THE INFLUENCE OF PESTICIDES ON POLYPHAGOUS PREDATORS OF PESTS

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ABSTRACT

Beetles belonging to the Carabidae and Staphylinidae prey on aphids, cabbage root fly, wheat bulb fly, cabbage white butterfly, wireworms, cutworms and slugs. The effects of aldicarb, chlorfenvinphos, diazinon, disulfoton, fonofos, gamma-HCH, parathion and phorate on these beetles were tested in 7 experiments. Some were very toxic, but chlorfenvinphos and carbophenothion caused an initial decrease in pitfall catches followed by an increased catch indicating that residues had an excitatory influence but it is not known if this increased activity was associated with increased predation.

INTRODUCTION

Many predators of pests are specific to particular species, but polyphagous predators that can prey on a wide range of species are common in agricultural fields and can be very important in keeping numbers of pests under natural control. They include certain mites, pseudoscorpions, centipedes, spiders and harvestmen, but probably the most important groups in controlling pests that live on or near the soil surface are the numerous species of beetles belonging to the Carabidae and Staphylinidae. Carabid beetles such as Bembidion lampros (Herbst.), Pterostichus melanarius (Ill.), Harpalus spp. and Trechus quadristriatus (Schrank.) prey on the eggs and larvae of cabbage root fly (Hughes 1959, Coaker & Williams 1963), while Harpalus rufipes (Degeer) can prey on cabbage white fly eggs (Pieris rapae L.) (Dempster 1967). Carabid beetles have also been reported to prey on stem-boring larvae such as wheat bulb fly (Delia coarctata Fall.) (Ryan 1967), slugs (Tod 1970) and wireworms (Fox & Maclellan 1956). More recently, they have been shown to be of considerable importance as predators of cereal aphids (Edwards et al. 1979, Sunderland et al. 1980, Edwards & George 1981), and it seems probable that they prey on pests that attack seedling sugar beet (Edwards & Dunning 1980, Thornhill & Edwards, in press).

Pesticides are used in increasingly large quantities and it is important to assess their effects not only on the pests they are applied to control, but also on the predators that help to keep pests under natural control. There have been various instances where elimination of predators has resulted in increased pest attack (Wallace 1959, Klostermeyer & Rasmussen 1953, Stone 1953, Wright 1962), but there have been relatively few studies into the effects of insecticides on polyphagous beetles (Edwards & Thompson 1975).

It is laborious to assess populations of these beetles by hand-sorting in the field or by taking soil samples, so the commonest method used in field studies is to bury pitfall traps level with the soil and record the numbers of beetles caught in them periodically. Although this is a simple technique, which provides extensive data on readily identifiable specimens, it does have certain drawbacks. The catches are not truly representative of populations because they are influenced by the activity of the beetles. However, they may be a better index of predatory potential than assessing numbers.

Unfortunately, beetles that are affected by pesticides may be more or less voracious than healthy ones; they may also fall into pitfall traps more readily.

The design of field experiments also presents problems. Although many of these beetles do not fly they are extremely active and can travel large distances. Hence, to assess the effects of pesticides on polyphagous beetles in the field, plots must either be very large or be surrounded by some kind of physical barrier. Data from both types of experiment will be discussed in this paper, which reviews the effects of a number of commonly used pesticides on polyphagous beetles.

EXPERIMENTAL METHODS

A series of experiments was performed over a period of four years in cereal fields to test the effects of chlorfenvinphos, (emulsifiable concentrate and granules) carbophenothion (e.c.), diazinon (e.c.), fonofos (gr.), phorate (gr.), disulfoton (gr.), and parathion (gr.) on polyphagous beetles. Plots 8.0 x 5.5 m were surrounded by polythene barriers buried 15 cm below the soil surface and standing 40 cm above it. They were supported by wooden posts joined by wire over which the polythene was folded. There were four replicate plots per treatment arranged in randomized blocks. Barriers were erected in early May and pesticides were applied soon after to spring-sown wheat either as a surface spray or granules evenly distributed over the soil surface. The pesticides were all applied at doses of 9.0 kg a.i. ha^{-1}. Eight 10 cm diameter x 10 cm deep pitfall traps containing no liquid were placed at random in each plot and marked by a cane one week before the pesticide application. Catches were collected and identified every 2-3 days from late May until August.

A second series of experiments was performed over a period of three years to assess the effects of gamma-HCH (e.c.) (lindane) sprayed on to the soil surface and incorporated into the soil and aldicarb (gr.) applied to the seed row prior to sowing of sugar beet (both at rates of 1 kg a.i. ha^{-1}) on numbers of polyphagous beetles. Plots were 25 m x 7.5 m, without barriers and treatments were replicated four times. Four 10 cm diameter x 10 cm deep pitfall traps containing a 10% saturated solution of picric acid with a little detergent were placed in the centre row of each plot. Catches were collected and identified weekly from April to June.

RESULTS AND DISCUSSIONS

The overall effects of the insecticides on the dominant and other species of beetles are summarized in Fig. 1. The effects in time of carbophenothion, chlorfenvinphos, diazinon and fonofos on populations of *P. melanarius*, the dominant species of carabid beetle, in the cereal experiments, are illustrated in Fig. 2. The effects of gamma-HCH and aldicarb in the sugar beet experiments are demonstrated in Fig. 3.

Clearly, pesticides differ greatly in their effects on polyphagous beetles. Some were very toxic and kill, or severely depressed the activity of all these beetles during the entire growing season of a crop. These included diazinon, fonofos, phorate, disulfcton and parathion. Other insecticides such as chlorfenvinphos, carbophenothion, gamma-HCH and aldicarb depressed the activity of polyphagous beetles initially to differing degrees; thereafter activity of some species, as reflected by larger pitfall catches, seemed to increase, often for the remainder of the growing season, although the rate of recovery differed between species. Similar

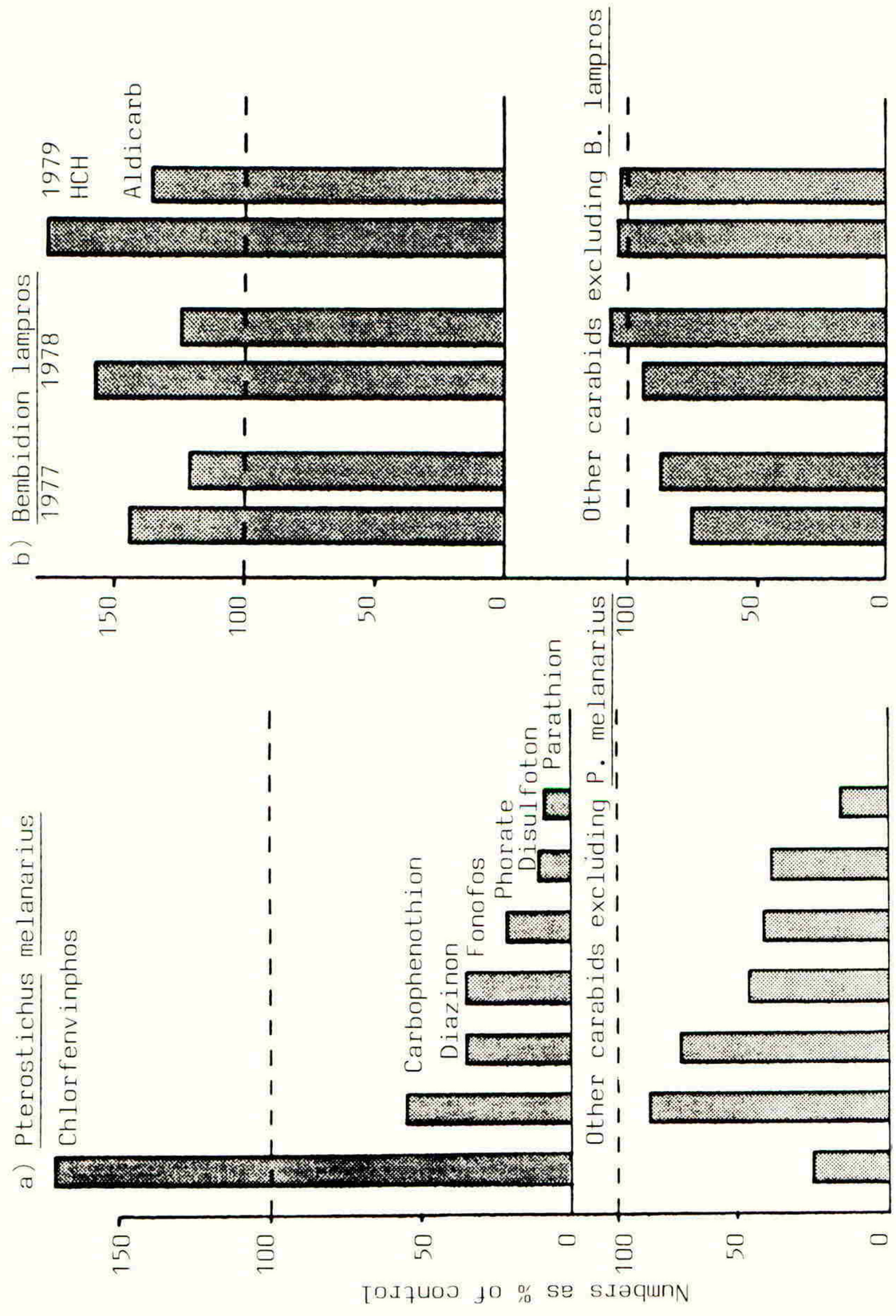

Fig. 1 Overall effects of insecticides on carabid beetle numbers in a) cereal fields, b) sugar beet fields

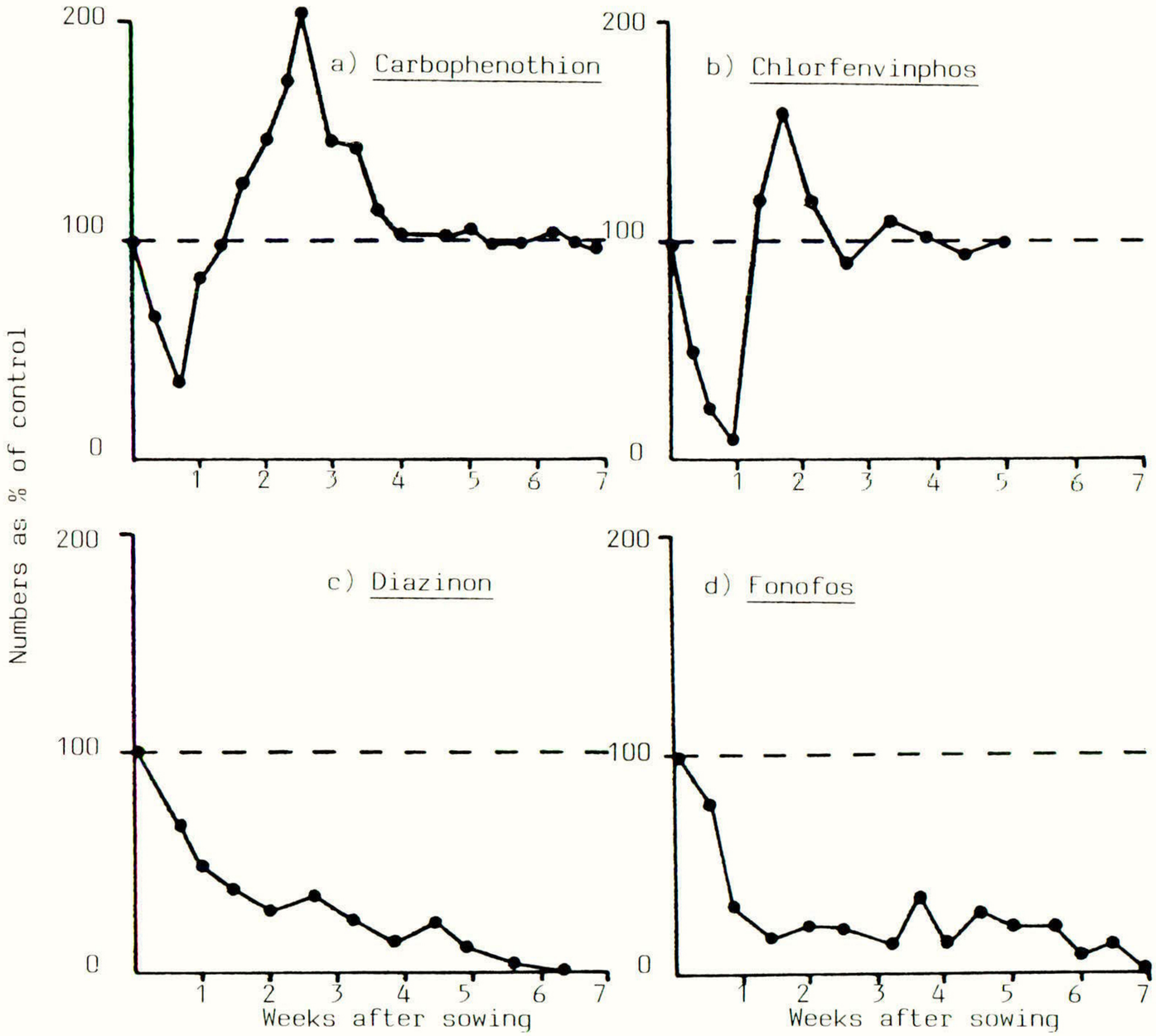

Fig. 2 Numbers of Pterostichus melanarius caught in pitfall traps in cereal fields in response to insecticide treatments

