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SLOW-RELEASE FORMULATIONS OF CHLORPYRIFOS FOR CONTROL OF THE LARVAE AND EGGS OF THE EGYPTIAN COTTON LEAFWORM, *SPODOPTERA LITTORALIS* (LEPIDOPTERA: NOCTUIDAE)*

M. KLEIN

Department of Entomology, Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel

ABSTRACT

The activity of a commercial formulation of chlorpyrifos (Dursban) was compared with that of five of its new slow-release formulations (C-20A, C-20B, 48H, GGA1 and GGA2) against the Egyptian cotton leafworm *Spodoptera littoralis* (Boisduval) larvae of various ages, in the laboratory, and against eggs and small larvae in the field. The commercial formulation was effective for one day at the most against young larvae only (1st and 2nd instars). C-20A, C-20B, GGA1 and GGA2 gave good results on young as well as on big larvae and for relatively long periods (2nd instar larvae, 7-9 days; 3rd and 4th instar larvae, 5 days; large 5th and 6th instar larvae, about 3-5 days) in the laboratory, whereas 48H was not promising. Superiority of the slow-release compounds was not proven in field tests.
KEY WORDS: Spodoptera littoralis, Chlorpyrifos, slow release formulations, residual effect, cotton pepper.

INTRODUCTION

The Egyptian cotton leafworm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) is one of the most serious pests of numerous cultivated plants in Israel (Avidov and Harpaz, 1969). Several of the most common commercial insecticides which have been used on cotton only against *S. littoralis* in the past are no longer effective. Chlorpyrifos has been used against this pest and several other species for more than a decade and it is probable that *S. littoralis* became partially resistant to this insecticide. Chlorpyrifos is still recommended on cotton only against eggs, 1st and 2nd instar larvae of *S. littoralis*, because older larvae are no longer sensitive to it (Klein *et al.*, 1982). The concentration needed for reasonable control of these stages is still below the range recommended by the manufacturers for aerial applications. Chlorpyrifos is used throughout the world against various pest species. Its effectiveness

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has been proven in the last few years in some states in the USA against the fall armyworm, *S. frugiperda* (J.E. Smith) on corn (Young, 1979), and against *Fumibotys fumalis* (Guenee) on peppermint (Pike and Gestzin, 1981); in India against the tobacco cutworm, *S. litura* Fabricius (Snatharam and Balasubramanian, 1980), and against the diamond back moth, *Plutella xylostella* Hufn. on cauliflower (Regupathy and Paranjothi, 1980); in Bulgaria against the black cutworm, *Agrotis ipsilon* (Nikolov, 1979); and in England against various insect pests attacking cereals (Dowsett *et al.* , 1979).

The most serious disadvantage of chlorpyrifos is its relative brief residual effect (Buck *et al.*, 1980; Ware *et al.*, 1979), which may limit its use. New insecticides against *S. littoralis* are scarce and therefore, it is of great importance to use the commercial insecticides more rationally, whether by careful application, exact timing, or by producing slow release formulations of the unstable compounds.

Five slow release formulations of chlorpyrifos, including a commercial formulation (Dursban) used in Israel were tested for their residual effect against larval instars of the Egyptian cotton leafworm, *Spodoptera littoralis* (Boisduval). To the best of my knowledge, this is the first time that slow-release formulations of chlorpyrifos were tested outside of the manufacturer's laboratories.

MATERIALS AND METHODS

Insecticide formulations

Chlorpyrifos, (*0,0*-diethyl *0*-(3,5,6,-trichloro-2- pyridyl) phosphorothioate) was tested using the following formulations; the standard commercial formulation as Dursban 48% EC; C-20A, 20% EC; C20B, 20% EC; 48H, 48% EC; GGA1, 10% EC; and GGA2, 10% EC. The last five formulations were prepared as slow-releasers (Dow Chemical Company, Kings Lynn, England), and the code numbers are those of the manufacturer. The formulations differed only in the way chlorpyrifos was encapsulated, a process which was not divulged to us. The formulations were adjusted to 0.2% with tap water before being used in the field for bioassays.

