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Toxicity and persistence of effectiveness of some organophosphorus insecticides against green aphid *Aphis gossypii* Glover on apple leaves

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Abstract

Eight organophosphorus insecticides were tested in the laboratory for their intrinsic toxicity as deposits on apple leaves to third instar nymphs of *Aphis gossypii* Glover. Demeton-S-methyl, chlorfenvinphos and phosphamidon were highly toxic, dimethoate and phosalone were moderately toxic, and monocrotophos, quinalphos and methamidophos were less toxic compounds. Persistence of effective toxicity of these insecticides at commercially recommended rates of application was examined under field conditions on apple cv Red Delicious. Phosphamidon, dimethoate and phosalone provided protection for more than three weeks following spray applications. Chlorfenvinphos gave protection for about 14 days, demeton-S-methyl for 10 days and monocrotophos for 4 days. Quinalphos and methamidophos were less persistent and effective.

1. Introduction

A combined field and laboratory study of the toxicity and persistence of organophosphorus insecticides was undertaken to obtain more detailed information than is normally available from field trials on the performance of insecticides against the aphid, *Aphis gossypii* Glover. Apple trees were sprayed and the toxicity of both fresh and naturally weathered deposits was tested in the laboratory. Besides being commonly available, *A. gossypii* Glover also causes various degrees of damage to apple during various stages of its growth (Hameed *et al*[1]). This paper describes the results of tests with eight organophosphorus insecticides considered potentially useful in controlling the aphid and coccid pests of apple during summer in Himachal Pradesh.

2. Materials and methods

The toxicity of insecticide deposits was determined by the bioassay technique described by Cranham and Tew[2], using fresh third instar nymphs of *A. gossypii* from an apterous, viviparous, parthenogenetic (showing almost transparent appendages of $1 \times 0{\cdot}5 \pm 0{\cdot}01$ mm size) line maintained on young potted apple plants. Three ml of spray solution of the commercial formulations was sprayed in a Potter tower on to the ventral surface of an apple leaf-disc (4·5 cm dia) at a deposit of 2·832 mg (± 5%) cm^{-2} of wet spray. The estimated deposits, as per regression equations (Table I) in $\mu g\ cm^{-2}$ for LD_{50}, LD_{90} and confidence limits (for all the insecticides) were calculated on that basis.

Table I

Toxicity of insecticides

Insecticides	LD_{50} (μg ai cm^{-2})	95% confidence limits (μg ai cm^{-2})	LD_{90} (μg ai cm^{-2})	95% confidence limits (μg ai cm^{-2})	Dosage (ppm)-mortality regression equations
Chlorfenvinphos	0·037 (13)	0·026–0·051	0·147 (52)	0·076–0·283	$Y = 2{\cdot}1446x + 2{\cdot}6013$
Dimethoate	0·062 (22)	0·048–0·082	0·207 (73)	0·013–0·348	$Y = 2{\cdot}4134x + 1{\cdot}7692$
Phosalone	0·074 (26)	0·057–0·096	0·286 (101)	0·147–0·555	$Y = 2{\cdot}1779x + 1{\cdot}9155$
Phosphamidon	0·048 (17)	0·034–0·062	0·181 (64)	0·082–0·397	$Y = 2{\cdot}1729x + 2{\cdot}3536$
Monocrotophos	0·161 (57)	0·110–0·241	0·691 (244)	0·280–1·708	$Y = 2{\cdot}0392x + 1{\cdot}4143$
Quinalphos	0·218 (77)	0·074–0·634	0·770 (272)	0·229–2·588	$Y = 2{\cdot}3348x + 0{\cdot}5980$
Methamidophos	0·283 (100)	0·229–0·354	0·835 (295)	0·541–1·291	$Y = 2{\cdot}7134x - 0{\cdot}4215$
Demeton-S-methyl	0·034 (12)	0·025–0·045	0·119 (42)	0·062–0·229	$Y = 2{\cdot}5983x + 2{\cdot}1657$

Heterogeneity : X^2 (3*df*) non-significant at $P = 0{\cdot}05$ in all cases. Y = Probit kill x = log concentration (ppm). Figures in parentheses are corresponding concentrations expressed in ppm (*vide* regression equations).

