Bull. Environ. Contam. Toxicol. (1985) 34:560–564

Environmental Contamination and Toxicology

Acute and Residual Toxicity of a New Pyrethroid Insecticide, WL85871, to Honey-bees

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In the past, judgements regarding the potential safety of pesticides to honey-bees have been made mainly on the basis of acute toxicity data alone. Generally only if a pesticide was shown to have low to moderate toxicity have field tests been carried out. More recently the need for a more realistic sequential testing scheme to evaluate the hazard of pesticides to honey-bees has been recognised (Shires 1983). In such a scheme progression through the various tests depends on a careful evaluation of the results obtained at each step. In acute laboratory tests pyrethroid insecticides have proved to be extremely toxic to bees by both topical and oral routes (Stevenson 1978). By contrast however, at least some pyrethroids are now known to have little or no effect on bees in the field (Shires and Debray 1982, Shires et al 1983). A suitable secondary laboratory cage-test procedure that enables an assessment of the residual toxicity of pesticides to bees has been described by Gerig 1979. This test provides a useful stage between laboratory acute tests and field evaluation. Compounds that are toxic to bees in standard acute laboratory tests but that may not be hazardous under field conditions are likely to be identified using this test method.

The objectives of the study reported here were to determine the acute and residual toxicity to bees of a new pyrethroid insecticide WL85871 (FASTAC[1] a mixture of (1R cis)S and (1S cis)R isomers of cypermethrin), and compare them with those found for the organophosphate insecticide dimethoate. In the oral and topical toxicity tests technical grade WL85871 and dimethoate were evaluated together with an emulsifiable concentrate formulation of WL85871. For each compound, parallel tests were carried out with the toxic reference compound, technical grade parathion-ethyl. In residual toxicity tests emulsifiable concentrate formulations of WL85871, phosalone and dimethoate were compared.

MATERIALS AND METHODS

For acute oral and topical toxicity tests ten or twenty bees, previously anaesthetised with carbon dioxide, were placed in small test chambers constructed out of 2 mm aperture stainless steel mesh.

[1] FASTAC is a Shell registered trademark.

Experiments using five dose rates of all test compounds, each replicated two to three times, were carried out to determine accurate LD_{50} values. In all acute tests, control chambers were set up containing bees treated with appropriate solvent blanks.

In the oral toxicity tests bees were deprived of food for two hours before administration of the test compounds. Appropriate concentrations of the technical grade test materials were prepared in acetone (1 part) and then diluted (19 parts) with 50% w/v sucrose solution. For the formulated insecticide, the required doses were prepared by dilution with sucrose solution only. These toxicant/acetone/sucrose solutions were placed in glass capillary feeding tubes mounted in the lids of the test chambers. The nominal dose taken during the test was 20 µl per bee, i.e. assuming an equal distribution of the feed. When all the test solutions had been consumed the capillary tubes were removed and replaced with larger-orifice feeding tubes containing toxicant-free sucrose solution.

In the topical application tests a series of doses of the test compounds were prepared in acetone (technical material) or water (formulated product). A 1 µl droplet, containing the test compound or solvent blank, was placed on the dorsal thorax of each bee using a blunt needle attached to a syringe and micro-applicator. Throughout the tests all bees were fed with a 50% sucrose solution. Observations on bee mortality were carried out 24 hours after both oral dosing and topical application.

Assessment of residual toxicity was carried out using groups of 100 bees held in large stainless steel mesh (2 mm aperture) cages with a glass front and base. Formulated test compounds were diluted in deionised water and applied to batches of flowering Phacelia campanularia plants using an 'Oxford Precision Band Sprayer' delivering a volume of about 340 litres ha^{-1}. All products were applied at typical field dose rates, i.e. WL85871 at 15 g ai ha^{-1}, phosalone at 1200 g ai ha^{-1} and dimethoate at 500 g ai ha^{-1}. A fourth batch of Phacelia flowers, which were to be used as a control, were sprayed with water alone. For each cage, four pots of flowering Phacelia plants were sprayed simultaneously and left to dry at room temperature for thirty minutes. The sprayed plants were then mounted in the top of the cages. Two hours after the start of the test a feeding tube containing 50% sucrose solution was provided. The absence of any sucrose feed during the early part of the test encouraged the bees to forage on the sprayed flowers. Observations on bee mortalities were carried out at 1, 2, 4, 24 and 48 hours after the test commenced. In addition, counts were made of the numbers of bees foraging the flowers at 1, 2 and 4 hours. On each occasion this involved recording the number of visits made by the bees to the flowers during five periods of 30 seconds. Three separate tests were carried out on each product using different batches of bees.

In both acute and residual toxicity tests all cages containing bees were held in a growth cabinet at 25 ± 1°C and 50% relative humidity. Adequate ventilation was supplied by fans mounted in the cabinet base.

