Source: Natural Enemies of Insects. [Kunchong Tiandi ISSN:1006-0413. CN21-1210/Q]
(1997) v.19 (2) p.49-54 Translated by Xiaorong Wu, Kansas State University; Edited by Mohan Ramaswamy, Kansas State University, 2003

Toxicity of G-P Compound Bioinsecticide to Aphids and Their Natural Enemies in Soybean Fields

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ABSTRACT The results of both laboratory and field tests on the toxicity of G-P compound bioinsecticide to aphids and their natural enemies in soybean fields were reported in this paper. In the laboratory tests, aphid mortalities of 77.3% to 80.5% were achieved 24 hours after the spraying of 1 to 400 diluted G-P bioinsecticide; and the mortalities reached 91.3% to 96.1% 48 hours after the spraying. The control effects of this bioinsecticide on aphids in field test were 91.0%, which was similar to the results of 1 to 1000 diluted of 40% omethoate. The G-P bioinsecticide showed low toxicity to the natural enemies of aphids.

KEY WORDS G-P compound bioinsecticide, soybean aphids, natural enemy, toxicity

G-P compound bioinsecticide was a compound insecticide made from germ metabolites and plant extracts, a new type of low toxicity, environmental friendly insecticide developed by our laboratory in a research project funded by the Department of Science and Technology of Shandong Province. The *Paecilomyces* strain U-2 was isolated from dead cotton aphids and preserved. Metabolites of *Paecilomyces* strain U-2 in liquid medium were mixed with plant extracts of white datura (stems and leaves), Chinese prickly ash (seed coat) etc. following certain technical procedures at specific ratios (technical procedures will be published in another paper). In order to explore its effects on controlling aphids in soybean fields and on natural enemies of aphids, the authors conducted both laboratory and field toxicity tests with G-P compound bioinsecticide. The results are as follows.

Material and Method

Reagents (1) G-P compound bioinsecticide: conidia suspension of the strain U-2 of a *Paecilomyces* sp. was inoculated in #4 liquid medium obtained after orthogonal experiments (major components were potato, sugar, and minerals). After shaking incubation in bottles at 27 ± 2 ºC for 6 days, the supernatant was separated by centrifuging at 3000 rpm for 20 min and then concentrated by 5 times under reduced pressure. Extracts from plants such as white datura, Chinese prickly ash etc. were added to the concentrates at the ratio of 5:1 following specific technical procedures. The preparation was used for the toxicity study without storage. (2) Gong Fu (lambda cyhalothrin) 2.5% oily emulsion: Brunner Mond Chemical Company (UK) Ltd. (3) 40% Omethoate oil emulsion: the second pesticide factory of Beijing.

Aphids and their natural enemies The aphids used for laboratory toxicity tests were collected from the same field where field toxicity tests were conducted. The aphid species

collected were mostly soybean aphid (*Aphis glycines*) together with some foxglove aphids (*Aulacorthum solani*) and cowpea aphids (*Aphis craccivora*). The natural enemies were captured from the test soybean field and fields of other crops, which included green lacewings, ladybirds, and hover (syrphid) flies. The green lacewing species included *Chrysopa sinica*, *C. formosa*, *C. septempunctata*, and *C. phyllochroma;* species of ladybirds were the varied color ladybird (*Leis axyridis* or *Harmonia axyridis*), Adonis' ladybird (*Adonia variegate*, also named *Hippodamia variegata*), *Propylea japonica*, seven-spot ladybird (*Coccinella septempunctata*), and thirteen-spot ladybird (*Hippodomia tredecimpunctata*); and the hover fly species were *Epistrophe balteata*, *Syrphus corollae*, *Paragus quadrifasciatus*, and *Sphaerophoria scripta*.

