TOXICITY OF PESTICIDES TO HONEY-BEES

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Summary

Laboratory and field methods of testing the toxicity to honey-bees of pesticides are described. A table is presented giving recommendations for the use of pesticides in New Zealand in such a way as to minimize the chances of honey-bee mortality.

INTRODUCTION

HONEY-BEES play an important role in New Zealand agricultural economy as pollinators of seed crops. White clover (*Trifolium repens* L.) seed production depends almost entirely on honey-bees (Palmer-Jones *et al.*, 1962). They are also the major pollinators of lucerne (*Medicago sativa* L.) (Palmer-Jones and Forster, 1965) and Montgomery red clover (*Trifolium pratense* L.). A recent study of fruit tree pollination has shown that bees are the main pollinators of Cox's orange pippin apple trees, at least in the Richmond area.

New Zealand agriculture depends increasingly on aerial and ground application of pesticides, many of which are toxic to honey-bees and bumble-bees. The problem is to protect honey-bees from pesticides without hindering normal farming operations. Serious losses of bees in orchards in 1947, through the indiscriminate use of lead arsenate, resulted in the passing of legislation which prohibited the treating of fruit trees and small fruits during the flowering period with compounds toxic to bees. In 1955, heavy bee mortality, caused through aerial dusting with lindane of choumoellier (*Brassica oleraceae* L.) in flower, brought home the need for further protection, and led to the passing of the Apiaries Protection Regulations 1957. These prohibit the application of pesticides toxic to bees to cruciferous and leguminous field crops, or to flowering plants within these crops, during the period (September to March) when they are attractive to bees. Protection of the beekeeping industry by legislation places an even greater obligation than before on the Wallaceville Apiculture Section to conduct screening trials of pesticides with the aim of finding out which ones can be used to control pests effectively without harming bees. It is not always advisable to assume that the results of overseas work apply locally because climatic conditions, the type of crop to which the pesticide is applied, the method and scale of application, and the concentration are usually different in New Zealand. It has been found, for instance, that the systemics demeton-methyl (Palmer-Jones *et al.*, 1957) and mevinphos (Palmer-Jones and Forster, 1963), formerly claimed safe to bees overseas, are highly toxic under New Zealand conditions. The herbicide 2,4-D, generally considered harmless to bees when applied in usual farm practice, may cause serious bee mortality when applied on a very large scale as in New Zealand land development projects (Palmer-Jones, 1964).

Apart from exchanging information with agricultural chemical firms and overseas workers, Wallaceville maintains a close liaison with the Entomology Division of the Department of Scientific

fic and Industrial Research. This enables newly developed pesticides, under test for control of clover case-bearer moth (*Coleophora* spp.), grass-grub (*Costelytra zealandica*), etc., to be also screened for honey-bee toxicity. Results of tests enable the Section to determine whether a compound can be applied without precautions to flowering crops, whether it can be applied only when bees are not flying, or whether it is unsafe to use throughout the flowering period.

METHODS

Laboratory techniques have been developed at Wallaceville for measuring the toxicity of pesticides to honey-bees (Palmer-Jones, 1958). It must be emphasized that, when pesticides are applied in the field, their effect on bees depends on repellency, method of application, systemic effect, and other factors which cannot be duplicated satisfactorily in the laboratory. Such tests provide a means of rapidly and cheaply assessing probable field toxicity of pesticides, but their limitations render field trials necessary before a pesticide is finally judged safe to bees.

LABORATORY TESTS

Pesticides may act on bees as stomach poisons, contact poisons (wet or dry), and fumigants. Bees may also be sprayed or dusted during application. These effects can be simulated in the laboratory.

Pesticides are usually applied in the early morning before bees commence to fly. Hence, in evaluating results of laboratory tests, their effects as stomach poisons, and contact poisons after deposition on the plant surface, are much more important than fumigant action, and direct contact effect during application.

Stomach Poisons

Bees may ingest pesticides in nectar, drinking water, or pollen contaminated by spraying. Nectar may also be contaminated within the plant by systemic action.

Feeders are charged with drops of a sugar solution containing a known strength of the pesticide. Then starved bees are fed the drops, individually, and kept under observation. A series of concentrations is dosed and the L.D.50 percentage is calculated. This may range from 20 μ g for toxaphene, say, to 0.5 μ g for demeton-methyl.

Contact Poisons

A thin film of the agricultural chemical is sprayed evenly over one side of a sheet of tin-foil of a standard area. The weight of the dry spray is obtained and the inside of a cage lined completely with the foil. Bees are exposed for an hour in the cage to a series of doses of the pesticide under test, so simulating contact effect on a sprayed plant.

Batches of bees are anaesthetized with CO₂ and sprayed or dusted with the pesticide, so simulating direct contact effect during application.

Fumigants

Fumigant effect is studied by using circular cages in the upper half of which bees are confined so that they are exposed to vapour ascending from the lower.

FIELD TESTS

When testing the effect of a pesticide on bees in the field, the maximum number of field bees should be exposed to the maximum quantity of chemical likely to be applied per acre of crop. Consequently, the aim is to apply the pesticide when flowers on the treated area are being visited by many honey-bees. It follows that the flowers of the crop must bear nectar attractive to bees, and weather conditions on the day of the experimental application must favour bee activity, because bees are most susceptible to the action of an agricultural chemical on the day of application.

Pesticides are generally applied in the early morning or evening, when bees are not flying, because conditions then are calm, and drift is avoided. Consequently, it is generally unnecessary to study the effect of applying them to pastures or crops actually being worked by bees.