RESULTS AND DISCUSSION

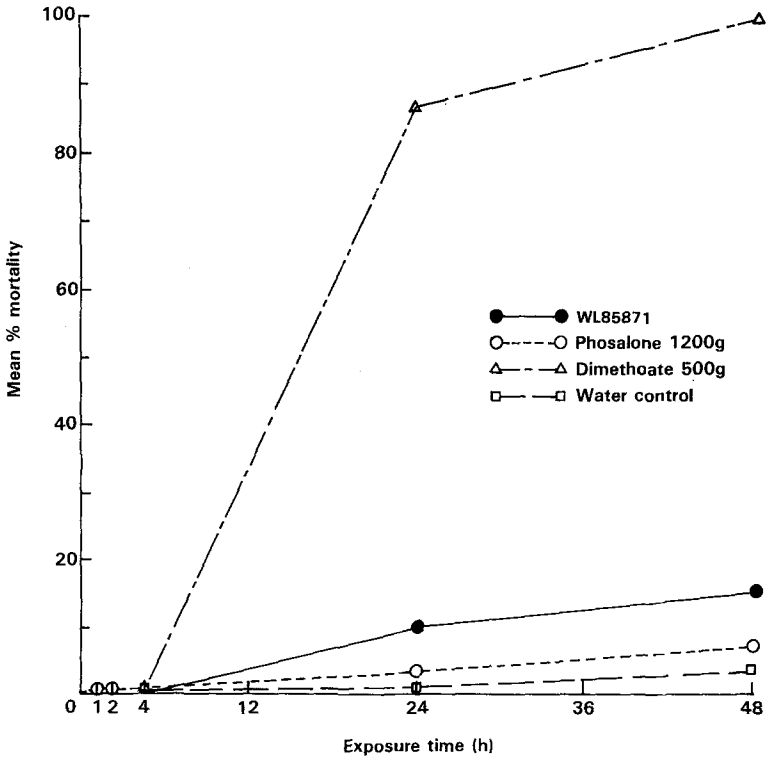
The toxicity of the test compounds to worker honey-bees in both topical and oral tests are summarised in Table 1. The results show that both WL85871 and dimethoate are highly toxic to bees with similar LD_{50} values being obtained by both topical and oral administration. WL85871 technical material appeared to be between two and four times more toxic than the formulated product. This difference may, however, be due to the use of acetone as a solvent for the technical material. The dimethoate results agree with those obtained by Stevenson (1978) in a similar laboratory study. Moreover, the repeatability of the tests based on the results obtained for parathion-ethyl was very good. The use of this compound as a test standard in laboratory acute tests on bees is being considered by the Internationl Commission for Bee Botany (Stevenson, 1980).

Table 1 - Acute oral and topical toxicity of the test compounds to worker honey-bees

Compound	24 hour LD_{50} ($\mu g\ bee^{-1}$) after topical application	24 hour LD_{50} ($\mu g\ bee^{-1}$) after oral administration
WL85871 (technical)	0.03	0.06
Parathion-ethyl (technical)	0.10	0.16
WL85871 (formulated)	0.11	0.13
Parathion-ethyl (technical)	0.07	0.13
Dimethoate (technical)	0.16	0.13
Parathion-ethyl (technical)	0.09	0.09

The mortality of bees exposed to treated Phacelia flowers in the residual toxicity test are summarised in Figure 1. Very low mortalities (≤5%) occurred in the cages containing water-treated control flowers. In the cages containing insecticide-sprayed flowers deaths started to occur between 4 and 24 hours after the tests commenced. At the end of the tests (48 hours) only 15% and 7% mortality had occurred in the WL85871 and phosalone cages respectively. By contrast, high bee mortality (≥97%) resulted in the cages containing dimethoate-treated flowers.

Figure 1 - Mean percentage mortality of honey-bees during 48 hour exposure to sprayed Phacelia flowers



Visual observations showed that foraging activity on the Phacelia flowers varied between repeat tests even with the same compound and probably reflected natural variability in the different batches of bees used. However, it was generally lower in insecticide-treated cages during the initial stages of the tests, but thereafter was similar to that in the untreated controls (Table 2).

Table 2 - Mean number of visits made by the bees to sprayed Phacelia flowers during observation periods of 30 seconds

Chemical (dose)		Time after start of the test		
		1 hour	2 hours	4 hours
WL85871	15 g	19	28	8
Phosalone	1200 g	22	11	10
Dimethoate	500 g	24	18	2
Water control		35	20	15

The acute laboratory tests show that WL85871 is highly toxic to honey-bees when administered directly. However, WL85871 appeared to be relatively non-hazardous as a residual deposit on sprayed flowers. This marked difference between acute and residual toxicity differs from that observed with dimethoate, which is similarly highly toxic to bees in acute tests but also hazardous as a residual deposit. The lack of effects of WL85871 in the residual toxicity test agrees closely with its demonstrated lack of effects on bees in field situations (Shires et al, in press). This correspondence between residual laboratory tests and field trials results suggests that this test can play an important role in the early identification of pesticides that may be non-hazardous in the field but highly toxic when applied directly in the laboratory.

Acknowledgements My thanks are due to Mr. K. Beevor, a professional bee keeper, for supplying the test bees and to Mr. R.J. Knight of Shell Research Limited, Sittingbourne, who supplied the data on WL85871 technical material. I am also grateful to Dr. S.W. Shires, whose valuable comments and careful editing much improved the final manuscript.

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Received June 8, 1984; accepted July 9, 1984.