Applications

Insecticides were applied to Acala SJ_2 cotton plants growing in a commercial field at Bet Dagan. The first application was carried out to plants about 45 cm high. At the stage of boll formation, the plants were sprayed to the run-off point on both sides of the leaves and after various time intervals the leaves were taken from different parts of the plant and brought to the laboratory.

Insects

Freshly hatched larvae from egg batches taken from fields in the western Negev were maintained in the laboratory on cotton leaves. Larvae were provided with moistened rolled leaves for the first 4 days (Klein *et al.*, 1982) by which time most of them had passed into the other larval instar. Thereafter, fresh leaves were supplied every second day until the larvae reached the appropriate age for testing. The study was conducted with a population that was not affected by insecticides in the egg stage. The treated leaves were placed near the larvae to avoid immediate contact with the

insecticide but they became contaminated as they crawled on the leaves to feed. Second instar larvae 0.5 cm long were tested in three replicates of ten insects each, in 9-cm-diam. Petri dishes. Two half-leaves from different plants and zones were introduced into each dish. Medium size larvae (3rd and 4th instars, mean length 0.7 and 1.5 cm, respectively) were tested in groups of ten in 500 ml glass jars. Each test was repeated twice, using two full-size leaves per jar. Larvae of the two older instars (5th and 6th, mean length 2.0 and 2.8 cm, respectively) were tested in groups of five each with four replicates in the same glass containers as above. Larval mortality was calculated after 24 hours. Untreated leaves served as controls.

The results were analyzed statistically using Duncan's New Multiple Range Test.

Field trials

Fifty egg batches or aggregates of first instar larvae were marked in highly infested cotton and green pepper fields. All plants in each plot were sprayed in a manner similar to that described above. Survival was recorded after 2, 4 and 7 days, taking into consideration the effect on the new egg batches and larvae that hatched after insecticide application.

RESULTS AND DISCUSSION

The effect of chlorpyrifos and of its slow-release formulations on *S. littoralis* larvae in the laboratory is detailed in Tables 1-3.

The commercial chlorpyrifos effectively controlled 2nd instar larvae only and for 1 day at the most (Table 1). It was effective only on a very small part of the larval population larger than the 2nd instar (Tables 2 and 3). Slow-release formulations C-20A, C-20B, GGA1 and GGA2, proved to have a fairly long residual effect: 7-9 days against 2nd instar larvae (Table 1), 5 days against 3rd and 4th instar larvae (Table 2), and 3-5 days against larvae larger than the 4th instar (Table 3). In some instances these tests were repeated two or three times with populations from different sources. Formulation 48H was superior to the commercial samples in its persistence (Table 1-3) but was inferior to the other slow-release formulations.

Most of the eggs hatched and larvae survived in the control plots of the field tests. All eggs and larvae which had been marked and sprayed were killed by all the formulations tested. No significant differences were obtained among the commercial and the slow-release formulations in killing eggs laid after application. Most eggs laid 1-2 days after application hatched, but all the larvae were killed. Later on eggs and larvae were slightly affected with a slight but non significant edge in favor of the slow release formulations.

The effectiveness of the commercial formulation of chlorpyrifos (Dursban) in controlling small *S. littoralis* larvae decreased sharply after one day, and in controlling larger larvae it decreased even sooner. This could be explained by the rapid disappearance of the active ingredient by natural factors, which is supposed to be prevented in the C-20A, C20B, GGA1 and GGA2 formulations tested in the laboratory. This might be the explanation also for the extreme variations in results among the different tests with small larvae (Table 1) and big larvae (Table 3) on day 0, 1 and 3 for the Dursban application. Certain populations could be more sensitive than

TABLE 1. MORTALITY OF SECOND-INSTAR LARVAE OF *SPODOPTERA LITTORALIS* SUPPLIED WITH COTTON LEAVES AT DIFFERENT TIMES AFTER APPLICATION OF CHLORPYRIFOS OR ITS SLOW-RELEASE FORMULATIONS

Formulation	Mortality (%)									
	Days after insecticide application									
	0*		1		3		5	7	9	11
	I**	II**	I	II	I	II				
Control	0 a***	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
Dursban	6.7 b	100.0 b	76.7 b	100.0 b	6.7 b	20.0 b	0 a	3.3 a	0 a	0 a
C-20A	86.7 c	86.7 b	100.0 b	100.0 b	50.0 c	66.7 c	96.7 c	96.7 c	30.0 b	0 a
C-20B	60.0 bc	100.0 b	100.0 b	100 b	96.7 d	93.3 d	100.0c	100 c	90.0 d	70 b
48H	63.3 bc	93.3 b	93.3 b	90.0 b	3.3 a	0 a	16.7b	56.7 b	6.7 a	0 a
GGA1	100.0 b		100.0 b		100.0 d				29.7 b	
GGA2	100.0 b		100.0 b		100.0 d				50.3 c	

*0 – The time when the spray had dried on the leaves.