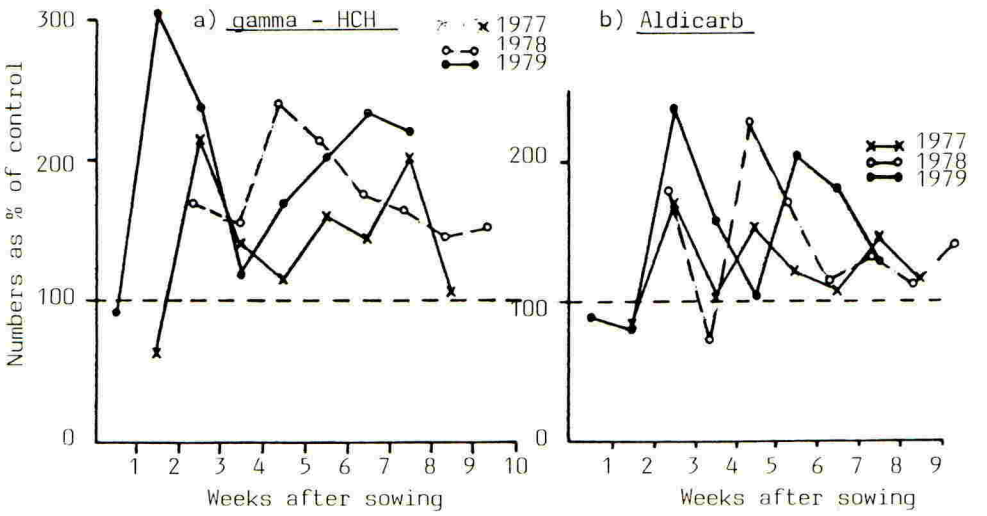

Fig. 3 Effects of a) gamma-HCH and b) aldicarb on Bembidion lampros numbers in a sugar beet field

results have been reported previously by Mowat and Coaker (1967) who stated that dieldrin treatments killed carabid beetles for a period but, as residues eventually decreased, pitfall catches showed there to be greater activity of beetles in treated plots than in untreated ones.

It is difficult to assess or predict in which of these ways a particular insecticide will affect polyphagous beetle activity, because the overall effect depends not only upon the toxicity of the chemical to different species but also on its method of application, persistence in soil and the dose used. However, chlorfenvinphos, gamma-HCH and aldicarb all increased activity of some species of beetles consistently in all three experiments, and fonofos decreased activity of all species in four experiments. It seems reasonable to suppose that if the increased activity of polyphagous beetles is dose-dependent for any particular insecticide, then increased activity will occur at the same time as the chemical residues gradually disappear.

In the cereal fields, P. melanarius was the dominant species with 27,118 of the 31,881 beetles trapped (i.e. 85%) belonging to this species. The other species trapped commonly were Pterostichus madidus (F.) and H. rufipes.

In the sugar beet fields, B. lampros was the dominant species, with 54% of the beetles trapped belonging to this species. The other common species were T. quadristriatus, P. melanarius, Clivina fossor (F.), Notiophilus biguttatus (F.) and Harpalus spp. There did not seem to be any great differences in susceptibility between species to the more generally toxic chemicals although P. madidus and H. rufipes tended to be less susceptible to most of the insecticides tested than P. melanarius in the cereal fields. However, whereas gamma-HCH stimulated the activity of B. lampros more than aldicarb, gamma-HCH depressed the activity of other species more than aldicarb (Fig. 1).

Numbers of staphylinid beetles tended to be affected less by the insecticides than those of carabid beetles.

The overall results of these experiments suggest that the recovery of polyphagous beetle populations in an isolated treated area could be slow, particularly for species with a long life cycle. However, some of these beetles are very mobile and plots treated with only moderately toxic and transient insecticides can be recolonized in as little as two weeks after the residues disappear. It may well be that those insecticides that have been most successful in controlling pests in the field are those that not only kill the pests but also increase the activity of their predators. For instance, chlorfenvinphos has been extremely successful in controlling cabbage root fly and wheat bulb fly, two pests which are preyed upon by carabids, and aldicarb and gamma-HCH have proved to be useful in controlling seedling pests of sugar beet, which may also be preyed upon by carabids.

ACKNOWLEDGEMENTS

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FIELD EVALUATION OF THE EFFECTS OF A NEW PYRETHROID INSECTICIDE, WL 85871, ON THE BENEFICIAL ARTHROPOD FAUNA OF OILSEED RAPE AND WHEAT

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ABSTRACT

The effects of a new synthetic pyrethroid insecticide, WL 85871, on the beneficial arthropod faunas of oilseed rape and wheat were investigated and compared with those resulting from parallel applications of organophosphorus compounds. The experimental design of the studies and the methods used to sample the arthropod communities of the crops are described. The effects of the chemical treatments on major entomophagous taxa are discussed.

INTRODUCTION

WL 85871 ('Fastac': (IR*cis*)S and (IS*cis*)R enantiomer isomer pair of (RS)-α-cyano-3-phenoxybenzyl (IRS)-cis,trans-3-(2,2dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate) is a new synthetic pyrethroid insecticide developed by Shell Research Limited. A five-year arable crop rotation study is in progress to compare the longer term effects on non-target invertebrates (particularly entomophagous taxa) of annual applications of WL 85871 with those resulting from the repeated use of non-pyrethroid compounds. Results from the first two growing seasons, when the crops were oilseed rape and winter wheat, are now available.

MATERIALS AND METHODS

The experimental design and procedures were the same for both seasons. Fieldwork was carried out in an 8 ha field on a farm near Sittingbourne, Kent, U.K. The field was divided into two approximately equal areas (Figure 1). One of these areas was sprayed each year with WL 85871, the other with an organophosphate insecticide appropriate to the crop and target pest complex (Table 1).

Within each treatment area, four 10m x 10m sampling plots were measured-out so that the distances between the plots and the treatment interface and the plots and the field boundary were the same for both parts of the field (Figure 1).

Epigeal arthropods were sampled using four 80mm diameter pitfall traps in each plot. Samples were collected at intervals before and after treatment by opening the traps for 48h. The crop foliage fauna was sampled by taking three D-vac suction net samples in each plot. Each sample comprised three sub-samples giving a combined sampling area of around $0.25m^2$. In addition, when the crop was winter wheat, water traps (250mm diameter yellow bowls, containing 1 litre of water) were used to sample the aerial arthropod fauna. Three water traps were placed at maximum crop height in each sampling plot. Samples were collected over 48h periods before and after treatment.

Figure 1

Diagram of the study site

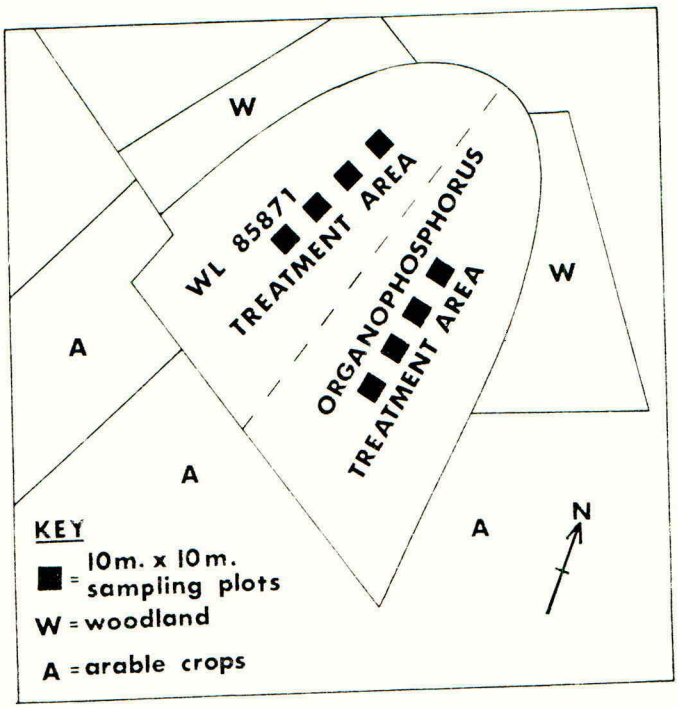

TABLE 1

Details of the insecticide treatments

Crop	Compound	Formulation	Dose rate	Time of application
Oilseed rape cv 'Jet Neuf'	WL 85871	100g l^{-1} EC	10g ai ha^{-1}	95% petal fall
	triazophos	420g l^{-1} EC	420g ai ha^{-1}	"
Winter wheat cv 'Rapier'	WL 85871	100g l^{-1} EC	15g ai ha^{-1}	Zadoks 69-73
	demeton-S-methyl	580g l^{-1} EC	240g ai ha^{-1}	"

Samples of arthropods were returned to the laboratory for identification and counting. The raw data were suitably transformed prior to analysis using ANOVAR techniques.

RESULTS

A wide range of entomophagous taxa was collected during both years of the study. However, the majority of groups were present only in small numbers. Discussion of the results is therefore necessarily restricted to the more abundant taxa.

a) Oilseed rape

Carabid beetles (mainly Agonum dorsale, Bembidion lampros Pterostichus spp. and Nebria brevicollis) and linyphiid spiders (mainly Lepthyphantes spp.) were the most abundant predators in the pitfall trap samples.

Data for the Carabidae are summarised in Table 2a. The WL 85871 treatment appeared to have no significant effect on these animals. In contrast, the application of triazophos resulted in a significant reduction in their numbers immediately after spraying. This was followed by a further decline in the numbers collected from the triazophos plots during the later part of the study.

TABLE 2

Effects of WL 85871 (10g ai ha^{-1}) and triazophos (420g ai ha^{-1}) on soil surface predators in oilseed rape.

a) Mean number of Carabidae per pitfall trap sample

	Time from treatment (days)						
	-17	-2	2	6	13	27	39
WL85871	7.1	5.8*	3.7	3.3	3.1	8.6*	9.9*
Triazophos	6.1	11*	4.8	4.4	4.1	4.3*	1.4*

b) Mean number of Linyphiidae per pitfall trap sample

	Time from treatment (days)						
	-17	-2	2	6	13	27	39
WL85871	0.7	6.8	2.5*	3.7*	7.2*	14*	14*
Triazophos	0.4	4.9	0.7*	1.5*	11*	25*	29*

*denotes significant difference between treatments at $p = 0.05$.

