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RESULTS OF A JOINT PESTICIDE TEST PROGRAMME BY THE WORKING GROUP: PESTICIDES AND BENEFICIAL ARTHROPODS (1)

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The side effect of 20 commercial pesticides (10 insecticides/acaricides, 6 fungicides, 4 herbicides) on 6 different beneficial arthropods was tested by members of the IOBC/WPRS Working Group "Pesticides and Beneficial Arthropods" in 3 countries. The tests were done according to standardized methods based on common rules, which, among others, emphasize the reduction of the beneficial capacity as the relevant parameter for evaluation. The beneficials tested were: *Trichogramma cacoeciae* MARCHAL, *Pales pavida* MEIG., *Phygadeuon trichops* THOMSON, *Leptomastix dactylopii* (HOW.), *Coccygomimus turionellae* (L.) and *Chrysopa carnea* STEPH. The insecticidal biopreparation Dipel, the acaricide Torque, the fungicides Nimrod, Cercobin-M, Ortho Difolatan, the herbicides Betanal and Illoxan were harmless to slightly harmful to all the natural enemies tested. These chemicals should be examined further for their possible recommendation for integrated control. Other pesticides gave less favourable results. It is hoped that the results would help other WPRS Working Groups and plant protection advisers in the development of rational control programmes.

APPROACH OF THE WORKING GROUP

The wide-spread and continuously increasing use of different types of pesticides, most of them of a non-selective nature, urges us to monitor their possible adverse impact on non-target organisms. Some of them are being tested regularly in most countries as a prerequisite for registration. Such organisms are usually of direct utility to man like domestic animals or game. Testing of natural enemies of pest organisms is nowhere obligatory although their important contribution to natural regulation of pest species as well as their use as biological control agents is widely known.

Therefore, the Working Group " Pesticides and Beneficial Arthropods " was set up

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by W.P.R.S./I.O.B.C. in 1974. Its aims are (1) to develop standardized test methods for entomophagous (predatory and parasitic) insects and mites; (2) to apply such tests in order to provide workers in integrated control as well as the general public with information about the side-effects of pesticides to such beneficial arthropods. The general approach, approved by the Council of W.P.R.S. and recommended also by the Panel of Experts on Integrated Pest Control of FAO, may be summarized as follows:

The standardization of certain aspects in the design of the test methods recommended by the Working Group enables the comparison of results. Such standardization comprises:

(a) the exposure of insects to a fresh, dry pesticide film, applied to an inert surface, to measure initial contact toxicity; (b) forced ventilation to avoid accumulation of pesticide fumes in the test cages; (c) use of laboratory reared beneficials; (d) application of formulated preparations in the highest concentration registered; (e) the performance of the test beneficials rather than the mortality is used to measure the effect of the chemical i.e. the amount of parasitized hosts per female or prey consumption and fertility in relation to the untreated individuals. The results indicate any change in the beneficial capacity of the test arthropod caused by contact with a pesticide. This parameter is more sensitive than recording mortality, and also more appropriate, because beneficial capacity can be reduced without mortality.

The reasons for the preference given to laboratory tests are explained in detail elsewhere (FRANZ, 1978a, 1978b). One reason is the better reproducibility of results because all external and some internal factors can only be kept constant in the laboratory. They are grouped into 4 classes which describe the degree of reduction of beneficial performance in comparison to untreated checks: < 50 % = harmless (1); 50-79 % = slightly harmful (2); 80-99 % = moderately harmful (3); > 99 % = harmful (4). Transfer of such results into the field with its great variability of external conditions does need judicious evaluation and adaptation to local field programmes for pesticide application. To facilitate this, " semi-field tests " are being developed for some test arthropods. The transfer to field conditions will be pursued by the W.P.R.S. Working Groups for integrated control in various crops. Some results of laboratory tests, however, can be directly accepted for the field. Harmlessness, proven under the stringent laboratory conditions, will most probably be confirmed in the field, but not necessarily vice versa. As the future trend of the development of ecotoxicological monitoring is towards inclusion of more organisms into obligatory tests, reproducible standardized tests will be strong tools for this purpose.

