves were air dried in a fume cupboard for 1 h, then transferred onto damp filter paper in the lid of the Petri dish. Ten 3rd or 4th instar apterous aphids were placed on each leaf and caged with a ventilated plastic vial cap, 20 mm diameter and 12 mm high, secured with a spring clip. Evaporation from the surface of the Petri dish was minimised with a Parafilm covering. The test aphids were maintained at $25 \pm 1^\circ\text{C}$ for 48 h until mortality was assessed. Aphids exhibiting no movement when touched were classified as dead. A typical experiment consisted of 4-5 concentrations of an insecticide for each of two aphid strains, with a water-treated control for each strain. Three replicates were tested for each concentration. The results were analysed with POLO (Robertson *et al* 1980) which compared the regressions and calculated the relative potency of an insecticide against different aphid populations.

The distribution of resistance between sites was examined with a single concentration of insecticide chosen to discriminate between resistant and susceptible aphid strains. Aphids from six test sites were exposed as before to diagnostic concentrations of demeton-s-methyl and pirimicarb, and their responses compared with the susceptible MARC strain. In a third treatment a synergist, piperonyl butoxide was added to pirimicarb.

Esterase assay

The carboxylesterase activity of individual aphids, and hence their ability to detoxify OP's was estimated using the Tile test described by Sawicki *et al* (1978). The total esterase activity of individual aphids was compared against a standard (1-naphthol). Homogenates which stain more deeply than the standard are from very resistant (R2) aphids, and those with less intensity are from aphids which are susceptible or slightly resistant to demeton-s-methyl (R1).

RESULTS AND DISCUSSION

Comparison of the Pukekohe and MARC strains of green peach aphid showed differing responses to seven of the nine insecticides tested (Table 1). The insecticides which were ineffective against Pukekohe aphids included three OP's, demeton-s-methyl, malathion and dimethoate which have had the longest use among the test chemicals. Two OP's acephate and methamidophos, one organochlorine endosulfan, and one carbamate methomyl were as effective or nearly as effective against Pukekohe aphids as against the MARC strain, but pirimicarb (a carbamate) showed decreased potency. The resistance factors at the LC_{50} (Rf) for methamidophos and methomyl indicate that recommended field rates of these insecticides should still be effective. The pattern of these results generally agrees with that found by Fellowes and Ferguson (1974) but our results show high resistance factors for field populations. In addition, aphids from the Pukekohe site were resistant to the carbamate, pirimicarb. Baker (1978) found this to be the most effective insecticide against resistant aphids. The resistance to deltamethrin may suggest cross resistance, because synthetic pyrethroids (SP's) are not commonly used on potatoes in the area, although resistance could have originated from SP use on cabbages.

The resistance factors (Rf) measured were similar to, or greater than, those which have been recorded in Australia, Canada and the UK. For example, in Australia Attia *et al* (1979) reported a Rf of 22 for demeton-s-methyl (cf 223 at Pukekohe), and 65 for dimethoate (cf 39 at Pukekohe). However, the interpretation of such comparisons is difficult (especially when different bioassays are used) and the pattern of resistance to various insecticide groups may be more informative. Where resistance has developed to OP's at other locations, acephate, methamidophos and pirimicarb have been shown to

retain their effectiveness (Devonshire *et al* 1975). This was also observed by Attia and Hamilton (1978) in Australia, although Attia *et al* (1979) later noted carbamate resistance in Australia. Although Hamilton *et al* (1981) showed cross resistance between demeton-s-methyl and methamidophos, the latter material retains its effectiveness against most Australian populations because the level of resistance is low. The resistance to deltamethrin at Pukekohe also parallels the overseas patterns quoted above. McClanahan and Founk (1983) showed that although some SP's were still effective in Canada, cross resistance had developed to fenvalerate and permethrin, and deltamethrin had failed in the field. In Australia, Hamilton *et al* (1981) suggested that cross resistance may result from non-specific esterase activity, or previous use of DDT.

TABLE 1: Comparative dose-mortality responses of green peach aphid from Pukekohe and Mount Albert Research Centre (MARC) exposed to residues of various insecticides on chinese cabbage leaves for 48 hours.