Experimental Hives

Apiaries within bee range of the experimental crop are located and the condition of hives checked before and at intervals after the pesticide is applied. The beekeeper is informed of the trial and arrangements made to compensate him for losses of bees and potential crop should this be necessary.

Counts of Field Bees

It is essential to count bees on the crop to obtain a picture of bee activity before and after a pesticide has been applied, and also to measure any repellency it may exert. Bee counts are made in replicated 100 sq.yd strips of crop, under climatic conditions suitable for maximum bee activity, and are expressed as bees per acre.

Caging and Observation of Field Bees

After application of the pesticide, field bees are picked off flowers of the treated crop and kept under observation in cages supplied with feeders of sugar syrup. These cages are maintained in a hive outside bee range of the treated crop.

Observation Hives

Sometimes it is advantageous to study the effect of pesticides upon hive activity and organization directly. Palmer-Jones (1960) has developed the use of two-frame hives for this purpose, one frame being above the other so that all parts of the combs are open to inspection. Foraging bees can be readily sprayed or dusted with pesticides, as they enter and leave such hives, and the effects observed.

The tests described have been used satisfactorily for ten years, the results obtained being applied through the Agricultural Chemicals Board and Apiary Instructors of the Horticulture Division.

Toxicity of the main pesticides to honey-bees is shown in Table 1, which gives recommendations for their use in such a way as to minimize the chances of mortality.

DISCUSSION

The present search for insecticides which are effective, yet leave no residues, has led to greater use of the many organophosphorus compounds which fulfil these requirements. But their effectiveness is often due to systemic action which may result in the contamination of nectar with plant metabolites highly poisonous to honey-bees.

TABLE 1: TOXICITY OF PESTICIDES TO HONEY BEES

<i>Not harmful</i>	<i>Should not be applied directly on bees visiting flowers, but in early morning or evening when they are not flying.</i>	<i>Highly toxic. Must not be applied to crops in flower at any time.</i>
FIELD TESTED IN NEW ZEALAND		
Dinoseb plus dinosam	DDT	Demeton-methyl
Endothal	Endosulfan†	Dimethoate
Pentachlorophenol	Endothion	Mevinphos
2,4-D*	"Strobane"	Phosphamidon
2,4,5-T (butyl and butoxyethanol esters)	Toxaphene	
	Trichlorphon	
TESTED OVERSEAS		
Binapacryl	DDD	Aldrin
Bordeaux mixture	Endrin	Azinphos-methyl
Captan	Ethion	BHC
Chlorfenson	Menazon	Calcium arsenate
Cuprous oxide	Methoxychlor	Carbaryl
Dicofol	Pyrethrum	Chlorthion
Ferbam	Rotenone	Diazinon
"Kepone"	Ryania	Dichlorvos
Maneb	TEPP	Dieldrin
Monuron		Disulfoton
Nabam		Fenthion
Nicotine sulphate		Heptachlor
Sulphur		Lead arsenate
TCA		Lindane
Tetradifon		Malathion
Thiram		Parathion
Zineb		Parathion-methyl
Ziram		Phorate

* Harmless to bees when applied on single farms. May cause mortality if applied on a very large scale.

† Must not be applied to brassicas in flower. Safe on other crops if applied before bees fly.

Laboratory studies of the effect of such contaminated nectar on bees are being carried out at Wallaceville. Plants, grown in an air-conditioned room, are treated with systemics, and nectar withdrawn and tested for bee toxicity. This technique permits the study of poisoning due to systemic action alone, contact effect being excluded.

The degree of economic loss a beekeeper may suffer through application of a pesticide will depend upon the period of the bee-keeping season when bee mortality occurs. Hives would be unable to recover sufficiently to gather a crop if they suffered heavy losses of field bees shortly before the main honey flow. Similar losses in the autumn, after the crop had been gathered, could be of little account.

Fortunately, most pesticides toxic to bees used in New Zealand break down rapidly and little contamination of nectar and pollen occurs in the hive. Therefore, although foragers may suffer heavy losses, the queen and developing bees are unaffected, and the hive usually recovers. Persistent pesticides are far more dangerous, contaminating both nectar and pollen in the hive, and so destroying

developing bees and queen. These effects were apparent in New Zealand after applications of lead arsenate in orchards in 1947, and lindane on choumoellier in 1955, both of which caused heavy losses of hives. Nectar and pollen were contaminated in hives so that, in addition to heavy losses of foragers, developing bees died in great numbers and it was necessary to sort out and destroy pollen combs.

Flower structure may have some effect on the toxicity of pesticides to bees. Endosulfan was applied to flowering broad beans (*Vicia faba* L.) and flowering white clover without causing bee mortality (Palmer-Jones, 1959; Palmer-Jones and Forster, 1963). Yet heavy bee mortality occurred when it was sprayed on choumoellier (*Brassica oleraceae* L.) (Palmer-Jones *et al.*, 1959). The choumoellier flower is much more open than those of the other plants and sprays would enter it more readily.

Occasionally animal pests may be controlled by compounds, such as 1080 (sodium fluoroacetate), which are dangerous to bees. The amount of 1080 in one ounce of poisoned jam used to control noxious animals is sufficient to kill up to 18,000 bees and trials have shown that bee colonies are severely affected if field bees gather such baits. However, though a close watch has been kept during the last six years for evidence of mass mortalities of bees, in association with nearby 1080 poisoning operations, no such evidence has been obtained (McIntosh *et al.*, 1964).

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