Laboratory toxicity tes. The test of toxicity to aphids: soybean seedlings were planted in small flowerpots and inoculated with certain kinds and amounts of aphids collected from soybean fields. The seedlings were moved into cages when they held enough aphids (150-200). Each cage was considered a treatment. Identical amounts of each insecticide were applied by a hand-held sprayer after appropriate dilution. The control was sprayed with water. The experiments were repeated three times, and the results were analyzed by normal statistical methods. For the test of toxicity to natural enemies: soybean plants growing in flowerpots with certain amounts of aphids were covered by specially made screen covers with a resealable window. About 10 to 15 natural enemies of different species were introduced into each plant through the resealable window. The diluted test insecticides were evenly applied from several angles with a hand held sprayer to make sure that natural enemies at different positions can all be sprayed. Controls were sprayed with identical amounts of water. All the experiments [treatments] were replicated three times.

Field toxicity tests The field toxicity tests were conducted at Linyin and Yuncheng of Shandong Province from late June to late July. The size of the test plots was 5m×6m with a separating space of more than 2 meters between plots. The aphid density in each test plot was examined before spraying. In each plot, 1.2 kg of liquid insecticide was evenly sprayed with a manual backpack atomizer. The aphid density in each plot was examined again at the 2^{nd}. and 4^{th} day after spraying and used to calculate the control effects.

Studies on the natural enemies in the test plots The studies were conducted according to a method reported by Dai, et al. (1995). Each treatment was a 20 m^2 plot. The identification of natural enemies was performed by referring to relevant publications (Ma, Zhenquan et al., 1986).

Results and Analyses

Toxicity of G-P compound bioinsecticide on aphids The toxic effects of spraying 1 to 400 diluted G-P compound bioinsecticide were compared with those of chemical insecticides—Gong Fu and Omethoate. Results (Table 1 and Figure 1) indicated that the mortalities of the three aphid species were between 77.3 to 80.5% 24 hours after spraying G-P compound bioinsecticide, and reached 91.3 to 96.1% 48 hours after spraying. 48 hours after the sprayings, the mortalities of the three tested aphid species with 1:400 diluted G-P were similar to or a little higher than those of the 1:1000 diluted omethoate, but slightly lower than those of 1:2000 diluted Gong Fu. Whereas within 24 hours of spraying, the mortality of aphids sprayed with G-P compound

bioinsecticide were markedly lower than those with chemical insecticides, which indicated that the G-P bioinsecticide acted more slowly on the aphids than Gong Fu and omethoate.

Table 1. Laboratory toxicity test effects of G-P bioinsecticide on three species of aphids

Aphid species	Insecticide & dilution		Aphid No.	24 hours after spraying		48 hours after spraying	
				Mortality (%)	Corrected mortality (%)	Mortality (%)	Corrected mortality (%)
Soybean aphid	G-P	1:400 dilution	349	78.8	77.3	91.9	91.3
	Cyhalothrin	1:2000 dilution	323	99.1	99.0	99.4	99.4
	Omethoate	1:1000 dilution	301	91.4	90.8	92.7	92.2
	CK	(clear water)	362	6.6		6.9	
Foxglove aphid	G-P	1:400 dilution	321	81.0	80.2	96.5	96.1
	Cyhalothrin	1:2000 dilution	298	100	100	100	100
	Omethoate	1:1000 dilution	342	95.9	95.7	95.9	95.7
	CK	(clear water)	306	3.9		3.9	
Cowpea aphid	G-P	1:400 dilution	286	81.5	80.5	93.7	93.3
	Cyhalothrin	1:2000 dilution	312	98.1	98.0	98.4	98.3
	Omethoate	1:1000 dilution	323	98.5	98.4	98.5	98.4
	CK	(clear water)	318	5.0		5.3	

