Influence of Posttreatment Temperature on the Toxicity of Fenvalerate

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Posttreatment temperature effects on the toxicity of fenvalerate (α -cyano-3-phenoxybenzyl-2-(4-chlorophenyl)-isovalerate) and other insecticides were assessed. Fenvalerate, pyrethrins and DDT were from 2.5 to 7.3 times more toxic to *Spodoptera litura* larvae at 15°C than at 25°C by topical application method and foliar dipping method. As for salithion and methomyl LD₅₀ values by topical application method were not affected by the posttreatment temperature, but the insecticidal activities by foliar dipping method showed a positive temperature coefficient. Fenvalerate, pyrethrins and DDT also showed a negative temperature coefficient of paralysing effect against *S. litura*, knockdown activity against *Laodelphax striatellus* and lethal activity against *Plutella xylostella*.

INTRODUCTION

The insecticidal activity of natural pyrethrins at low temperatures has been reported for several insect species, such as *Macrodactylus subspinosus* (HARTZELL and WILCOXON, 1932), *Apis mellifera* (BÖTTCHER, 1938), *Circulifer tenellus* (HARRIES et al., 1945), *Musca domestica* (CHAMBERLAIN, 1950), *Blattella germanica* (GUTHRIE, 1950) and *Periplaneta americana* (BLUM and KEARNS, 1956). These results showed that natural pyrethrins had a negative temperature coefficient. YOKE and SUDDERUDDIN (1975) reported that bioresmethrin also had a negative temperature coefficient of toxicity against *Musca domestica*. HARRIS and KINOSHITA (1977) reported that some synthetic pyrethroids were more toxic to *Gryllus pennsylvanicus* at low temperatures. NARAHASHI (1971, 1976) concluded that the nerve blocking action in insects of allethrin increased at low temperatures.

On the other hand, fenvalerate possessed high insecticidal activity (OHNO et al., 1976) and the mode of action of this compound, which does not have a cyclopropane ring in the acid moiety, was similar to that of pyrethrins (HIRANO, 1977). This paper describes the effect of posttreatment temperatures on the efficacy of fenvalerate and other insecticides.

MATERIALS AND METHODS

Experimental insects. The following stock colonies were reared in this laboratory

at $27\pm 1^{\circ}\text{C}$ and $60\pm 5\%$ in relative humidity:

Tobacco cutworm (*Spodoptera litura* FABRICIUS) were reared on artificial diet (YASUDOMI et al., 1975).

Diamondback moth (*Plutella xylostella* L.) were reared on Japanese radish seedlings.

Smaller brown planthopper (*Laodelphax striatellus* FALLEN) were reared on rice seedlings.

Chemicals. The following chemicals were used in this study.

Fenvalerate (α -cyano-3-phenoxybenzyl-2-(4-chlorophenyl) isovalerate): technical grade (98.1%), 20% EC,

Pyrethrins: 20% pyrethrum extract, 3% EC,

DDT: technical grade (98.7%), 20% EC formulated from the technical grade material,

Methomyl: technical grade (98.4%), 45% WP,

MPMC (3,4-xylyl-N-methyl carbamate): 30% EC,

Salithion: technical grade (94.0%), 25% EC,

Cyanofenphos: 25% EC,

Malathion: 50% EC.

Experimental method

- (1). Topical application method against tobacco cut worms:

This method was based on a previous paper (HIRANO, 1977). Just after the application, applied larvae were put in an incubator (NK type, Nippon-Ikaki) at 15°C , 20°C and 25°C . LD_{50} value was calculated from the mortality at 48 hr.

- (2). Foliar dipping method against tobacco cutworms:

Each insecticide (EC and WP) was diluted with water to a prescribed concentration. And a same size Chinese cabbage leaf was dipped into each solution. After air-drying, the treated leaves were put into a plastic cup (11 cm in diameter). Ten 4th instar larvae were released and the cup was put in the same incubator as experiment 1. LC_{50} value was calculated from the mortality at 48 hr. Untreated leaves and larvae were weighed before treating and at 48 hr, after treating.

