Sonderdruck aus Bd. 104 (1987), H. 2, S. 211–214

Zeitschrift für angewandte Entomologie

VERLAG PAUL PAREY · SPITALERSTRASSE 12 · D-2000 HAMBURG 1

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Laboratory evaluation of dimethoate repellence to honey bees[1]

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Abstract

Honey bees (*Apis mellifera* L.) were presented with a choice of air contaminated with dimethoate (Cygon® 400) or clean air in a Y-tube olfactometer. Air was contaminated by passage over treated filter papers. No avoidance of the insecticide was found at residues of 0.0056 mg ai/sq cm (corresponding to the recommended field rate on apples), or at 5, 10, or 15 times this amount. Bees were repelled by droplets of 10% Cygon and by benzaldehyde (a standard honey bee repellent) at two rates. Permethrin (Ambush® 2E, 0.011 and 0.0022 mg ai/sq cm) did not repel bees.

In a spatial test, 100% mortality occurred when caged bees contacted dimethoate residues (1.486 to 0.046 mg ai/sq cm) on filterpaper rings surrounding feeder vials. Dimethoate residues of 0.012 and 0.006 mg ai/sq cm caused neither bee mortality nor a decrease in syrup consumption from treated feeders.

1 Introduction

Applications of dimethoate (0,0-dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate) for insect control have been suspected to interfere with pollination of several crops. Anecdotal reports often cite foraging honey bees (*Apis mellifera* L.) apparently being repelled by the insecticide. Such reports have prompted investigations of the effects of dimethoate on honey bees visiting onions (WALLER et al. 1979; WALLER and BARKER 1979), alfalfa (BARKER et al. 1980), lemons (WALLER et al. 1984) and apples (DANKA 1983; DANKA et al. 1985). Toxicity, not repellency, was usually evident when dimethoate was applied properly to each crop. However, repellency may occur when dimethoate is applied at excessive rates or during bloom (DANKA 1983; DANKA et al. 1985). In the laboratory, consumption tests of dimethoate-contaminated sucrose syrup (WALLER and BARKER 1979; WALLER et al. 1979; BARKER et al. 1980) indicated a feeding inhibition due to sublethal intoxication.

We screened honey bee olfactory and contact responses to dimethoate (Cygon® 400; American Cyanamid). In the olfaction tests, we used a Y-tube olfactometer in which bees were presented with a choice of clean versus dimethoate-contaminated air. The effects of benzaldehyde and permethrin (Ambush® 2E; ICI Americas) were evaluated as standards, since each of these chemicals is known to repel honey bees in some field situations (TOWNSEND 1963, ATKINS 1981). In the contact tests, we used the principle of ATKINS et al.

[1] Authorized for publication as Paper No. 7592 in the Journal Series of the Pennsylvania State University Agricultural Experiment Station.

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J. Appl. Ent. 104 (1987), 211–214

ISSN 0044-2240

(1975), who surrounded feeder vials with contaminated silica-gel "flowers" and checked for a feeding inhibition by caged bees.

In the tests we report here, insecticide concentrations and application rates corresponded to label recommendations for apples, or multiples thereof. The field rates are: dimethoate, 125 ml Cygon 400/100 l water applied for thorough coverage, yielding 0.0056 mg ai/sq cm; permethrin, 586 ml Pounce 3.2 EC/ha, yielding 0.0022 mg ai/sq cm (Ambush 2E is not labelled for apples in the United States). These rates were selected because this laboratory study was part of a larger program to determine the effects of dimethoate sprays on honey bee foraging and pollination in apples (DANKA 1983; DANKA et al. 1985).

2 Materials and methods

2.1 Olfactometer tests

A 9-mm inside diameter (ID) glass Y-tube was used to test bee responses to dimethoate vapors. Stem and branches of the olfactometer were 10-cm long and joined at 60° angles. Distal ends of the branches were connected by ground-glass fittings to 8-cm long, 15-mm ID glass tubes which held residues of the test chemical. A 10 ml/min airflow from a pump was directed through a 4000-ml Erlenmeyer flask to diminish pulsation, then cleaned by passage through an activated-charcoal filter. The air flow was split into the two lines leading to the residue tubes; float-type flowmeters were used to ensure equal flow in each line. The olfactometer was set up on a horizontal, white benchtop and illuminated with ca. 300 foot-candles of overhead fluorescent lighting.