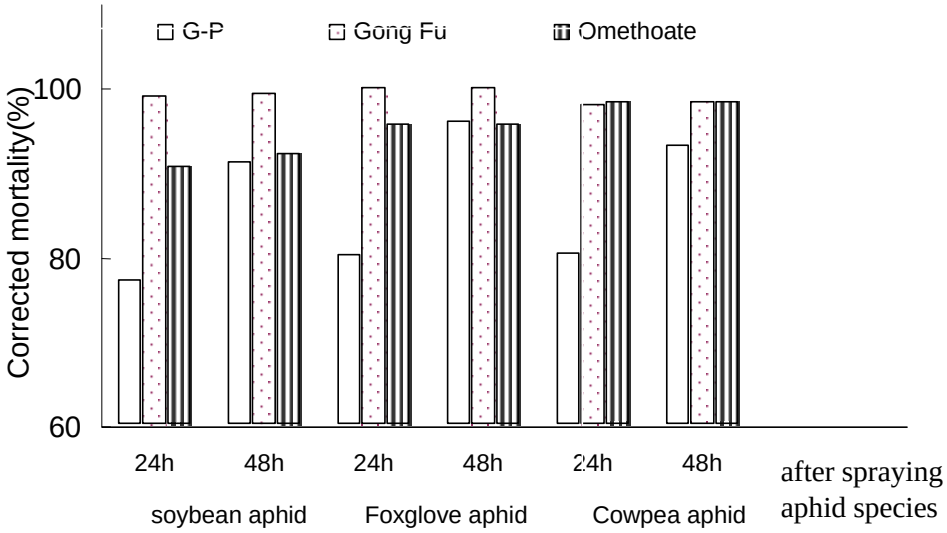

Figure 1. Toxicities of the three insecticides on the three aphid species

Toxicity of G-P compound bioinsecticide at different concentrations The toxicity of four different dilutions of G-P on aphids were tested. Results in Table 2 and Figure 2 showed that the toxicities of 1:200 and 1:400 diluted G-P solutions on aphids were very close. Once the dilution factor was over 400, aphid mortalities decreased rapidly as the dilution factor went up. The changing patterns of aphid mortalities over insecticide concentrations were similar for both the 24 hour line and the 48 hour line.

Table 2. Toxicity of different dilutions of G-P bioinsecticide on aphids (three species together)

Dilutions of G-P bioinsecticide	Aphid No.	24 hours after spraying		48 hours after spraying	
		Mortality (%)	Corrected mortality (%)	Mortality (%)	Corrected mortality (%)
1:200 dilution	412	79.2	78.4	96.4	96.3
1:400 dilution	396	78.8	78.0	95.6	95.4
1:800 dilution	368	64.6	63.3	82.4	81.8
1:1600 dilution	393	55.2	53.6	67.2	65.9
CK (clear water)	405	3.5		3.8	

Effects of G-P bioinsecticide on natural enemies in laboratory tests Statistical data are shown in Table 3. From 24 to 96 hours after the spraying of 1:400 diluted G-P compound bioinsecticide, the corrected mortalities were between 6.4% and 12.8% for green lacewings; the mortalities for ladybirds were between 3.6% to 7.7% and between 8.3% to 16.8% for hover flies. However, the mortalities of natural enemies were 85.7 to 89.4% for green lacewings, 54.5 to 56.2% for lady beetles, and 68.2 to 76.2% during the same time periods after spraying of 1:1000 diluted omethoate.

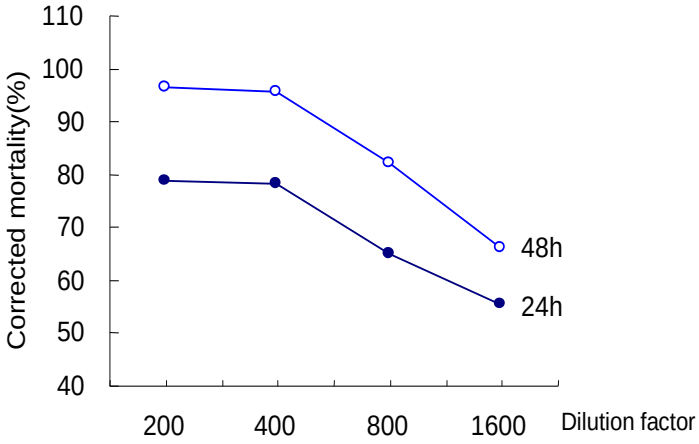

Figure 2. Relation between G-P dilution and aphid mortality

Table 3. Laboratory toxicity test results of G-P bioinsecticide on natural enemies of aphids