- (3). Film contact method against tobacco cutworms:

This method was also based on a previous paper (HIRANO, 1977). The applied glass dish was put in a biotron (KB-type, Koito-Kogyo) at 15°C and 25°C . ET_{50} value was calculated from the percent paralysis of the larvae at the elapsed time.

- (4). Foliar dipping method against diamondback moth larvae:

Insecticide application was the same as experiment 2. After air-drying, the treated leaves were put in a plastic cup (5.5 cm in diameter). Fifteen 3rd to 4th instar larvae were released and the cup was put in the same incubator as experiment 1. LC_{50} value was calculated from the mortality at 48 hr.

- (5). Knockdown activity against smaller brown planthopper:

Each EC formulation was diluted with water and sprayed on potted rice plants. After air-drying, each treated pot was covered with a glass cylinder and put in the same biotron as experiment 3. Fifteen adult planthoppers were released into each cylinder and the number of knocked-down insects was counted at the elapsed time and KT_{50} value calculated. All experiments were performed in triplicate.

RESULTS

As shown in Table 1, fenvalerate was more toxic to *Spodoptera litura* at the lower temperatures by both topical application method and foliar dipping method as were pyrethrins and DDT. Methomyl and salithion LD₅₀ values by topical application method were not affected by the posttreatment temperatures. Nevertheless, the insecticidal activities of these two compounds by foliar dipping method were higher at the higher temperatures than at the lower temperatures. When the increase of body weight and the food consumption were investigated at the three temperature conditions (15°C, 20°C and 25°C), they were higher at the higher temperatures than at the lower temperatures as shown in Table 2. Fenvalerate, pyrethrins and DDT also showed higher paralysing effects at the lower temperatures as shown in Table 3.

Fenvalerate, pyrethrins and DDT were more toxic to *Plutella xylostella* larvae at 15°C than at 25°C. But salithion and methomyl showed higher efficacy at 25°C than at 15°C against this insect by foliar dipping method as shown in Table 4. The knock-

TABLE 1 EFFICACY OF 5 INSECTICIDES AT THE THREE POSTTREATMENT TEMPERATURES AGAINST TOBACCO CUTWORMS

Chemicals	Temperature	Topical application			Foliar dipping	
		LD ₅₀	(μ g/larvae)	R. T. ^a	LC ₅₀ (ppm)	R. T.
Fenvalerate	25°C	0.024	(0.021—0.028) ^b	1.0	5.2 (4.4—6.2)	1.0
	20°C	0.017	(0.015—0.020)	1.4	4.0 (3.3—4.8)	1.3
	15°C	0.0092	(0.0078—0.011)	2.6	1.7 (1.4—2.0)	3.1
Pyrethrins	25°C	0.35	(0.30—0.41)	1.0	180 (140—220)	1.0
	20°C	0.25	(0.20—0.30)	1.4	140 (120—170)	1.3
	15°C	0.14	(0.12—0.17)	2.5	48 (41—57)	3.8
DDT	25°C	4.7	(3.3—6.7)	1.0	240 (200—310)	1.0
	20°C	1.3	(0.92—1.8)	3.6	140 (130—160)	1.7
	15°C	0.64	(0.39—1.0)	7.3	61 (53—68)	3.9
Salithion	25°C	0.15	(0.13—0.17)	1.0	3.4 (2.4—5.2)	1.0
	20°C	0.15	(0.14—0.17)	1.0	4.0 (2.4—8.0)	0.85
	15°C	0.14	(0.12—0.16)	1.1	6.2 (4.6—8.1)	0.55
Methomyl	25°C	0.023	(0.020—0.027)	1.0	3.5 (2.3—6.7)	1.0
	20°C	0.021	(0.017—0.026)	1.1	4.1 (2.4—8.2)	0.85
	15°C	0.023	(0.019—0.028)	1.0	5.2 (3.0—9.6)	0.67

^a Relative toxicity : Efficacy at 25°C is 1.0.

^b Figures in parentheses indicate 95% confidence limit.