The Linyphiidae was the only family of spiders collected in large numbers during this trial. Both chemicals appeared to reduce their abundance immediately after spraying (Table 2b), but the effect was greater in the plots treated with triazophos. The numbers of linyphiids subsequently increased in both areas, recovering to pre-treatment levels within two weeks of application of the compounds. During the later part of the study, more linyphiids were collected from the triazophos plots than from the WL 85871 plots.

In studies of this sort, it is important to consider results obtained for entomophagous taxa in relation to the efficacy of the chemicals against target pest species. Data pooled for Meligethes spp., Ceutorhynchus spp. and cecidomyiid pod midges are summarised in Table 3, and indicate that both treatments had a similar impact on the pest complex of the crop.

TABLE 3

Effects of WL 85871 (10 g ai ha^{-1}) and triazophos (420g ai ha^{-1}) on the pest complex of oilseed rape.

Mean number of pests per D-vac sample

	Time from treatment (days)					
	-2	3	6	13	28	39
WL 85871	14	3.8	8.7	15	32	15
Triazophos	11	3.6	7.0	19	20	13

Data pooled for Meligethes spp., Ceutorhynchus spp. and Cecidomyiidae.

b) Winter wheat

As in the previous year's study, Carabidae and Linyphiidae were abundant in the pitfall trap samples. Table 4a indicates that neither WL 85871 nor demeton-S-methyl had any marked effects on the carabids. It can be seen from Table 4a that the numbers of carabids collected from plots treated with demeton-S-methyl declined during the later part of the study.

Data for the Linyphiidae are summarised in Table 4b and indicate that WL 85871 had a greater impact on their abundance than demeton-S-methyl. However, the numbers of linyphiids collected from the WL 85871 plots had recovered to pre-treatment levels within fifteen days of spraying. Indeed, on the last sampling occasion, significantly more linyphiids were collected from the WL 85871 plots than from the demeton-S-methyl plots.

Braconid Ichneumonoidea and Empidoidea (Diptera) were the most abundant entomophagous taxa collected in the D-vac and water trap samples. Data for the Braconidae are summarised in Table 5a and show that their numbers were reduced by both treatments. This effect appears to have been slightly greater in the plots treated with WL 85871. Both treatments also resulted in a decrease in the numbers of Empidoidea collected immediately after treatment (Table 5b). No treatment-related differences in abundance were recorded for these animals, and their numbers in both areas of the field had recovered to pre-treatment levels within fifteen days of spraying.

TABLE 4

Effects of WL 85871 (15g ai ha^{-1}) and demeton-S-methyl (240g ai ha^{-1}) on soil surface predators in wheat.

a) Mean number of Carabidae per pitfall trap

	Time from treatment (days)							
	-18	-11	-6	2	8	15	29	50
WL 85871	4.9	6.7	7.8	4.6	5.5	7.2*	7.6*	12*
Demeton-S-methyl	5.3	5.3	6.8	6.6	5.1	3.9*	1.9*	1.5*

b) Mean number of Linyphiidae per pitfall trap

	Time from treatment (days)							
	-18	-11	-6	2	8	15	29	50
WL 85871	9.1	6.2	5.1	2.8*	3.9*	9.9	22	13*
Demeton-S-methyl	8.7	5.1	5.3	7.1*	11*	12	23	8.9*

*denotes significant difference between treatments at p = 0.05.

TABLE 5

Effects of WL 85871 (15g ai ha^{-1}) and demeton-S-methyl (240g ai ha^{-1}) on crop foliage predators and parasitoids.

a) Mean number of Braconidae per D-Vac sample

	Time from treatment (days)					
	-5	2	8	15	30	50
WL 85871	7.6	0.9	1.9	4.2*	3.7	0.3
Demeton-S-methyl	6.0	0.9	3.1	12*	3.9	0.1

b) Mean number of Empidoidea per water trap sample

	Time from treatment (days)						
	-18	-11	-6	2	8	15	29
WL 85871	4.5*	9.5	6.1	1.5	1.3	2.3	6.5
Demeton-S-methyl	1.8*	5.1	3.0	3.5	1.9	3.1	7.0

*denotes significant difference between treatments at p = 0.05.

As noted earlier, the significance of such results is best considered in relation to the effects of the test compounds on pest populations. Data pooled for the Aphidoidea, Thysanoptera and Cecidomyiidae are summarised in Table 6 and show that WL 85871 had a greater impact on the pest complex of the crop than demeton-S-methyl.

TABLE 6

Effects of WL 85871 (15g ai ha^{-1}) and demeton-S-methyl (240g ai ha^{-1}) on the pest complex of wheat. Mean number of pests per D-vac sample.

	Time from treatment (days)					
	-5	2	8	15	30	50
WL 85871	56	11*	6.3*	21*	9.9*	6.0*
Demeton-S-methyl	56	6.9*	11*	85*	32*	14*

(*denotes significant difference between treatments at $p = 0.05$).

(Data pooled for Aphidoidea, Thysanoptera and Cecidomyiidae).

DISCUSSION

The most abundant entomophagous taxa collected during the two years of this study were typical of the crop ecosystems investigated (Basedow et al, 1976; Prueffer-Klein, 1977; Sunderland and Vickerman, 1980; Chambers et al, 1982). All four treatments had transient effects on some of the groups present, and treatment-related differences were recorded for several taxa. Viewed in the longer term, WL 85871 treatments had a similar impact on entomophagous taxa to the organophosphorus compounds with which they were compared.

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PP321 - EFFECT ON HONEY BEES

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ABSTRACT

PP321 is a novel pyrethroid insecticide from ICI, Plant Protection Division, formulated as "Karate". It is effective at low rates of application against insect pests on many crops.

Laboratory tests showed PP321 to be toxic to honey bees, but, when 10 g/ha was applied at mid-day to flowering winter rape, it was found to have no lethal or sublethal effect on foraging honey bees.

BACKGROUND AND OBJECTIVES

PP321 is a novel pyrethroid insecticide from ICI, Plant Protection Division. It has been shown to be very effective in control of many pest insects, including the principal ones on oilseed rape (Jutsum et al, 1984). The widely-used organophosphate insecticides, whilst highly effective against pests on rape are also extremely toxic to beneficial insects, especially to honey bees to which the flowering crop is highly attractive. An insecticide which can be used safely at any stage of growth of the crop, including application during full flower at times when bees are actively foraging, clearly has enormous advantages for farmers and spraying contractors.

Some pyrethroids, although having a high acute toxicity in laboratory tests, have been shown to be comparatively safe in field use. (Anon, 1983; Atkins et al, 1978; Bocquet et al, 1980; Shires and Debray, 1982; Shires and Murray, 1983; Wilkinson and Bull, 1984). The object of the work described in this poster was to determine the toxicity of PP321 to bees, both in the laboratory and on a flowering crop, the latter under conditions of maximum potential risk to honey bees.

LABORATORY TESTS

Materials and Methods

Two separate tests were done each for technical PP321 and for a 5% emulsifiable concentrate (as used in the field test, below).

Each material was supplied in measured doses to worker honey bees. For contact tests the PP321 was applied topically, as a 1 microlitre drop to each bee from a Burkhard microapplicator. The technical material was applied dissolved in acetone while the formulation was dispersed in water. For oral tests the doses were supplied in 50% sucrose solution.

In each test there were three replicates, each of ten bees per dose and for control treatments.

Treated bees were kept in the dark at 25°C, 70% RH. They were observed at intervals of 1,2,4,24 and 48 hours for lethal and sublethal effects, and mortalities were recorded.

Abbotts' correction was used to correct for natural deaths, then logit transformation of percentage kill was plotted against log dose per bee.

Results and conclusions

LD_{50} values (μg/bee) obtained with PP321, permethrin and cypermethrin as technical material are shown in Table 1. These tests were all carried out by ICI Plant Protection Division.

TABLE 1

24 hour LD_{50} values for bees of three pyrethroids.

LD_{50} (μg/bee) - mean values

Test	PP321	Permethrin	Cypermethrin
Contact	0.051	0.05	0.025
Oral	0.97	0.19	0.22

Values for formulated PP321, (0.095 μg active ingredient/bee contact, and 0.570 oral) indicate a toxicity level similar to that of the technical material.

Thus, although PP321 is, in general, considerably more active against pests than permethrin and cypermethrin, it is less toxic to honey bees orally and possibly less so by contact than cypermethrin. The lower application rates of PP321 give an additional margin of safety.

FIELD TEST

Materials and methods

Six fields of winter rape, each of at least 25 ha, were chosen such that each was at least 1 km from any other major source of forage for honey bees. The crop was in full flower throughout the tests. Five healthy colonies of bees were moved onto each field two days before the day for which spraying was scheduled.

There were two consecutive tests during May 1984. In each, one field was an untreated control, one was a toxic control ("Gusathion MS" applied at a rate which gave 420g azinphos-methyl/ha) and one was the test field (PP321 5% EC at 10 g ai/ha). Applications were by helicopter using a spray volume of 56 l/ha. Spraying was done on days when bees were actively foraging on the rape flowers. In each case the PP321 was applied at about midday, with azinphos-methyl being applied to toxic control plots immediately afterwards.

Mortality at the hives was assessed by placing "dead bee trays" at the entrances to collect bodies cleared out of the colonies by the workers. They were fitted to three hives on each field, and dead bees were removed and counted at 24 hour intervals. The other two hives were fitted with pollen traps, which dislodged pollen from returning foragers.

Mortality, in dead bee trays, was observed pre-treatment for one day in the first test and for six days (due to postponement of spraying) in the second test. Post-treatment mortality was observed for fourteen days in both tests.

Foraging activity on six 50m x 1m strips per field was monitored for two days and seven days pre-treatment, respectively, in the first and second tests. Post-treatment observations were for three and four days respectively.

The brood in the hives fitted with dead bee trays was assessed at suitable times before and after treatment to check for any sublethal effects.

Results and conclusions

There was a sharp increase in mortality in colonies on the toxic standard fields following treatments, but not on the PP321 or control fields. The counts of dead bees collected from "dead bee trays" are shown in Table 2.

TABLE 2

Effect of applying PP321 or azinphos-methyl on bee mortality on treated fields.

Mean No. of dead worker bees per colony during 96h following treatment			
Trial	PP321	Azinphos-methyl	Control
1	21	248	24
2	24	1393	64

In both trials azinphos-methyl caused a reduction in foraging activity during the whole of the post treatment observation period. On fields treated with PP321 there was no evidence of such a reduction except during the first day.

Detailed analysis of the brood assessment results is yet to be done, but provisional examination shows that PP321 had no effect on oviposition or on development of the brood.

Identification of pollen and residue analysis of pollen, honey and wax have not yet been completed.

GENERAL CONCLUSIONS

Although PP321 is more active than permethrin and cypermethrin against arthropod pests it is clearly selective in favour of honey bees.

In the laboratory PP321 is less toxic orally than both other pyrethroids and possibly less toxic by contact than cypermethrin. In the field permethrin and cypermethrin have both been shown to present little hazard to foraging honey bees (Wilkinson and Bull, 1984; Shires and Debray, 1982). As the recommended use rates of PP321 are lower than those of the other compounds, it would be expected to have an even greater margin of safety. Under the stringent conditions of the field trials described here, using PP321 at a normal rate and timing for rape pest control, no detrimental effects on honey bees have been detected.

These results therefore indicate that PP321 will be a valuable treatment in situations where bees are at risk from conventional insecticide use.