Natural enemy	Insecticide & dilution		No. of natural enemy	24 hours after spraying		48 hours after spraying		96 hours after spraying	
				Dead No.	Corrected mortality (%)	Dead No.	Corrected mortality (%)	Dead No.	Corrected mortality (%)
Green lacewings	G-P	1:400 dilution	32	3	6.4	5	12.8	5	9.8
	Omethoate	1:1000 dilution	29	25	85.7	26	89.4	26	88.9
	CK	(clear water)	31	1		1		2	
Ladybirds	G-P	1:400 dilution	28	1	3.6	3	7.7	3	7.7
	Omethoate	1:1000 dilution	33	18	54.5	19	56.2	19	56.2
	CK	(clear water)	31	0		1		1	
Hover flies	G-P	1:400 dilution	24	2	8.3	4	12.4	5	16.8
	Omethoate	1:1000 dilution	22	15	68.2	16	71.3	18	76.2
	CK	(clear water)	21	0		1		1	

Aphid control effect of G-P bioinsecticide in field tests The results of aphid control effects with G-P compound bioinsecticide in field tests are shown in Table 4.

The aphid control effect with 1:400 diluted G-P compound bioinsecticide was similar to that with 1:1000 diluted omethoate (the statistical results on the 4th day was slightly higher than that

of the omethoate); the control effect of G-P bioinsecticide at four days after the spraying was a little better than that at two days after the spraying.

Table 4. Toxicity results of G-P bioinsecticide on aphids in field tests

Insecticide	Dilution	Average aphid density before spraying (No./plant)	2 days after spraying			4 days after spraying		
			aphid density	Reduction in aphid density (%)	Control effect (%)	aphid density	Reduction in aphid density (%)	Control effect (%)
G-P	1:400	42.3	4.9	88.4	89.5	4.3	89.8	91.0
Omethoate	1:1000	40.8	4.3	89.4	90.4	5.4	86.8	88.3
CK	clear water	39.2	43.5	-11.0		44.2	-12.8	

Studies on the natural enemies in the test plots The kinds and amount of natural enemies in the fields were examined on the 4th day after the sprayings. The results (Table 5) indicated that the kinds and amounts of natural enemies in the G-P sprayed plots were slightly less than those in the controls, but were much more than those in the omethoate sprayed plots.

Table 5. Results of field studies on natural enemies

plot		No. of natural enemies in 20 m^2 area							
		Green lacewings	Hover flies	Ladybirds	Robber-flies	Braconid wasps	Stinkbugs	Others*	Total
G-P	1:400	12	1	10	1	2	6	22	54
Omethoate	1:1000	3	0	6	0	1	2	15	27
CK	clear water	11	2	14	2	1	8	30	68

* others: including mantis and spiders.

Discussion

The results of both laboratory and field tests showed that the G-P compound bioinsecticide was highly toxic to the major aphids in soybean fields. The aphid mortality reached 90% and above, which showed good prospects for the application of this low toxicity bioinsecticide.

As shown by the toxicity results, the aphid mortality reached its peak 48 hours after the spraying of the G-P bioinsecticide, which indicated that its toxic effects on aphids were slower than those of chemical insecticides such as Gong Fu and omethoate. The toxicity of G-P compound bioinsecticide on aphids in soybean fields depended on the concentration of the spraying. The killing effect of G-P bioinsecticide significantly decreased when the dilution factors were over 400. Since the killing effects of 1 to 200 and 1 to 400 diluted solutions were similar, the appropriate dilution factor for field application would be 1:400.

Compared to the chemical insecticide omethoate, G-P compound bioinsecticide showed lower toxicity to natural enemies of aphids and killed far fewer natural enemies during applications, which was proven by both laboratory and field tests. We had also observed the behaviors of the surviving natural enemies after spraying of G-P bioinsecticide. When the surviving natural enemies were transferred to unsprayed plants with enough aphid density, the insect-feeding amounts of these survivors were less than those in the control group, which was especially obvious for the surviving green lacewings.

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