**Two different tests (I and II) on different days were carried out on days 0, 1 and 3

***Within each column, figures followed by different letters differ significantly at the 5% confidence level (according to one-way analysis of variance and Duncan's New Multiple Range Test).

TABLE 2. MORTALITY OF MEDIUM-SIZE LARVAE OF *SPODOPTERA LITTORALIS* SUPPLIED WITH COTTON LEAVES AT DIFFERENT TIMES AFTER APPLICATION OF CHLORPYRIFOS OR ITS SLOW-RELEASE FORMULATIONS

Formulation	Mortality (%)				
	Days after insecticide application				
	3	4	5	7	10
Control	0 a*	0 a	0 a	0 a	0
Dursban	0 a	0 a	0 a	0 a	0
C-20A	80 b	100 c	60 b	0 a	16.7
C-20B	66.7 b	100 c	100 b	0 a	0
48H	0 a	35 b	35 b	0 a	6.7
GGA1	100 b	90 c		90.0 c	10.0
GGA2	100 b	87 c		60.3 b	0

*Within each column, figures followed by different letters differ significantly at the 5% confidence level.

others to low concentrations of active material which still remained at the time on the leaves. A decrease in chlorpyrifos residues of about 90% of its original, was observed by Morton (1979) during the first 24 hours following spraying cotton.

Strains of *S. littoralis* resistant to commercial chlopyrifos were isolated in Egypt (Abbassy *et al.*, 1980; Madi *et al.*, 1983). This is expected to occur in Israel, too, because of the widespread use of the material against a polyphagous pest such as *S. littoralis*. The slow-release formulations of chlorpyrifos, C-20A, C20B, GGA1 and GGA2, were efficient against older larvae in laboratory trials. Cotton and pepper plots which were sprayed with these materials showed slightly less damage from insects than plants treated in the field with the standard chlorpyrifos. The laboratory and field tests showed contradictory results, showing that one cannot depend on laboratory tests alone. In laboratory tests ventilation is limited, and therefore, slow releasers acted for long periods, whereas in field tests as a result of good ventilation, the insecticide volatilizes or decomposes more rapidly and its residual effect is relatively short. Dew present on some nights in summer reduces the effectiveness of slow releasers. Developing a method of preserving the residual activity of chlorpyrifos by improving methods or materials for micro encapsulation or by other techniques appear to be worthwhile and should be pursued.

TABLE 3. MORTALITY OF BIG LARVAE OF *SPODOPTERA LITTORALIS* SUPPLIED WITH COTTON LEAVES AT DIFFERENT TIMES AFTER APPLICATION OF CHLORPYRIFOS OR ITS SLOW-RELEASE FORMULATIONS

Formulation	Mortality (%)									
	Days after insecticide application									
	0			1		3		5		10
	I*	II	III	I	II	I	II	I	II	
Control	0 a**	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
Dursban	10 b	60 b	65 b	60 b	0 a	65 b	0 a	0 a	0 a	25 ab
C-20A	100 d	100 c	90 c	100 c	100 c	100 c	30 b	100 c	15 b	25 ab
C-20B	100 d	100 c	100 c	100 c	80 c	100 c	20 b	100 c	0 a	45 b
48H	40 c	60 b	70 b	65 b	25 b	65 b	0 a	50 b	5 a	15 ab
GGA1	100 d			100 c		100 c		15 b		
GGA2	100 d			100 c		80 bc		5 a		

*Three different tests on different days were carried out for day 0, and two different tests for days 1, 3 and 5.

**Within each column, figures followed by different letters differ significantly at the 5% confidence level.

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