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RESPONSE BY HETEROPTERA TO DIFFERENT APPLE ORCHARD SPRAY PROGRAMS

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ABSTRACT

Selective and non-selective insecticide and fungicide treatments were compared in season-long programmes in a Swiss apple orchard, for the control of arthropod and fungal pest complexes. The effects of these treatments on the European red mite, Panonychus ulmi (Koch), and its predators were studied over a period of five years. Together with the predacious mite Amblyseius finlandicus (Oudemans) and the lady beetle Stethorus punctum LeConte, several heteropterous species played an important role in keeping P. ulmi numbers below the damage threshold. Most important of them were anthocorids, of which Orius minutus (L.) was the most numerous species. About 10 species of Mirids were present, but only Blepharidopterus angulatus Fallén showed some response to mite outbreaks. The number of nabids was negligible. The study demonstrated that integrated chemical and biological control of P. ulmi is possible through the combined effect of selective pesticides and the action of various beneficials.

INTRODUCTION

The purpose of this study was to select compounds that are toxic to phytophagous mites, and relatively innocuous to predators so that it would be possible to keep mite populations below the damage threshold. The evaluation of the importance of various heteropterous antagonists was part of this study.

MATERIALS AND METHODS

An orchard was subdivided into three blocks, where block A was sprayed with chlordimeform during the first year and with diflubenzuron for the following four years as examples of selective insecticides, block B was treated with the broad spectrum compound azinphos-methyl, whilst block C was not sprayed at all for codling moth control. Fungicides, acaricides and aphicides were the same in all three blocks. Tab. 1 lists details of all sprays.

TABLE 1 Schedule of pesticide treatments

Pest	Block	TREATMENTS grams AI/100 l	1977	1978	1979	1980	1981
Laspeyresia pomonella	A	Chlordimeform 50	6/23,7/5 7/22,8/5				
	A	Diflubenzuron 20		7/3,8/4,8/21	7/2,8/2	6/24,7/23,8/18	
		10					6/9,7/7,8/4
	B	Azinphosmethyl 30	6/23,7/5 7/22,8/5	7/3,7/20,8/4 8/21	7/2,7/19,8/2 8/22	6/24,7/10,7/23 8/5,8/18,9/2	6/17,7/7,7/21 8/4
	C	No insecticide					
Panonychus ulmi	A B C	CGA-29'170 [1] 50		7/20 [3],8/21		3/12	3/31
		+ oil 350					3/31
	A B C	CGA-79'596 [2] 40			8/2		
	A B C	Cyhexatin 30					8/31 [3]
Aphids	A B C	Pirimicarb 30,77/78 10 80	4/4	6/20		5/2	
Venturia inaequalis	A B C	Phaltan 60-100	3/25,4/4,4/14 4/25,5/5,8/22	4/7,4/17,4/26 5/5			8/28
	A B C	Mancozeb 160	5/17,5/31,6/20 7/6,7/28				
	A B C	Captan 125		5/18,6/1,6/20 7/11,7/31,8/29			
Podosphaera leucot.	A B C	Sulfur 350	3/25,4/4,4/14 4/25,5/5,5/17 5/31,6/20,7/6 7/28,8/22	4/7,4/17,4/26 5/5			
	A B C	Bupirimate 20		5/18,6/1,6/20 7/11,7/31,8/29			
V. inaeq.+ P. leucotr.	A B C	Captan + Etaconazole (50:2) 52			4/5,4/12,4/23 5/3,5/14,5/25 6/4,6/18,7/2 7/16,7/30,8/13 8/27	4/11,4/22,5/2 5/13,5/23,6/3 6/18,7/2,7/24 8/18	4/6,4/15,4/28 5/12,5/29,6/8 6/22,7/13,8/4

1/ 5-(4'phenoxyphenoxy-1-pentin)

2/ 7-n-propylamino-6-nitro-4-trifluormethyl-1,3-benzodithiol-2-on dithiocarbonate

3/ only in the azinphos-methyl block

RESULTS AND DISCUSSION

This paper concentrates on the Heteroptera. Effects of the treatments on other insect groups are reported elsewhere (Sechser et al, 1984).

Mites serve as a principal food for many heteropterous species. Some suppression of mites was achieved with phaltan and mancozeb, but their replacement by captan during the second year led to a tremendous resurgence of European red mite (ERM) (Fig. 1). The mite problem was brought under control for the following three years by the combined effect of selective acaricides and several beneficial groups, except for some problems in the azinphos-methyl block.

Amongst the Heteroptera, anthocorids were the most important group, of which Orius minutus (L.) and Anthocoris nemorum (L.) were dominant. Representatives of the genus Orius have repeatedly demonstrated their potential as specific mite predators (Holdsworth 1972, Parrella et al. 1981).

The higher population level of ERM in the first year and the marked rise in the second year in the azinphos-methyl block led also to higher numbers of anthocorids (Fig. 2). The high numbers of anthocorids by the end of the season in the third year led to the practical extinction of the ERM in the fourth year.

The response of mirids to the population development of the ERM was less pronounced than with anthocorids (Fig. 3). About 12 carnivorous mirid species were present and their frequency is summarized in Table 2. In our study Blepharidopterus angulatus was the most numerous.

One possible explanation for the variety of mirid species found in this chemically treated orchard was certainly the use of many selective pesticides, but at least as important was certainly the close proximity of a deciduous forest which offered many ecological niches for the survival of a broad spectrum of insect species.

Other heteropterous families (Nabidae, Pentatomidae) were present only in negligible numbers.

This long term study demonstrated that anthocorids and mirids can play an important role in suppressing mite populations below the damage threshold.

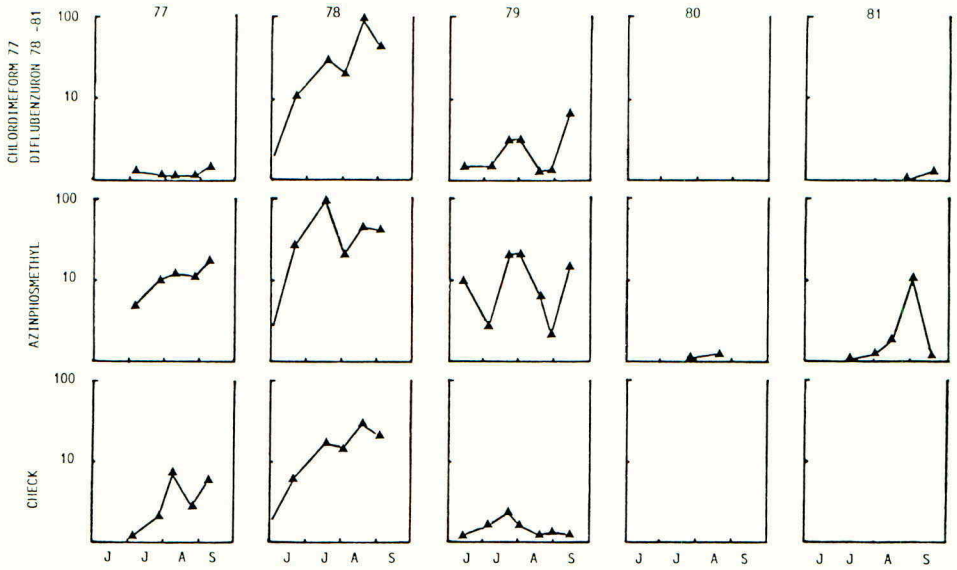

FIGURE 1 SEASONAL HISTORY OF PANONYCHUS ULMI POPULATIONS UNDER TWO DIFFERENT INSECTICIDE TREATMENTS AND A CHECK TREATMENT OVER A FIVE-YEAR-PERIOD (1977 - 81), NUMBER OF MOBILE STAGES PER LEAF.

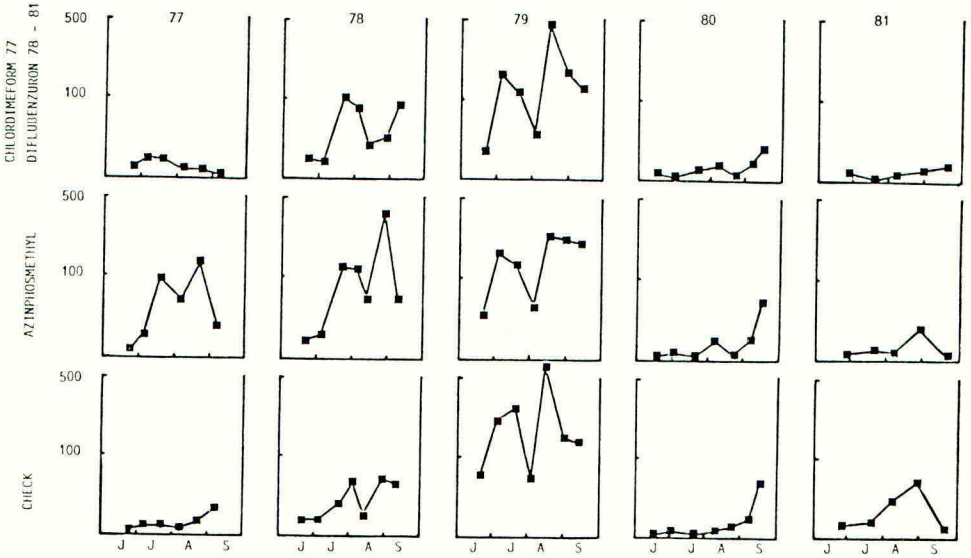

FIGURE 2 SEASONAL HISTORY OF PREDACIOUS ANTHOCORID POPULATIONS UNDER TWO DIFFERENT INSECTICIDE TREATMENTS AND A CHECK TREATMENT OVER A FIVE-YEAR-PERIOD (1977 - 81), NUMBER OF MOBILE STAGES PER 100 BEATEN BRANCHES.

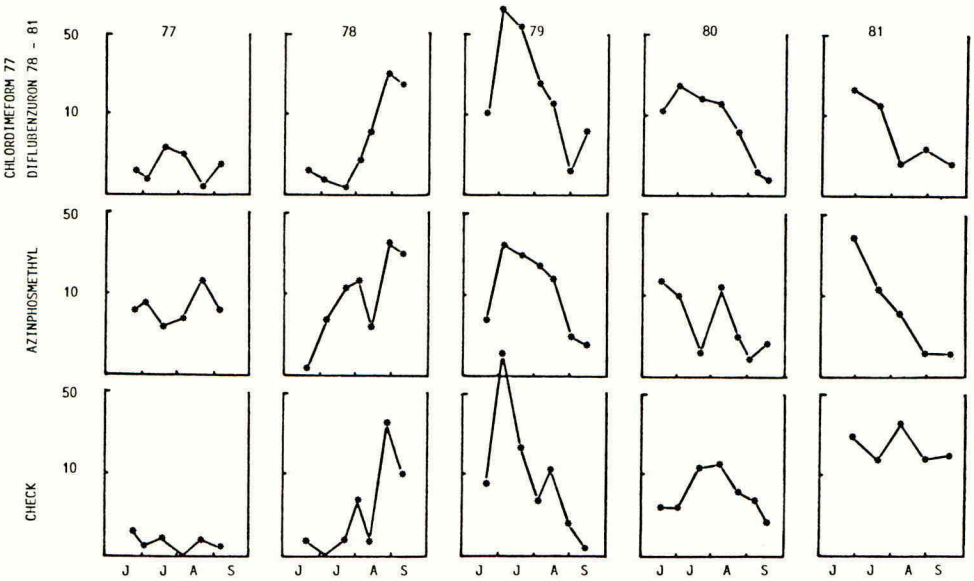

FIGURE 3 SEASONAL HISTORY OF PREDACIOUS MIRID POPULATIONS UNDER TWO DIFFERENT INSECTICIDE TREATMENTS AND A CHECK TREATMENT OVER A FIVE-YEAR-PERIOD (1977 - 81), NUMBER OF MOBILE STAGES PER 100 BEATEN BRANCHES:

TABLE 2 Frequency of mirid specimens on 500 to 700 beaten branches per season.A chlordimeform 1977, diflubenzuron 1978-81,B azinphos-methyl,C check.x=1-10,xx=11-20,xxx>20 specimens