Insecticide Site	n (1)	LC ₅₀ (2)	95% CL (3)	Slope (4)	SE (5)	Rf (6)
acephate (Orthene 75)						
Pukekohe	360	40	28,54	3.24	0.29	-(7)
MARC	150	27	-(8)	3.32	0.98	
deltamethrin (Decis 2.5 EC)						
Pukekohe	420	19	10,68	1.21	0.14	10.8
MARC	120	1.1	0.9,1.4	3.42	0.59	
demeton-s-methyl (Metasystox (i))						
Pukekohe	420	103	64,217	1.54	0.16	223
MARC	270	0.3	0.01,0.7	1.10	0.26	
dimethoate (Rogor E)						
Pukekohe	360	551	404,771	2.51	0.23	39.4
MARC	210	9.9	0.9,23	1.53	0.26	
endosulfan (Thiodan 35 EC)						
Pukekohe	330	520	-(8)	2.72	0.39	-(8)
MARC	105	423	-(8)	5.89	0.95	
maldison (Malathion 50 EC)						
Pukekohe	390	4684	3541,6257	2.79	0.25	46.0
MARC	210	99	30,252	1.90	0.22	
methamidophos (Tamaron)						
Pukekohe	300	41	22,90	2.38	0.27	2.0
MARC	130	20	12,36	2.64	0.42	
methomyl (Lannate L)						
Pukekohe	270	125	89,244	2.31	0.32	2.7
MARC	240	39	33,46	5.32	0.73	
pirimicarb (Pirimor 50)						
Pukekohe	360	42	28,60	2.03	0.20	20.6
MARC	180	2.4	-(8)	3.89	1.53	

(1) no. of insects tested; (2) lethal conc. of spray for 50% mortality (mg ai/litre); (3) confidence limits; (4) slope of probit mortality regression; (5) SE of slope; (6) Resistance factor = LC₅₀ Pukekohe/LC₅₀ MARC; (7) no significant difference between regressions at P=0.05; (8) not calculable.

The survey of Pukekohe crops (Table 2, Pukekohe and sites 1-6) showed that demeton-s-methyl resistance is widespread. However there was some evidence that pirimicarb resistance is more localised. This may reflect the limited use of this insecticide and suggests that the resistance to it is a recent development. In Australia, the synergist piperonyl butoxide (PB) increased the potency of pirimicarb (Attia *et al* 1981). We obtained similar results against one or two strains at Pukekohe, but not a third (Table 2). These results suggest that the effectiveness of pirimicarb should be monitored to provide a basis for future control recommendations. The distribution of

resistance to other insecticides is unknown, but high variability in most dose-response regressions (Table 1) suggests that the resistance is heterozygous, as observed by McClanahan and Founk (1983) for field-collected populations in Canada.

The level of carboxylesterase detected by esterase assays indicated that 54% of aphids from the Pukekohe site were highly resistant to demeton-s-methyl, and corresponded to the R2 category of Sawicki *et al* (1978). This type of resistance occurs in England and Wales but is not widespread (Furk 1986). It is probably related to more intensive use of insecticides in certain areas, and lower fitness of R2 aphids in the absence of insecticides.

The distribution of R2 resistance at Pukekohe is unknown, but its correlation with demeton-s-methyl resistance suggests it is widespread. Furk (1983) suggested that there was no significant increase in the incidence of R2 resistance in Britain when selection pressure was reduced. The future incidence of insecticide resistance in South Auckland is therefore likely to depend on insecticide usage in the area.

The pattern of insecticide resistance at Pukekohe will be further investigated to allow the development of pest control advice and the consideration of management strategies.

TABLE 2: Percent mortality of green peach aphid from various sites, when exposed to diagnostic concentrations of two insecticides and a synergist, piperonyl butoxide (PB). Untreated mortality was zero.

Site	Demeton-s-methyl (10 mg ai/litre)	Pirimicarb (10 mg ai/litre)	Pirimicarb + PB (10 mg ai/litre, 1:10 w/w)
Pukekohe	0	8	
1	1.6	0	0
2	13		
3	10		
4	0	87	100
5	13	23	93
6	0		
MARC	98.3	100	97

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