COOPERATIVE TESTING PROGRAMME

It is well known that various groups of entomophagous arthropods differ in their susceptibility to pesticides (BARTLETT, 1963; FRANZ, 1974). Therefore, the Working Group members developed guidelines for testing various groups of parasites and predators: *Trichogramma cacoeciae* MARCHAL *(Trichogrammatidae)*; *Pales pavida* MEIG. *(Tachinidae)*; *Phygadeuon trichops* THOMSON *(Ichneumonidae)*; *Leptomastix dactylopii* (HOW.) *(Encyrtidae)*; *Coccygomimus turionellae* (L.) *(Ichneumonidae)*; *Chrysopa carnea* STEPH. *(Chrysopidae)*. Although more groups of beneficial arthropods will be added in the near future, a *first cooperative testing programme* was started in 1977 using the 6 guidelines available. The side-effects of 20 pesticides on 6 different beneficial arthropods were tested by group members in 3 countries to make available to the grower a better understanding of side-effects on entomophagous insects after pesticide use. Half of the preparations tested (10) were insecticides/acaricides as the most dangerous group of pesticides. Table 1 shows that such compounds were chosen which had shown previously some degrees of inocuity, at least to some beneficial species. As little is known about the side-effects of fungicides (6) and herbicides (4), a cross section was made considering both, frequency of use and probable toxicity to beneficials. The pesticides listed in table 1 were selected after thorough discussions with members of the Working Group and of the Department for Plant Protection Products and Application Techniques of the Federal Biological Research Centre at Braunschweig. Samples of the preparations were distributed by the Darmstadt Biological Control Institute (8). Results were sent to the Information Centre of the Working Group (Centre de Recherches de Colmar, Station de Zoologie, INRA, Colmar). The available data were distributed by P. Blaisinger to each contributor. Frequent cross information assured that all co-workers knew about the actual status of the project as soon as they started to deliver results. The guidelines used had been drafted in the preceding years, reviewed and modified by a special committee of the Working Group, and finally accepted. Only those guidelines on *Trichogramma cacoeciae* (Hassan, 1977), on *Chrysopa carnea* (Suter, 1978), and on *Leptomastix dactylopii* (Viggiani & Tranfaglia, 1978) have been published. The names of the researchers involved are indicated in table 1, in brackets after the name of the test insect.

RESULTS AND DISCUSSION

The results of the tests are presented in table 1. The pesticides are listed according to their increasing toxicity in each pesticide-group. All results listed refer to the effects of initial contact toxicity. Mortality is not specifically listed because it contributes to the reduction of beneficial capacity as explained above. If total mortality has occurred, the pesticide is classified as harmful (class 4). What is shown in table 1 is the result of diminished performance plus mortality as expression of the intrinsic sensitivity of the test insects to contact with a pesticide. This way of measuring the effect of a pesticide to beneficial arthropods has proven to be particularly sensitive and meaningful.

Interpretation of these data leads to the following conclusions :

(1) Only very few pesticides can be considered to be harmless to beneficial arthropods as far as these were represented among the tested species. In the case of Diflubenzuron (Dimilin), the exposure of adults was certainly not relevant to the specific action of this insecticide. As a chitinase-blocker, it could only influence larval stages, and these were only tested for *Chrysopa carnea* because the others are not exposed to the ground in nature. Thus, the mode and stage of exposure of the predator or parasite is decisive for the final effect.

(2) Not only insecticides/acaricides can be detrimental to beneficial arthropods. Additional information on the side-effect of several fungicides and herbicides on some beneficial species were published by Hassan (1974), Franz *et al.* (1976), Tanke & Franz (1978).

(3) The beneficial insects were affected differently by the pesticides tested. In table 1, the beneficials were arranged according to their increasing tolerance. *Trichogramma*

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TABLE 1

Side-effects of 20 pesticides on 6 beneficial arthropods

Results of a co-operative test of WG " Pesticides and Beneficial Arthropods " 1978/79
(Laboratory tests; initial toxicity)

	Pesticides \ Beneficial species tested (name of experimenter)	Concentration tested %	Trichogramma cacoeciae (HASSAN)	Pales pavida (HUANG)	Phygadeuon trichops (NATON)	Leptomastix dactylopii (VIGGIANI)	Coccygomimus turionellae (BOGENSCHÜTZ)	Chrysopa carnea (SUTER & BIGLER)
insecticides/acaricides	Dipel (Bac. thuringiensis)	0.10	1	1	1	1	1	1
	Torque (Fenbutatin-oxid)	0.05	1	1	1	1	1	1
	Dimilin (Diflubenzuron)	0.05	1	1	1	1	1	4
	Kelthane Hoechst (Dicofol)	0.15	3	3	2	4	1	1
	Spruzit-Nova-flüssig (Pyrethrum + Pip. but.)	0.10	4	3	1	3	1	1
	Plictran 25 W (Cyhexatin)	0.10	4	2	1	1	2	4
	Pirimor-Granulat (Pirimicarb)	0.10	4	4	4	2	1	1
	Metasystox (i) (Demeton-S-methyl)	0.10	4	3	4	4	2	4
	Thiodan 35 Spritzp. (Endosulfan)	0.10	4	4	4	2	4	1
	Rubitox-Spritzpulver (Phosalon)	0.20	4	4	4	4	4	1
fungicides	Nimrod (Bupirimat)	0.04	1	1	1	1	1	1
	Cercobin-M (Thiophanat-methyl)	0.10	1	1	1	1	1	1
	Ortho Difolatan (Captafol)	0.20	1	1	2	1	1	1
	Dithane Ultra (Mancozeb)	0.20	3	1	1	1	1	3
	Euparen (Dichlofluanid)	0.20	4	2	2	2	1	2
	Afugan WP 30 (Pyrazophos)	0.05	4	4	4	1	4	3
herbicides	Betanal (Phenmedipham)	2.25	1	1	1	1	1	2
	Illoxan (Diclofop-methyl)	0.75	2	1	1	2	1	1
	Kerb 50 W (Propyzamid)	0.75	3	1	1	2	1	1
	Aretit flüssig (Dinoseb)	1.25	4	4	4	4	4	4