	Year	77	78	79 [a]	80	81
		(600)	(700)	(700)	(700)	(500)
Atractotomus mali	A	x	x		0	0
	B	0	x		0	0
	C	0	0		0	x
Blepharidopterus angulatus	A	0	x	xxx	xxx	x
	B	0	0	xxx	xxx	x
	C	0	0	xxx	xxx	x
Campylomma verbasci	A	x	x		0	0
	B	xxx	x		x	x
	C	x	0		x	0
Deraeocoris lutescens	A	x	xx		x	x
	B	xx	xxx		x	0
	C	x	xx		0	xx
Heterotoma meriopterum	A	x	x		x	xx
	B	x	x		0	x
	C	0	x		0	x
Malacocoris chlorizans	A	x	x		0	x
	B	x	0		x	x
	C	0	0		x	xxx
Ortnotylus marginalis	A	0	0		0	x
	B	0	0		0	xxx
	C	0	0		0	x
Phytocoris spp.	A	x	0		x	x
	B	x	x		0	x
	C	0	0		x	xxx
Pilophorus perplexus	A	0	x		x	x
	B	0	x		0	x
	C	0	0		x	xx
Other Miridae	A	x	x	xxx	xxx	x
	B	0	x	xxx	x	0
	C	x	xx	xxx	xx	x

[a] only Blepharidopterus identified in the counts

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PP321: BEHAVIOUR IN TERRESTRIAL AND AQUATIC ECOSYTEMS

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ABSTRACT

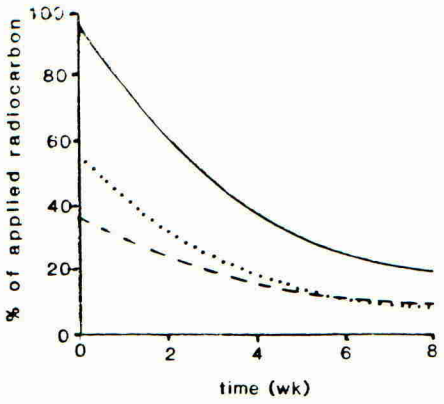
The behaviour of PP321 and PP563 in terrestrial and aquatic ecosystems has been studied. In aerobic soil, both compounds were degraded (half-lives ∿3 weeks) via hydrolytic and oxidative pathways to yield products which were extensively mineralised to CO_2. In flooded soil, degradation was somewhat slower (half-lives ∿11 weeks) and was mainly hydrolytic. The hydrolysis product was the only compound detected in the aqueous phase of the flooded soil/water system. In an aquatic flow-through system with a maintained concentration of PP563, residues in carp accumulated (plateau bioaccumulation factor of 2250) but were rapidly eliminated in clean water. In water/sediment studies the parent compound remained adsorbed to the soil and only the degradation products of PP563 were present in the water. These showed only low levels of bioaccumulation (bioaccumulation factor ∿20) in fish and again rapid elimination in clean water. Thus, the introduction of these insecticides and their degradation products into natural aquatic systems is unlikely to result in accumulation in aquatic organisms.

INTRODUCTION

PP321 ('Karate') is a broad spectrum pyrethroid insecticide which comprises one enantiomer pair [i.e. a 1:1 mixture of the (1R,3R),S & (1S,3S),R esters] of cyhalothrin, [PP563; (RS)-α-cyano-3-phenoxybenzyl-1(RS)-cis-3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropane carboxylate in which the ratio of the (1R,3R),S and (1S,3S),R-esters to the (1R,3R),R and (1S,3S),S-esters is 40:60]. PP563 is being developed primarily for animal health use, while PP321 is being developed for use in the control of a variety of agricultural pests at rates of 5-30g ai ha^{-1} (Jutsum *et al*, 1984). We have studied the behaviour of PP563 and its constituent isomers, including the enantiomer pair PP321, in terrestrial and aquatic ecosystems as part of a large programme of work aimed at assessing the likely environmental impact of these compounds.

SOIL STUDIES

PP563, ^{14}C-labelled in the cyclopropane ring, was applied to a sandy loam soil at 100g ha^{-1} (equivalent to 40g ha^{-1} PP321) and incubated in the laboratory under both aerobic and anaerobic (flooded) conditions, at 20°C, for up to 26 weeks. Periodic analysis of the aerobically incubated soils showed that the half-life for the degradation of PP563 was ∿3 weeks (Figure 1). The two constituent enantiomer pairs were degraded at slightly different rates with PP321 the more persistent (half-life ∿3½ weeks). In the flooded soil/water system both enantiomer pairs were degraded more slowly but at the same rate (half-lives ∿11 weeks)



——— PP563

– – – – PP321 ie (1R,3R),S,&(1S,3S),R-esters

..... (1R,3R),R&(1S,3S),S-esters

Fig. 1. Rates of degradation of PP563 and PP321 in aerobic soils.

The principle degradative reactions in aerobic soils were hydroxylation [to yield α-cyano-3-(4'-hydroxyphenoxy)benzyl cis-3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate; compound XI; up to 11% of the applied radiocarbon] and hydrolysis [to yield cis-3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylic acid; compound Ia; up to 7%]. These initial degradation products were, themselves, rapidly further degraded with 74% of the applied radiocarbon mineralised to $^{14}CO_2$ during 26 weeks. In the flooded soil, hydrolysis was the main degradative reaction (up to 10% compound Ia in the soil phase) and hydroxylation was less important (up to only 1.4% compound XI). Compound Ia was the only radioactive compound detected in significant amounts (up to 12% of the applied radiocarbon) in the aqueous phase of the flooded soils. The fate of the α-cyano ester cleavage products derived from the PP563 'alcohol' moiety could not be followed during this study but it can be deduced from previous work (Roberts and Standen, 1977) on the fate in soil of the common 'alcohol' moiety of cypermethrin. With this compound, ester cleavage is followed by rapid elimination of HCN and oxidation to yield 3-phenoxybenzoic acid (compound II). Similarly, the 4'-hydroxy derivative of cypermethrin yields 3-(4'-hydroxyphenoxy)benzoic acid. These degradation products of the 'alcohol' moiety are extensively mineralized to $^{14}CO_2$. The proposed pathway for the degradation of PP563 and PP321 is shown in Figure 2.

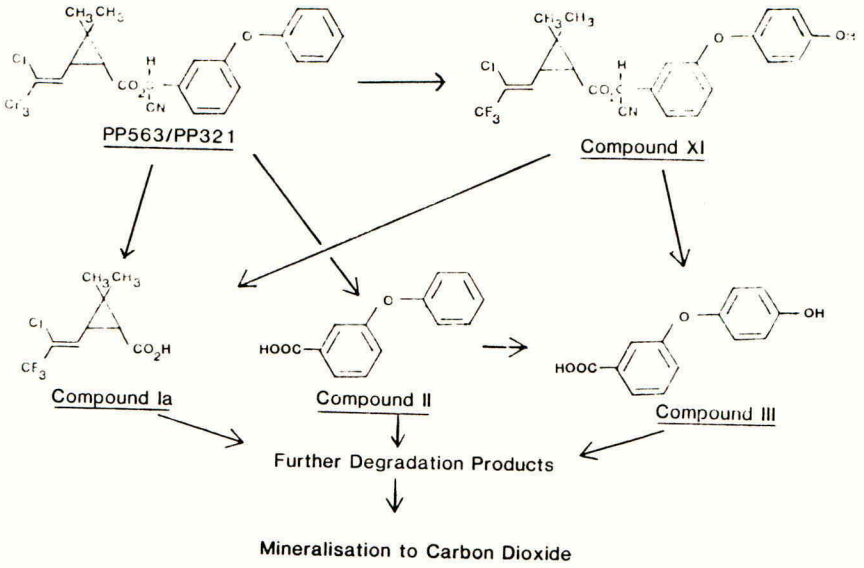


Fig. 2. Proposed pathways for PP563 and PP321 degradation in soils.

ACCUMULATION STUDIES

Flow-through system

Carp (Cyprinus carpio) were exposed to a maintained concentration of ^{14}C-cyclopropane labelled PP563. The ratio of PP321 to the other enantiomer pair of PP563 in the water was approximately 40:60. The concentration of residues in the fish and water was regularly monitored. After 14 days exposure the concentration of ^{14}C-residues in the fish reached a plateau with a bioconcentration factor (concentration of residues in the fish/ concentration of residues in the water) of 2250 (see Figure 3). When the fish were removed to clean, flowing water the elimination of residues was rapid, with 50% being lost in 10 days. Analysis of the fish showed approximately 65% of the radioactivity in the fish to be the parent compound and the ratio of PP321 to the other enantiomer pair of PP563 to be approximately 45:55.

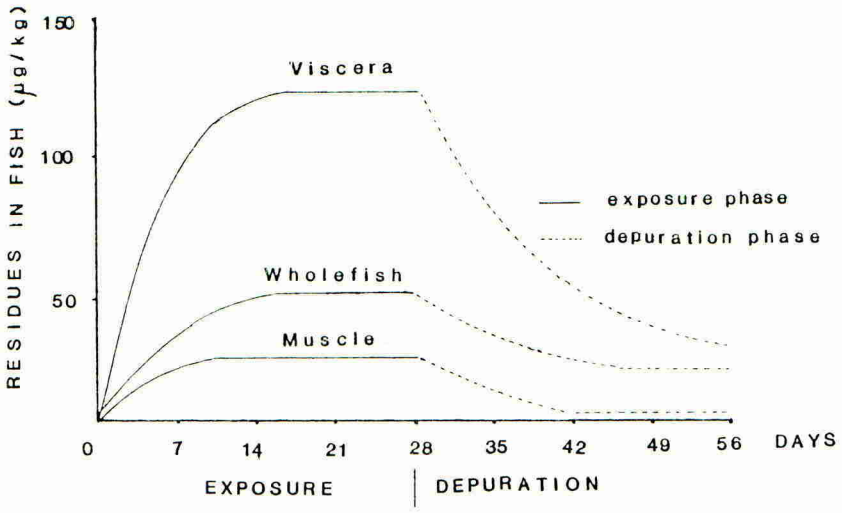


Fig. 3. PP563: Accumulation and elimination in carp in a flow-through system.

Water-sediment studies

PP563, ^{14}C-labelled in the cyclopropane ring, was applied to a sandy loam soil in a 2 m diameter stainless steel tank at a rate equivalent to 50 g ha^{-1} (equivalent to 20 g ha^{-1} PP321) and incubated in the laboratory at ambient temperature for three weeks. The soil was then flooded to a depth of approximately 50 cm and channel catfish (Ictalurus punctatus) and Daphnia magna were introduced into the system.

Periodic analysis of the soil during the three week incubation period showed that the ratio of PP321 to the other enantiomeric pair of PP563 increased from 40:60 to 50:50, in agreement with results from other laboratory studies. After flooding, the soil, water, fish and Daphnia were sampled to determine the distribution of ^{14}C-residues throughout the system. No PP563 was detected in the water phase; the only ^{14}C-residues were identified as compound Ia (see Figure 2). Analysis of the organisms for ^{14}C-residues showed maximum bioconcentration factors of 19 for fish and 200 for Daphnia. The fish and Daphnia were transferred to uncontaminated, flowing water after exposure periods of 30 and 21 days respectively, to monitor the elimination of accumulated residues. 50% of the accumulated residues were eliminated from the fish after seven days and from the Daphnia after one day.

Degradation of PP563/321 in soil/water systems will result in the formation of compound II (see Figure 2) which, being weakly adsorbed, will be released into water. Previous work with ^{14}C-benzyl labelled cypermethrin has shown that compound II only accumulates to a low level in fish (bioconcentration factor = 16) and is rapidly eliminated in clean water.