Aphids were confined to a glass cage on treated leaf-discs. The cage consisted of a ring (18 × 15 mm), sealed with paraffin wax to the central portion of the disc, within which were placed five third instar nymphs of *A. gossypii*. The top was closed with a weighed disc of nylon cloth and the glass cage with the leaf-disc was then transferred to a moistened filter paper having constant access to water to prevent desiccation of the leaf. The test material was stored for 24 hours at 27 ± 1° C and 70 ± 5% RH before mortality counts were made. Moribund insects were considered dead. After preliminary experiments, the range of toxicity (c. 90 to 10%) of each insecticide for 5 concentrations, replicated 10 times was determined. The data were corrected by Abbott's[3] formula and subjected to probit analysis (Finney[4]).

Commercial formulations of 8 insecticides listed in Table III were sprayed to 'run-off' (using a hand sprayer) on June 25, 1976, ensuring complete wetting of both the surfaces of leaves of apple trees cv Red Delicious (c. 3 m high).

Persistence of toxicity of each insecticide on sprayed trees was assessed by randomly collecting 40 leaves from a height of c. 2 m all around the tree, at various intervals following treatment.

The leaf sample was grouped into 10 squares of 4 leaves each and 2 leaves from each square were taken randomly for 10 replicates for each insecticide. Leaf-discs of 4·5 cm dia were taken from 2 leaf subsamples and a glass cage (18 × 15 mm) was fixed in the central portion of each leaf-disc. The test aphids were confined to the discs as described earlier. Mortality counts were recorded for each insecticide, until a corrected percentage mortality around 10 to 20% was obtained (Table II). The age of the deposit was calculated from the time of releasing the aphid on the leaf-disc. The data were subjected to analysis of variance from which 95% confidence limits were calculated. The deposits ($\mu g\ cm^{-2}$) at various intervals, recording mortality ranges c. 90 to 10%, were estimated by means of dosage-mortality regression equations of the insecticides (Table I) taking into account the mean deposit value as described earlier. The deposits ($\mu g\ cm^{-2}$) of each insecticide worked out from Table II were plotted on X-axis against respective time intervals (Y-axis). Effective life of insecticides was derived from the days corresponding to their 'minimum effective levels', *i.e.*, LD_{90} values (Fig. 1).

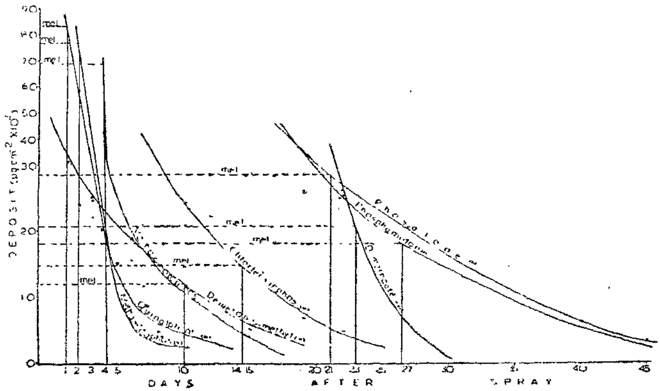

FIG. 1. Persistence of insecticides on apple leaves.

3. Results and discussion

Experiments on intrinsic toxicity of the insecticides as deposits on apple foliage, based on their LD_{50} values (Table I), showed that demeton-S-methyl, chlorfenvinphos and

Table II

Persistence of toxicity of field-weathered insecticide deposits on apple leaves against *A. gossypii* Glover.