Preparation for a test began by spraying a premeasured amount of diluted test chemical as uniformly as possible onto a 25-cm^2 piece of filter paper with a chromatograph sprayer. The filter paper was cut into 25 5-cm^2 sections after it had air dried (< 1 h); 5 sections were randomly chosen for use in tests. Four replicates of this protocol were used to test 20 bees per chemical dosage. To test 10 % Cygon and 2 concentrations of benzaldehyde, a 100-µl droplet of test solution was placed directly onto each 5-cm^2 filter paper. When tested, a treated filter paper was loosely rolled (sprayed side inward) and inserted into the residue tube. The other residue tube was loaded with a filter paper sprayed with diluent only (water for the insecticides, 95 % ethanol for benzaldehyde). A sperate test was done to check for an effect due to type of diluent used.

Honey bees used in the study came from a colony maintained in a flight cage in the laboratory. The colony was fed sucrose solution and bee-collected pollen while being held for testing. All bees tested were presumably of foraging age, since they were flying in the cage.

Testing commenced by introducing a bee into the Y-tube stem and allowing her to walk up the stem to make a directional decision at the branch junction. A trial ended when the bee moved 7 cm up either branch. Each bee was used for 5 such trials with one filter paper. Between bees, glassware was cleaned by immersion in a chromic acid bath followed by water and ethanol rinses. Frequencies of bee choices to treated and control branches were evaluated with chi-square one-sample tests.

2.2 Spatial tests

Using a modified version of the method of ATKINS et al. (1975), 6 473-ml waxed-paper containers were established, each with 25 young bees taken from brood combs of a colony. A vertical, 5.0 × 2.5 cm piece of empty wax comb was provided so bees could cluster and store food. Three gravity feeder vials were accessible in the plastic lid of the cage; 2 held sucrose syrup (50 % by volume) and the other water. The flowers encircling the sucrose feeder vial lids were 4.0-cm diameter filter-paper discs with a 2.0-cm central hole. One flower was treated with dimethoate (using a chromatograph sprayer) and the other with water only. Prepared cages were held in 27 °C, 35–50 % RH incubators under constant fluorescent lighting. Syrup consumption and bee mortality were assessed after 24 h. Consumption differences were evaluated with *t*-tests.

3 Results

3.1 Olfactometer tests

Field-rate dimethoate residues (0.0056 mg ai/sq cm) did not repel honey bees ($P = 1.000$); 50 choices by bees were to the contaminated branch of the Y-tube, and 50 were to the untreated branch. Residues at 5, 10, and 15 times the field rate also failed to repel bees ($P = 0.689$, 0.317 and 0.072, respectively). Bees were repelled by vapors of 10 % Cygon ($P = 0.016$); this concentration is 80 to 160 times that which is recommended for use on apples. Permethrin at 0.011 and 0.0022 mg ai/sq cm failed to elicit repellence ($P \geq 0.424$). Benzaldehyde residues at 10 % and 0.00125 % repelled bees ($P \leq 0.005$). Position of the treated branch of the Y-tube (i.e., left versus right) never had an effect on bee responses for any chemical dosages ($P \geq 0.162$). The type of diluent used also did not affect results ($P = 0.317$).

3.2 Spatial tests

Dimethoate residues of 0.046, 0.093, 0.372 and 1.486 mg ai/sq cm killed all bees within 24 h. Bees survived at lower dosages, but syrup consumption from treated and control vials was similar (at 0.012 mg ai/sq cm: treated = 0.94 ± 0.38 ($\bar{x}$ ± std. dev.) mg consumed, control = 0.78 ± 0.40 mg consumed, $P = 0.247$; at 0.006 mg ai/sq cm: treated = 0.40 ± 0.12 mg consumed, control = 0.35 ± 0.08 mg consumed, $P = 0.209$).