CONCLUSIONS

These data show that both enantiomers of PP321 and the other two enantiomers of PP563 are readily degraded in aerobic and flooded soil systems. Although the parent compounds have been demonstrated to accumulate in fish in flow-through systems in the laboratory they are rapidly eliminated in clean water. In water/sediment systems the parent remains adsorbed to the sediment and only the degradation products are present in the aqueous phase. In such systems only very low levels of accumulation occur and again residues are rapidly eliminated in clean water. Thus the introduction of these insecticides and their degradation products into natural aquatic systems is unlikely to result in accumulation in aquatic organisms.

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LABORATORY STUDIES ON THE EFFECTS OF INSECTICIDES ON TRICHOGRAMMA CACOECIAE

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ABSTRACT

Diluted EC formulations of WL 85871, triazophos, endosulfan and chlorfenvinphos were sprayed at different dose rates onto eggs of Spodoptera littoralis which had been previously parasitised by Trichogramma cacoeciae. The emergence of parasite adults from the treated eggs, their ability to move and then parasitise a fresh batch of eggs was recorded. These data were then used to calculate the effects of the treatments on the "beneficial capacity" of the parasites. At typical field dose rates both triazophos and endosulfan caused 100% reduction in beneficial capacity. By comparison about 60% reduction was observed with WL 85871 and no reduction was observed with chlorfenvinphos.

INTRODUCTION

Trichogrammatid wasps are recognised as important polyphagous parasites of Lepidoptera eggs in a diversity of crop ecosystems throughout the world (Bull et al., 1979; Burburtis and Koepke, 1981; Gross et al., 1981; Ferro et al., 1974; Islam, 1976; Oatman and Platner, 1978).

The potential of Trichogramma spp. as natural pest control agents has led to their widespread use in biological control (e.g. Burburtis and Koepke, 1981; Gross et al., 1981; Oatman and Platner, 1971) and integrated control programmes (e.g. Bull et al., 1979; Hamel, 1977). Indeed, Trichogramma have been one of the most extensively and successfully used of all arthropod biological control agents (Kfir, 1981). As a result, a considerable research effort has been dedicated to assessing the toxicity of pesticides to Trichogramma (e.g. Hassan, 1977; Kot et al., 1975; Krukierek et al., 1975).

Work carried out under the auspices of the International Organisation for Biological Control has demonstrated that adult Trichogramma are very susceptible to pesticides (Hassan, 1977). Of the many insecticides tested by Hassan, only two (diflubenzuron and Bacillus thuringiensis) proved not to be highly toxic. Under field conditions, however, insecticides will be applied when other developmental stages of the parasite are present. Thus, the effects of an insecticide on pre-adult stages will be important in determining its overall impact on post-treatment parasite populations. Indeed, the varying susceptibility of different life stages of Trichogramma to pesticides has been long-established (e.g. Kot et al., 1975; Krukierek et al., 1975).

The aim of this study was to develop a laboratory method for assessing acute and sub-lethal effects of pesticides to pre-adult Trichogramma. The test has been used to compare the toxicity of four insecticides - WL 85871 ((IRcis)S and (IScis)R enantiomer isomer pair of (RS)-α-cyano-3-phenoxybenzyl (IRS)-cis, trans-3-(2,2-dichlorovinyl)-

2,2-dimethylcyclopropanecarboxylate), endosulfan, triazophos and chlorfenvinphos - to pre-adult T.cacoeciae. All four compounds are highly toxic to adult T. cacoeciae (Inglesfield, unpublished data).

MATERIALS AND METHODS

The Trichogramma used in this study were a thelytokous parthenogenetic race of T. cacoeciae. Prior to their use in these experiments, these animals had been maintained in a controlled-environment cabinet under a cycled environmental regime (16h light/8h dark photoperiod; temp. 28°C, RH 90% during hours of light; 18°C, 70% RH during darkness). Stocks were cultured on eggs of Spodoptera littoralis and fed with a mixture of honey and agar solution.

The test procedure involved spraying parasitised Spodoptera eggs with different dose rates of insecticide. The emergence of T. cacoeciae from these eggs and their subsequent ability to move and parasitise supplies of fresh eggs were then quantified. The test procedure can be summarised as follows:

Day 0: Adult T. cacoeciae were introduced to a 50mm x 25mm diameter plastic tube containing 24 to 48h old Spodoptera eggs.

Day 1: Freshly parasitised eggs were transferred to another tube taking care to exclude any adult parasites.

Day 4/5: Parasitised eggs were counted into batches of around one hundred. Each batch was then sprayed with insecticide. Solutions of the test chemicals were applied using a Potter precision spray tower (Burkard Manufacturing Co. Ltd., Rickmansworth, UK) fitted with a 0.5mm diameter nozzle and calibrated to deposit 2 $\pm$ 0.2ml of solution per cm^2. After drying, sprayed egg batches were transferred to clean plastic tubes.

Day 9/10: Agar/honey food strips were introduced to each tube in anticipation of parasite emergence.

Day 10/12: Tubes containing newly-emerged parasites were covered with black paper to exclude light and connected via a 15mm length of glass tubing to a fresh plastic tube containing about one thousand 24 to 48h old Spodoptera eggs. The positive phototactic responses of T.cacoeciae ensure that healthy specimens should migrate into the fresh tube.

Day 11/13: Each pair of tubes was separated. For each of the original tubes, the number of eggs with emergence holes and the number of remaining adults were recorded.

The number of adults which had moved into each of the second tubes was recorded and the freshly-parasitised egg batches were transferred to clean containers.

Day 26/28: Adult parasites emerging from these eggs were counted.

All tests were conducted under the environmental regime described earlier. Details of the test compounds and the dose rates used in these experiments are summarised in Table 1.

TABLE 1

Details of the test chemicals

Compound	Formulation	Dose rates tested (g ai ha^{-1} equivalent)
WL 85871	'Fastac' 100g l^{-1} EC	2,5,10,20,50,100
Triazophos	'Hostathion' 420g l^{-1} EC	20,50,100,200,500,1000
Endosulfan	'Thiodan 35' 350g l^{-1} EC	20,50,100,200,500,1000
Chlorfenvinphos	'Birlane' 240g l^{-1} EC	50,100,200,500,1000,2000

Solutions of the chemicals were prepared by diluting the formulated materials with deionised water. Three replicates were treated with each dose rate of each compound. A further three replicates were sprayed with water to serve as controls.

This procedure enabled the following three parameters to be estimated for each dose of each compound (using mean value from the replicates):

a) Effect on parasite emergence (R), estimated as;

$$R = ((E_t/I_t)/(E_c/I_c)) \times 100\%$$

where: R = % reduction in emergence of adult parasites; E_t and E_c = number of eggs with parasite emergence holes; I_t and I_c = initial number of parasitised eggs. (t = treated, c = control).

b) Effect on parasite movement (M), estimated as;

$$M = ((P_t/Q_t)/(P_c/Q_c)) \times 100\%$$

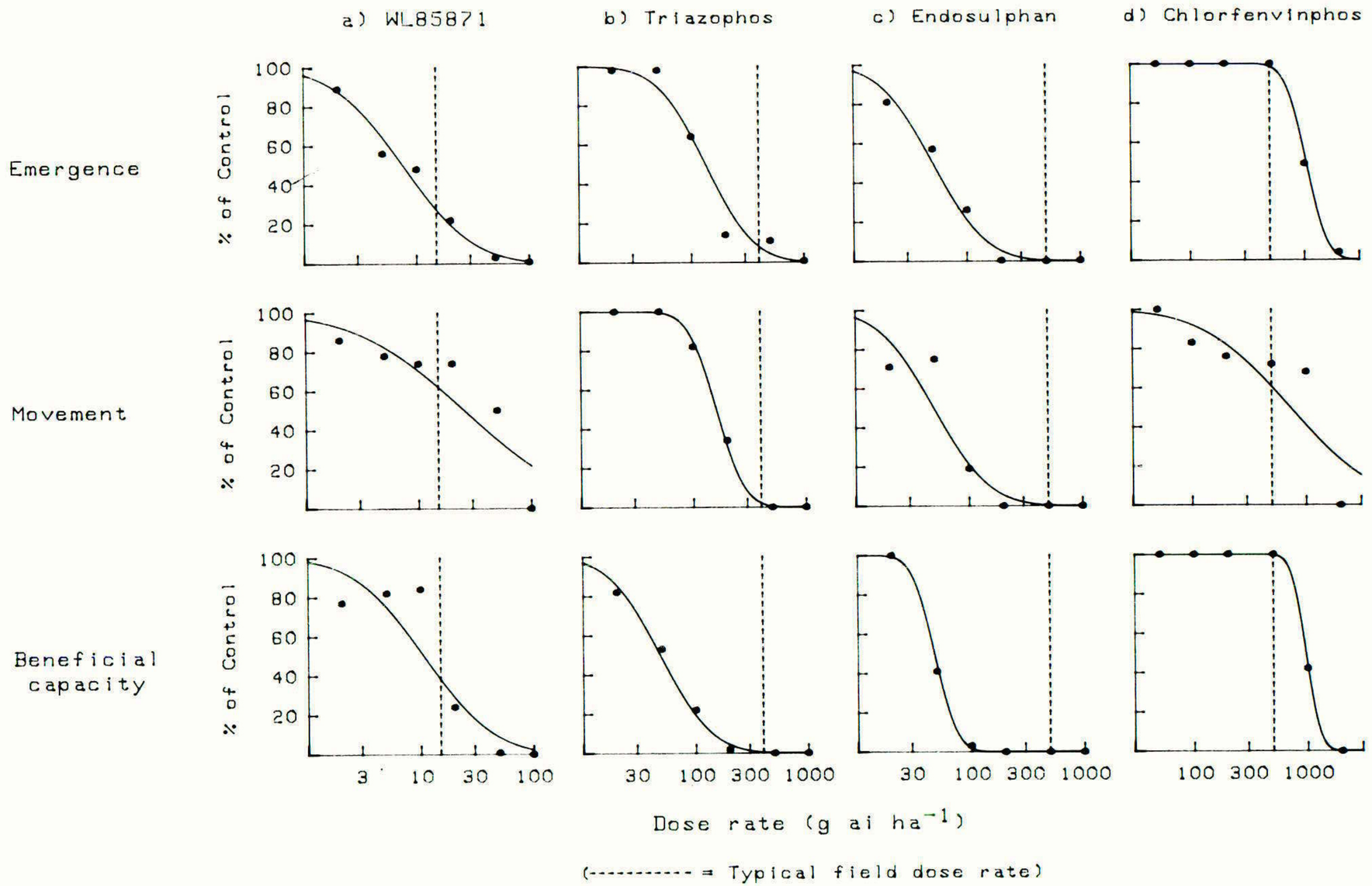
where: M = % reduction in parasite movement down light gradient; P_t and P_c = number of parasites moved into second tube; Q_t and Q_c = number of parasites remaining in first tube. (t = treated, c = control).

c) Effect on "Beneficial capacity" (B), estimated as;

$$B = ((A_t/I_t)/A_c/I_c)) \times 100\%$$

where: B = % reduction in "Beneficial capacity". A_t and A_c = number of adult parasites emerged in second generation (3rd tube). I_t and I_c = initial number of parasitised eggs treated. (t = treated, c = control).

Fig.1. The effects of 4 insecticides on the emergence, movement and beneficial capacity of Trichogramma cacoeciae



RESULTS AND DISCUSSION

The results of these studies are summarised in Figure 1. Typical field dose rates for each chemical are indicated on the graphs. It can be seen that both triazophos and endosulfan severely affected the emergence, movement and subsequent 'beneficial capacity' of the parasites at doses below their typical application rates. On the basis of these results both compounds can be classified as being highly toxic to pre-adult T.cacoeciae. In contrast, WL 85871 at typical dose rates had markedly less effect on emergence and beneficial capacity of the parasites, and little effect on their ability to move between tubes. Finally, chlorfenvinphos had no effect on either emergence or 'beneficial capacity' of the parasites, and little effect on their movement. This chemical can be classified accordingly as being non-toxic to pre-adult T.cacoeciae.