Days after spray*	Mean corrected % kill (average of 10 replications of 2 leaves each) ± 95% confidence limit							
	Methamidophos	Quinalphos	Demeton-S-methyl	Monocrotophos	Chlorfenvinphos	Dimethoate	Phosphamidon	Phosalone
1	100	100						
2	85±4·4		100	100				
3	78±3·9	88±3·8	89±3·0					
4		72±3·5		90±5·6				
5		54±3·7						
6	55±4·4		67±3·2					
7	41±2·9	29±2·4		68±3·7	100			
8	10±2·0	16±3·5						
10			52±3·0	53±3·6	86±3·7			
12					79±1·3	100		
13			30±5·6	28±3·5				
15			18±3·5	13±3·4				100
16					48±3·9			
19					23±3·6	92±1·9	100	
22					17±3·6	89±0·7	92±2·7	89±2·7
24						62±3·9		
26						32±3·0		
27						13±3·6	70±2·5	73±2·8
33							43±3·2	
36							35±3·9	50±6·6
40							13±3·6	22±3·0
45								11±1·1

* Sprayed on June 25, 1976. The weather conditions during the experimental period are given in Fig. 2. Periods above 100 show deposits giving 100% corrected % kill of the insect.

phosphamidon were highly toxic to *A. gossypii*. Dimethoate and phosalone were moderately toxic, and monocrotophos, quinalphos and methamidophos were less toxic insecticides. A better guide to likely field performance is the 'minimum effective level' (m.e.l.) at LD_{90} (Gratwick *et al*[5] and Gratwick and Tew[6]). In the compounds tested, there were small differences in the ranking order of LD_{90}s' compared to their LD_{50}s'.

Phosphamidon and phosalone seemed to be highly persistent as the mortality of the insects up to 100% was recorded as late as 15th and 19th day following treatment (Table II), followed by dimethoate the deposit of which gave 100% kill up to 12th day and chlorfenvinphos up to 7th day. Methamidophos proved to be the least persistent compound giving 100% kill only one day following treatment. The deposits of methamidophos and quinalphos dissipated the fastest compared to the other insecticides. Comparisons of persistence of insecticides in conjunction with their m.e.l. (Fig. 1) indi-

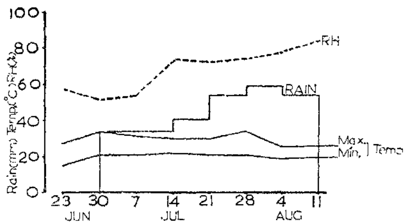

FIG. 2. Weather conditions during experimental period.

cated that phosphamidon and dimethoate being mainly systemic in action, provided protection for more than three weeks following the spray (Table III). Phosalcne being inherently a less toxic material proved more persistent. Against codling moth, phosalone had been reported effective for three weeks following spray under conditions which are relatively cool and humid (Hameed and Allen[7]). Among the other highly toxic compounds, chlorfenvinphos gave adequate protection for over two weeks followed by demeton-S-methyl (10 days). Monocrotophos gave protection for 4 days, while methamidophos and quainalphos being less toxic did not give the desired protection. Rains were negligible when the experiment was laid out and increased slightly after the third week; humidity was relatively low and the maximum and minimum temperatures were almost constant (Fig. 2). It is, therefore, unlikely that rainfall and

Table III

Effective lives of insecticides based on LD_{90} values

Insecticides	Per cent a.i. sprayed	Effective life (days) *vide* figure 1
Dimethoate	0·030	23·0
Phosphamidon	0·050	26·5
Phosalone	0·050	21·1
Chlorfenvinphos	0·050	14·4
Monocrotophos	0·050	4·0
Quinalphos	0·050	2·0
Methamidophos	0·060	1·0
Demeton-S-methyl	0·025	10·0

humidity could have affected the dissipation of insecticides directly. Persistence of insecticides on apple leaves, as has been observed in the experiment under the stated temperature conditions seemed to have been ideal.

4. Acknowledgement

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