4 Discussion

The failure of dimethoate to repel honey bees, except at an axaggerated dosage, supports results of previous field and laboratory studies (see chap. 1). To date, dimethoate has not shown significant repellence via olfaction, contact, or ingestion. Dimethoate is highly toxic to bees, however; our spatial tests show that dimethoate can kill all bees exposed to dosages at which other chemicals elicit repellence (Atkins et al. 1975). Thus, pollination disruptions due to dimethoate may still occur, resulting either from mortality or from sublethal intoxication of foragers (Waller and Barker 1979). Tests on apple (Danka 1983; Danka et al. 1985) found no pollination problems when dimethoate was applied at proper rates and with proper timing.

Zusammenfassung

Laboruntersuchungen zur Repellentwirkung von Dimethoat gegenüber Apis mellifera L.

In einem Y-förmigen Rohr-Olfaktometer wurden Honigbienen, *Apis mellifera* sowohl mit Dimethoat (Cygon® 400) kontaminierte als auch reine Luft angeboten. Die Luft wurde mit Dimethoat angereichert, indem man sie über ein behandeltes Filterpapier strömen ließ. Bei Rückständen von 0,0056 mg ai/cm^2 (entsprechend der im Freiland bei Äpfeln verwendeten Menge) oder bei 5-, 10- oder 15facher Menge konnte keine Meidung der mit dem Insektizid angereicherten Luft festgestellt werden. Bei Tropfen 10 %igen Cygons sowie Benzaldehyde (ein Standardrepellent gegenüber Honigbienen) in 2 Konzentrationen wurde eine Repellentwirkung nachgewiesen. Permethrin (Ambush® 2E; 0,011 und 0,0022 mg ai/cm^2) wies keine Repellentwirkung gegenüber Bienen auf.

In einem Käfigversuch trat 100 %ige Mortalität ein, wenn die eingekäfigten Bienen über mit

Filterpapierringen versehene Fütterungsfläschchen Kontakt mit Dimethoat-Rückständen (1,486 bis 0,046 mg ai/cm^2) hatten. Dimethoat-Rückstände von 0,012 und 0,006 mg ai/cm^2 bewirkten jedoch bei den Bienen weder eine erhöhte Mortalität noch einen Rückgang des Sirup-Verzehrs.

References

ATKINS, E. L., 1981: Repellents reduce insecticidal kills of honeybees. Proc. XXVIII. Intern. Apic. Congr., Acapulco.

ATKINS, E. L.; MACDONALD, R. L.; MCGOVERN, T. P.; BEROZA, M.; GREYWOOD-HALE, F. A., 1975: Repellent additives to reduce pesticide hazards to honeybees: laboratory testing. J. Apic. Res. *14*, 85–97.

BARKER, R. J.; LEHNER, Y.; KUNZMANN, M. R., 1980: Pesticides and honey bees: nectar and pollen contamination in alfalfa treated with dimethoate. Arch. Environm. Contam. Toxicol. *9*, 125–133.

DANKA, R. G., 1983: The effects of dimethoate sprays on honey bee foraging behavior in Pensylvania apple orchards. M. Sc. thesis, Penns. State Univ.

DANKA, R. G.; COLLISON, C. H.; HULL, L. S., 1985: Honey bee (Hymenoptera: Apidae) foraging during bloom in dimethoate-treated apple orchards. J. Econ. Entomol. *78*, 1042–1047.

TOWNSEND, G. F., 1963: Benzaldehyde (artificial oil of almonds) for the removal of honey. Am. Bee J. *103*, 293.

WALLER, G. D.; BARKER, R. J., 1979: Effects of dimethoate on honey bee colonies. J. Econ. Entomol. *72*, 549–551.

WALLER, G. D.; BARKER, R. J.; MARTIN, J. H., 1979: Effects of dimethoate on honey bee foraging. Chemosphere *7*, 461–463.

WALLER, G. D.; ERICKSON, B. J.; HARVEY, J.; MARTIN, J. H., 1984: Effects of dimethoate on honey bees (Hymenoptera: Apidae) when applied to flowering lemons. J. Econ. Entomol. *77*, 70–74.

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