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LABORATORY ASSESSMENT OF INSECTICIDE SELECTIVITY - PRACTICAL RELEVANCE

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ABSTRACT

In laboratory tests pyrethroids were 3 to 100 times more toxic to Ephestia kuhniella than to its parasite Venturia canescens. Such results provide an important guide for selection of appropriate insecticides to reduce hazard to beneficial species. Estimates of hazard expressed as the ratio between laboratory toxicity (LD50) and field application rate are shown to have useful predictive value for honeybees, and have been confirmed by field observations. The use of the same approach to measure selectivity in favour of Chrysopa carnea and Aphidius matricariae is discussed.

INTRODUCTION

The extent of the hazard caused by insecticide treatments to beneficial insects present at the time of application depends largely on any toxicological selectivity in favour of or against them. This selectivity can be expressed as the combined effects of the toxicity of the insecticide to the beneficial species and the recommended application rate which is a reflection of toxicity to the pest. Other factors will be important such as behaviour and habits of parasites, predators and pollinators, and any special properties of the insecticide formulation.

This paper describes laboratory estimation of toxicity of insecticides to a moth (Ephestia kuhniella) and its parasite (Venturia canescens) and to three beneficial species - the honeybee (Apis mellifera), an aphid parasitoid (Aphidius matricariae) and an aphid predator (Chrysopa carnea) - likely to be at risk during insecticide application for aphid control. The implications of the results are discussed.

MATERIALS AND METHODS

Toxicity of the insecticides (technical grade) was estimated by topical application using a micro-applicator (Arnold, 1957). Solvents and drop sizes are indicated below, butanone being used for smaller sizes to overcome excessive evaporation. Median lethal dose (LD50) values were calculated by probit analysis.

Ephestia kuhniella adults: acetone, 1 µl (Elliott et al., 1983).
Venturia canescens adults: acetone, 0.5 µl (Elliott et al., (1983).
Apis mellifera workers: acetone, 1.0 µl (Anon., 1979).
Chrysopa carnea larvae: butanone, 0.25 µl.
Aphidius matricariae adults: butanone, 0.05 µl.
Aphidius matricariae larvae in mummified aphids: butanone, 0.1 µl.

Mortality was estimated after 24 or 48h, except for A. matricariae mummies when adult emergence was assessed.

RESULTS

LD50 values for E. kuhniella and V. canescens are presented as µg insecticides per g of insect (Elliott et al., 1983) (Table 1). The "selectivity" factor was calculated as the ratios of these LD50 values for the two species.

TABLE 1

Selectivity between Ephestia kuhniella and Venturia canescens, from Elliott et al., 1983.

Insecticide	Ephestia LD50 (µg/g insect)	Venturia LD50 (µg/g insect)	Ratio Venturia/ Ephestia
Bioallethrin	0.11	11	100
Flucythrinate	0.026	1.8	69
Permethrin*	0.13	1.8	14
Deltamethrin	0.032	0.39	12
Bioresmethrin	0.25	2.4	9.8
Fenvalerate	0.23	1.9	8.1
Pirimicarb	10	77	7.7
Phosalone	12	4.7	0.39
Standard error as % of LD50	15-25	37-53	

*estimated figures based on results for two isomers.

LD50 values for A. mellifera, C. carnea and A. matricariae were calculated as µg insecticide/insect (Table 2).

TABLE 2

Toxicity of insecticides to three beneficial species.

Insecticide	LD50 (µg/insect) Apis	Chrysopa	Aphidius adults	Aphidius mummies
Pirimicarb	>50	>10	0.022	>2
Permethrin	0.11	0.060	0.0033	0.12
Cypermethrin	0.055	0.074	0.0017	0.040
Deltamethrin	0.051	0.029	0.0003	
Demeton-S-methyl	0.26	0.045	0.0018	0.74
Triazophos	0.055		0.00012	
Standard error as % of LD50	15-20	18-30	15-27	c. 60

These values were compared with typical recommended application rates for aphid control (Table 3). The rates reflect toxicity to the pest and are therefore a realistic basis for comparison particularly when including systemic and contact insecticides. The ratio of the application rate to the LD50 represents the number of LD50 doses applied per hectare for each beneficial species. Thus although the laboratory toxicities of cypermethrin and triazophos to honeybees are similar, the ratios differ greatly.

TABLE 3

Selectivity ratios between laboratory toxicity (LD50) and recommended field application rates for Chrysopa carnea, Aphidius matricariae and Apis mellifera.

	Field rate g per ha	Ratio Rate (g per ha) / LD50 (µg per insect) x10-6			
		Apis worker	Chrysopa larva	Aphidius adults	Aphidius mummies
Pirimicarb	140	<3	<10	6,400	<70
Permethrin	50	450	830	15,000	400
Cypermethrin	25	450	340	15,000	620
Deltamethrin	10	200	340	33,000	
Demeton-S-methyl	240	920	5,300	130,000	340
Triazophos*	400	7,300		3,300,000	

* Included for comparison. Not used for aphid control.

DISCUSSION

Ephestia kuhniella and Venturia canescens

Pyrethroid insecticides are selective in favour of the parasite with a ten-fold range in the ratio for the compounds listed. When pirimicarb and phosalone are included the range of selectivity is x0.39 to x97 indicating the importance of such data when selecting appropriate insecticides, particularly as part of an integrated control programme.

Apis mellifera, Chrysopa carnea and Aphidius matricariae

The extreme selectivity of pirimicarb as an aphicide is reflected in the data in tables 2 and 3, giving an indication of selectivity ratios which can be considered to indicate absence of hazard.

Field trials have confirmed that permethrin, cypermethrin and deltamethrin applications are not hazardous to foraging A. mellifera, whereas demeton-S-methyl and triazophos are (e.g. Findlay et al., 1982; Gerig, 1981; Shires, 1983; Stevenson et al., 1978). This is considered due to a combination of the low application rates, i.e. selectivity, and the "repellent" action of pyrethroids (Smart and Stevenson, 1982). It is therefore possible to relate the figures in table 3 for Apis to expected safety or hazard during field applications.

C. carnea has been shown to be tolerant to some pyrethroids (Ishaaya & Casida, 1981) and the ratio values for permethrin, cypermethrin and deltamethrin in table 3 are low compared with demeton-S-methyl.

A. matricariae adults appear to be at high risk, except from pirimicarb (table 3), but the mummified stage of this parasite of Myzus persicae should offer considerable protection. These results would explain a field observation by Smart et al. (1983). When demeton-S-methyl was applied to barley, numbers of cereal aphids and cereal aphid parasites fell sharply, but seven days later, when aphids were still absent, parasites were found, presumably newly emerged from protected mummies. Adults also emerged from mummies collected from the treated crop.

These results show that laboratory estimates of toxicity to beneficial insects may indicate the degree of hazard in the field, provided application rates are taken into account. The level of hazard may be quantified as in Table 3. However, confirmation by field experiment will always be necessary to take account of all relevant factors.

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A LABORATORY TOXICITY TEST FOR CARABID BEETLES

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ABSTRACT

A laboratory toxicity test was developed for evaluating the toxicity of pesticides to predatory ground beetles, Carabidae. The toxicity of up to 8 pesticides to 4 species of carabid was evaluated using 4 exposure routes. In general results were consistent with published field data, except exposure of beetles to a deposit on glass overestimated field toxicity. A laboratory test in which Pterostichus cupreus or Agonum dorsale are exposed directly, or to spray deposits, on a loamy sand or artificial soil surface for 6 days has promise as a laboratory ecotoxicity test.

BACKGROUND

In association with the International Organisation for Biological Control (IOBC) work group 'Pesticides and Beneficial Insects' ICI has developed a laboratory test for evaluating the toxicity of pesticides to predatory ground beetles (Carabidae). The objective of the IOBC is to identify pesticides which do not interfere with beneficial pest predators and parasites or can be used for integrated control. The group consists of contributing laboratories from many countries. Each year about 20 pesticides are tested. The carabid test was designed to give realistic levels and routes of exposure. Sensitivity was checked by comparing laboratory results with those from the field and reproducibility by comparing results in different years. The effect of soil type was also evaluated.

METHODS

Beetles were exposed to chemicals by the following four routes which are believed to be important in the field.

1) spray deposit on soil;
2) direct spray on the beetle (diurnal species only are likely to be at risk by this route);
3) spraying a vessel of soil and growing barley in which the beetle had been established for 24 hours. This was an attempt to simulate the field situation closely;
4) spraying the food of beetles.

An additional route was:

5) exposure of beetles to a dry spray deposit on glass.

Beetles were first tested at the commercially recommended spray dose (N). If there was no or little mortality after 6 days then fresh beetles were exposed to a 5 x N dose. If there was a high mortality then 0.2 x N was used. This generally provided a lethal threshold concentration to enable a comparison with field data.

Four species, known to be predators in agricultural crops, were tested; Agonum dorsale, Pterostichus cupreus, P. melanarius and Nebria brevicollis, to select one species for the proposed method. Three criteria were of primary importance in selection:

1) availability;
2) survival in captivity;
3) susceptibility to pesticides.

Eight pesticide products were used, gamma HCH, dimethoate, cypermethrin, pirimicarb, chlorfenvinphos, carbophenothion, trichlorphon and carbendazim. They were chosen for:

1) availability of field toxicity data;
2) likely range of toxicity to carabids;
3) different types of uptake, ie fumigant or contact.

Repeatability was evaluated by exposing P. cupreus, A dorsale and N. brevicollis to direct sprays and soil deposits of gamma HCH, dimethoate and cypermethrin in different years.

The influence of soil type on the toxicity of pesticide deposits on soil was evaluated by spraying azinphos-methyl, vamidothion, carbaryl, dimethoate, cypermethrin and deltamethrin at 0.2N, N, 5N, onto the surface of a coarse sand, loamy sand soil, and an artificial soil containing 10% peat, 20% clay and 70% sand. P. cupreus or N. brevicollis were exposed to the sprayed surface for 6 days.

RESULTS

A. dorsale was in general the most susceptible species, followed by the Pterostichus species. Least susceptible was N. brevicollis. The results with different chemicals varied with the method of application (Table 1). Gamma HCH was more toxic when applied to the soil surface; chlorfenvinphos when sprayed directly on the beetles. Dimethoate, cypermethrin, (knockdown followed by recovery) carbophenothion, and trichlorphon had the same activity by both routes. In general applications to beetles in pots of soil containing barley, which combined direct spraying with soil residual treatment, gave results similar to those of the most active single application. However, trichlorphon was more active in the barley test than by either single exposure. When the beetles were exposed to dry deposits on glass, toxicity was generally much higher. Where comparisons could be made the laboratory data were consistent with results from the field. Repeatability was in general satisfactory for both dimethoate and cypermethrin, but gamma HCH, which has fumigant action was more toxic in the second year. The most likely explanation for this was a change in the level of ventilation during tests.

Soil type influenced sensitivity to azinphos-methyl, carbaryl, vamidothion and dimethoate. In all these cases coarse sand provided the most sensitive surface. Loamy sand soil and an artificial soil provided similar results. No differences in sensitivity were observed between soil type for the pyrethroids, cypermethrin and deltamethrin.