Classes for evaluation: 1 = harmless, 2 = slightly harmful, 3 = moderately harmful, 4 = harmful.

was the most sensitive species, *Chrysopa* the most tolerant. There are some unexpected figures, but in most cases the 3 small hymenopterous parasites *(Trichogramma, Phygadeuon* and *Leptomastix)* along with the tachinid *(Pales)* react more sensitively than the larger ichneumonid and, particularly, than *Chrysopa.* It is quite obvious from the figures in table 1 that the value of such experiments for practical integrated control increases with the number of beneficials tested.

(4) Tests of the effect of pesticides to honey bees have been carried out in several countries, in some of them as obligatory prerequisite for registration. Results of these tests are only similar to tests using entomophagous arthropods for more or less harmless pesticides. In most other cases, bees are either more or less sensitive than the majority of parasites or predators. Higher sensitivity of bees was observed, for instance, on pyrethrum, lower sensitivity after exposure to Endosulfan, Phosalon, Dichlofluanid, Afugan and other pesticides. Results, however, cannot be directly compared because tests on honey bees are different. In addition to contact exposure, they include also other ways of application like ingestion and they use the double of the highest concentration registered. Evaluation is made for mortality whereas in our tests, as stated above, contact toxicity and its effect on the beneficial capacity has been investigated. Generally spoken, honey bees seem to be more tolerant to pesticides than parasitic Hymenoptera and than many other entomophagous insects.

(5) The completion of the series of guidelines covering also other groups of entomophagous arthropods is an urgent necessity. The Working Group plans to finalize and accept in 1980 guidelines on predatory mites, *Encarsia formosa* GAH., *Syrphus corollae* F., *Cryptolaemus montrouzieri* MULS., and *Anthocoris nemorum* L., in addition to that on *Coccinella septempunctata* L. which has already been approved. The tachinid *Pales pavida* will be replaced by *Drino inconspicua* MEIG. because the latter attacks the host in a more usual way and is easily kept in permanent rearings.

It is hoped that this first cooperative test will have more complete successors soon and that international cooperation in this field will pave the way to more regular tests on side-effects of pesticides on beneficial arthropods as contribution to a compatible way of biological and chemical control and to the progress in integrated plant protection.

RÉSUMÉ

Résultats d'un programme commun d'essais de pesticides par le groupe de travail « Pesticides et arthropodes utiles »

Les effets subsidiaires de 20 pesticides commerciaux (10 insecticides/acaricides, 6 fongicides, 4 herbicides) sur 6 espèces différentes d'arthropodes utiles ont été étudiés dans 3 pays par les participants au groupe de travail de l'OILB/SROP « Pesticides et arthropodes utiles »... Les essais ont été effectués selon des méthodes uniformisées fondées sur des règles communes qui, parmi d'autres critères, mettent en relief la réduction des capacités entomophages comme paramètre d'évaluation. Les auxiliaires considérés furent : *Trichogramma cacaeciae* MARCHAL, *Pales pavida* MEIG. *Phygadeuon trichops* THOMSON, *Leptomostix dactylopii* (HOW.), *Coccygomimus tarionellae* (L.) et *Chrysopa carnea* STEPH. La biopréparation insecticide Dipel, l'acaricide Torque, les fongicides Nimrod, Cercobin-M, Ortho Difolatan, les herbicides Betanal et Illoxan se sont révélés inoffensifs ou légèrement nocifs pour tous les ennemis naturels testés. Ces produits chimiques doivent faire l'objet d'études complémentaires en vue de leur recommandation possible en lutte intégrée. Les autres pesticides ont donné des résultats moins favorables. Il est souhaité que ces informations soient utiles pour les autres groupes de travail de la SROP et pour les conseillers en défense des cultures, en vue du développement de programmes phytosanitaires rationnels.

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