TABLE 1

Effect of 8 pesticides on Pterostichus cupreus in the laboratory

Chemical Name	Rate (g ai/ha)	% Mortality Exposure			
		Soil	Beetle	Soil Beetle + Barley	Glass
Gamma HCH	400	7	7	0	100
	2000	100	7	100	-
Dimethoate	70	0	7	0	100
	350	47	100	100	100
Cypermethrin	25	20(1)	7(1)	0(1)	100
	125	20(1)	20(1)	60(1)	-
Pirimicarb	140	0	0	0	0
	700	0	0	0	0
Chlorfenvinphos	2000	0	40	20	100
	10000	20	100	100	-
Carbophenothion	400	7	0	40	100
	2000	20	34	56	100
	10000	20	100	-	-
Trichlorphon	1500	0	0	40	100
	7500	100	80	80	100
Carbendazim	250	20	0	0	0
	1250	0	0	0	20

___ Normal rate
(1) High knockdown effect

Control mortality was <10%

Effects in the field

HCH - 600 g ai/ha - reduction
Schemey (1958)

Dimethoate - 336 g ai/ha - partial reduction -
Vickerman and Sunderland (1977)

Cypermethrin - 25 g ai/ha - partial reduction -
Vickerman pers comm

Pirimicarb - 140 g ai/ha - no reduction -
Vickerman pers comm

Chlorfenvinphos - 8,800 g ai/ha - no reduction -
Edwards et al (1971)

Carbophenothion - 8,800 g ai/ha - partial reduction -
Edwards et al (1971)

CONCLUSION

A laboratory test in which P. cupreus or A. dorsale are exposed directly to spray and to spray deposits on soil for 6 days has promise as an indicator of the toxicity of pesticides to carabids in the field.

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BACTERIAL FLY CONTROL

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Most insect pests have pathogenic viruses, bacteria, fungi and protozoa associated with them and some of these microbial control agents have been developed to commercial products. To date, the group of Bacillus thuringiensis-strains has been the most successful microbial insecticide. So far the commercial use of B. thuringiensis has been limited to the control of lepidopterous pests in growing crops and forests and lately also to the control of mosquito and black fly larvae in lakes, rivers and ponds.

In Finland, B. thuringiensis serotype H-1 has been used to control fly larvae in livestock buildings now for more than three years. The common housefly and other fly species affecting livestock in buildings are important carriers of human and animal diseases and they are also a severe nuisance to livestock and operatives. In many cases there may also be annoyance caused in dwellings adjacent to farms.

Chemical insecticides have proved not to be the only answer in controlling flies. In fact, in the past few years, problems regarding fly control have arisen in a number of countries. Fly populations have exhibited wide resistance to insecticidal treatments, particularly in the UK, Germany and Holland.

Chemical insecticides are targetted against adult flies, which means that the enormous breeding capacity of only a few flies often leads to a continuous need for insecticidal treatments. In some cases the risk of residues reduces the possibilities of using chemical insecticides, for instance in buildings with egg-laying hens.

In contrast, B. thuringiensis serotype H-1 controls fly larvae in manure and due to its safety, the product can be applied to the manure in the presence of animals. The effect of B. thuringiensis serotype H-1 against fly larvae is based on thuringiensin produced by the bacteria during the vegetative growth phase. The normal moulting procedure is prohibited and the larvae cannot develop to adult flies.

Extensive toxicological tests both in Finland and in other countries have shown that B. thuringiensis serotype H-1 is safe to livestock and human beings. Practical experience from Finland during three consecutive years has shown that the product is effective in controlling flies in livestock buildings.

ISOLATION AND CHARACTERISATION OF ANTIMYCOTIC BACTERIA FROM RHIZOSPHERE SOIL

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ABSTRACT

Techniques are described to identify root associated bacteria capable of producing antibiotic substances which may influence the activities of root infecting fungi.

INTRODUCTION

The region of soil surrounding the roots of higher plants constitutes a complex ecological system, called the rhizosphere, in which the microorganisms, (especially fungi), influence for good or ill the growth of the plant. Thus, it would be of great value to be able to modulate the mycoflora associated with the roots of crop plants.

One of the factors influencing the rhizosphere fungi is the activity of bacteria. These, too, colonize the root, growing on the exudates and senescent plant tissues,and compete with the fungi in a variety of ways. The most widely studied area is the production of siderophores, compounds which bind ferric iron making it available for uptake by the bacteria but unavailable to fungi. Denied iron, growth of the fungi is inhibited and invasion of plant tissues is prevented (Schroth and Hancock,1982).

Other mechanisms of competition between bacteria and fungi are probably equally important but have received less attention.There have been several reports of soil microorganisms producing antimycotics and it is probable that these are active in rhizosphere interactions. We wanted to understand the diversity of such compounds produced by bacteria in the rhizospheres of crop plants and the range of fungi affected by these in the hope of comprehending their role in rhizosphere ecology.

MATERIALS AND METHODS.

The following strains of bacteria were used in our studies: strain A4 is the Pseudomonas cepacia strain of Kawamoto and Lorbeer (1976),B5 is P.aureofaciens ATCC 15926, a producer of pyrrolnitrin and V5 is a pseudomonad producing tropolone (Lindberg, 1981). The other strains used are pseudomonads isolated from the rhizosphere of different crop plants.

Gaeumannomyces graminis var.tritici was obtained from J. Cook, Pullman, Wa., Pythium ultimum from T.Suslow, Berkeley,Ca., Ceratocystis ulmi from R. Scheffer, Baarn, NL., Fusarium roseum var.culmorum from B.Mani, Basel, CH. and the others from the culture collection of the Institut für Pflanzenpathologie und Pflanzenschutz, Göttingen, FRG.

Inhibition tests were performed by either placing an agar plug from the edge of a growing fungal colony on the centre of potato dextrose agar (Oxoid M139) and spotting the bacteria on opposite sides of the fungus or by seeding the liquid agar (45°C) with fungal spores and inoculating the bacteria after solidification on top of the agar. This technique allows for 8-10 isolates to be tested per plate.

Seeded agar was also used for screening for new rhizoplane bacteria which produce antifungal compounds. Roots of crop plants were roughly washed, macerated in 0.1 M $MgSO_4$, and appropriate dilutions were plated out on trypticase soy agar (TSA,Becton Dickinson and Co) or potato dextrose agar (PDA) with the incorporated fungal spores.

Alternatively pieces of washed roots were placed on the surface of the spore agar. For selective isolation of fluorescent pseudomonads the medium of Sands and Rovira (1970) was used, either without cycloheximide or with a cycloheximide resistant fungal test strain.

RESULTS AND DISCUSSION.

In order to identify the widest range of antimycotics we chose a set of fungi as diverse as conveniently possible and examined the specificity of inhibitory activity of a number of soil bacteria (mostly pseudomonads) some provided by other labs and some newly isolated from cereal roots.
Representative results are presented in Table 1.

From these results we see that no single fungus is an ideal bioassay organism for antimycotic activity. We are, therefore, using a battery of different fungal species in screening the bacterial isolates.

Where it is possible to prepare rich yields of spores with good germination percentages we prefer to incorporate these into agar medium and to spread bacterial suspensions over the surface. In forming colonies, the bacteria influence spore germination and hyphal growth and thus modify the fungal lawn which would, otherwise, cover the agar uniformly.

TABLE 1: Inhibition of selected strains of fungi by bacterial isolates on PDA

Fungi	Bacteria*						
	A4	B5	C5	K2	K5	L5	V5
Gaeumannomyces graminis var. tritici	+	++	+	++	++	+	++
Pythium ultimum	++	++	+++	+	+++	-	+
Fusarium nivale	+++	+++	++	+	+	-	+
Fusarium roseum var.culmorum	+	++	-	+	++	+	-
Sclerotinia sclerotiorum	-	++	-	++	+	+	-
Ceratocystis ulmi	+++	+	++	+++	+	+++	+
Helminthosporium solani	+++	+++	-	+	+	+	++
Botrytis cinerea	+	++	-	+++	+	+	-
Rhizoctonia cerealis	++	++	-	++	+	++	++
Geotrichum candidum	+++	++	-	-	-	-	-
Phoma lingam	+++	++	-	++	+	+	++
Microdochium bolleyi	+++	+++	-	-	-	-	+
Pseudocercosporella herpotrichoides	+++	++	+	++	+	-	++

* - = no inhibition, + = inhibition zone < 2mm, ++ = inhibition zone 2-5mm, +++ = inhibition zone > 5mm

To examine the antimycotic activity of total rhizosphere bacterial populations we wanted to use "non selective" media e.g. TSA or PDA. Fig.1 shows the effects on the fungal lawn in PDA of bacteria from a wheat rhizosphere.

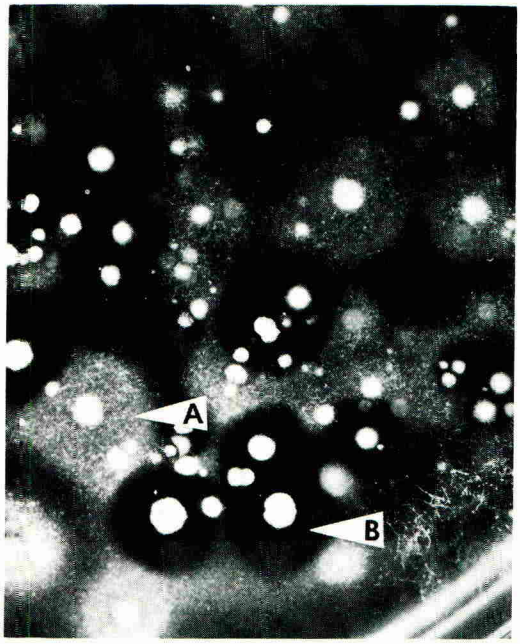

Fig. 1 Bacterial colonies formed from washings from wheat roots on PDA containing fungal spores. Arrows A and B show zone of stimulation and inhibition of fungal growth, respectively.

Some colonies stimulate growth of the fungus, and some have little influence, but others have a strong inhibitory effect. Where this effect extends well beyond the edge of the visible bacterial colony we suppose that a diffusible antimycotic is being liberated by the bacteria. We hope to be able to isolate and characterize these antimycotics.

Alternatively,plating can be made on selective agars which permit only particular types of bacteria to produce colonies. For example, using the selective medium of Sands & Rovira (1970) upon which fluorescent pseudomonads are almost the only bacteria to form colonies, one can directly survey antimycotic activities attributable to bacteria of this taxonomic group.

Thus, by using a variety of media and a suitable range of tested fungi we consider it possible to determine the abundance of bacteria, producing antimycotic activities to characterize the range of organisms sensitive to these antibiotics and to identify the groups of bacteria responsible for their production. The ability of some bacterial isolates to stimulate the growth of certain fungi must also be considered though we have no evidence that this stimulation can occur under natural conditions.

It is also possible to assay the antimycotic bacteria on roots (or fragments of roots) directly, by placing these structures on the surface of agar containing a suspension of fungal spores. The antifungal potential of the microflora of the roots of different species or members of the same species subject to different agronomic practices (e.g. bacterization) can be determined.

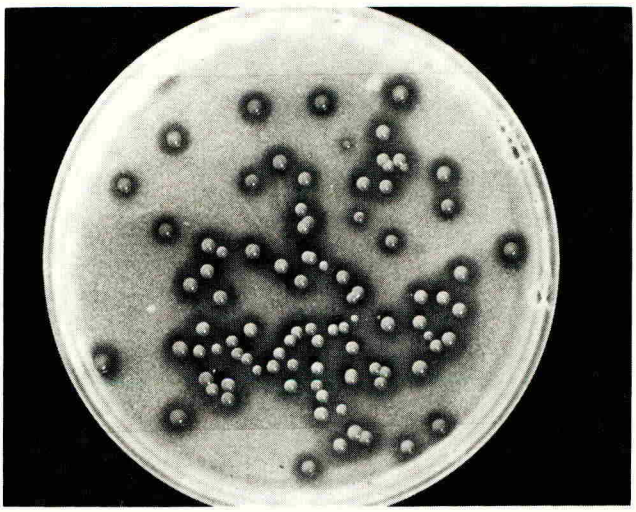

Fig. 2 Zones of inhibition of fungal growth surrounding colonies of a purified bacterial strain.

Antimycotic producing isolates obtained by this technique will be studied intensively. Colonies showing interesting activity can be isolated and the spectrum of their activity tested. Usually, it is possible to examine antimycotic activity of colonies formed by single cells (Fig.2) and where the zones of inhibition are well defined one can isolate mutants which have lost anti fungal activity, an essential step in genetic study of production of antimycotics.

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