Table 2. THE LEAF CONSUMPTION AND THE INCREASE OF BODY WEIGHT OF TOBACCO CUTWORMS FED FOR 48 hr AT THREE TEMPERATURE CONDITIONS

Temperature	Consumption of leaves by 10 larvae	Average body weight (mg)		
		before release	after release	increase
15°C	1.73 g	61.4	82.4	21.0
20°C	2.38	60.5	125.4	64.9
25°C	3.66	64.2	183.0	118.8

Table 3. EFFECT OF TEMPERATURE ON THE PARALYSIS AND THE MORTALITY OF TOBACCO CUTWORMS

Chemicals	Dosage mg/m ²	15°C		25°C	
		ET ₅₀ (min) ^a	Mortality %	ET ₅₀ (min)	Mortality %
Fenvalerate	0.013	201 (179—235) ^b	53		
	0.025	131 (119—144)	97		
	0.05	104 (94—112)	90	> 240	3
	0.10	70 (62—77)	100	218 (182—310)	57
	0.20			103 (86—121)	85
	0.40			62 (49—70)	100
Pyrethrins	0.5	82 (59—115)	23		
	1.0	51 (43—60)	63	> 240	10
	2.0	36 (26—44)	63	> 240	33
	4.0			151 (98—380)	50
DDT	2.5	> 240	67		
	5.0	177 (160—195)	90		
	10	161 (145—177)	93		
	20			> 240	50
	40			234 (198—302)	73
	80			172 (154—191)	100
Salithion	0.5	> 240	20	82 (73—90)	80
	1.0	76 (69—82)	100	37 (32—42)	100
	2.0	47 (41—54)	100	24 (21—28)	100
Methomyl	0.1	> 240	37	80 (69—92)	40
	0.2	114 (98—135)	60	43 (35—51)	93
	0.4	74 (64—81)	97	< 30	100
Untreated		> 240	0	> 240	0

^a 50% effective time.^b Figures in parentheses indicate 95% confidence limit.

Table 4. EFFICACY OF 5 INSECTICIDES AT THE TWO POSTTREATMENT TEMPERATURE CONDITIONS AGAINST DIAMONDBACK MOTH

Chemicals	LC ₅₀ (ppm)		R. T. ^a
	15°C	25°C	
Fenvalerate	4.1 (3.4—4.9) ^b	6.0 (5.0—7.4)	1.5
Pyrethrins	< 250	290 (230—350)	> 1.2
DDT	370 (270—730)	580 (390—900)	1.6
Salithion	31 (25—41)	21 (18—24)	0.68
Methomyl	430 (350—540)	270 (230—320)	0.63

^a Relative Toxicity : Efficacy at 25°C is 1.0^b Figures in parentheses indicate 95% confidence limit.

down activity of fenvalerate against *Laodelphax striatellus* was higher at 15°C than at 25°C as were pyrethrins and DDT. But MPMC and malathion knockdown activities were higher at 25°C than at 15°C as shown in Table 5.

Table 5 EFFECT OF TEMPERATURE ON KNOCKDOWN AND MORTALITY OF SMALLER BROWN FLANTHOPPERS

Chemicals	Conc. (ppm)	15°C		25°C	
		KT ₅₀ (min)	Mortality %	KT ₅₀ (min)	Mortality % ^b
Fenvalerate	50	39 (35—44) ^a	97	107 (83—137)	73
	250	13 (10—15)	100	19 (15—23)	100
Pyrethrins	50	<5	100	≈5	100
DDT	250	30 (23—38)	100	193 (169—240)	100
Malathion	250	>240	43	146 (120—193)	90
MPMC	250	66 (59—72)	100	34 (31—37)	100
Untreated		>240	3	>240	3

^a Figures in parentheses indicate 95% confidence limit.

^b Observed at 24 hr.

DISCUSSION

It seemed that the intake of chemicals by the larvae at the higher temperatures was greater than at the lower temperatures if the chemicals did not possess repellent or paralysing activity (See Table 2). Moreover, as the larvae moved more actively at the higher temperatures, the larvae ought to have more chance of contact with the chemicals than at the lower temperatures. As for methomyl and salithion, the difference of efficacy between topical application method and foliar dipping method seemed to be due to this reason. On the other hand, fenvalerate, pyrethrins and DDT showed higher lethal activity at the lower temperatures even in this experimental condition. As for DDT, relative toxicity value at 15°C by topical application method was higher than that by foliar dipping method. It seemed to be due to the same reason as with the case of methomyl and salithion. But in case of fenvalerate and pyrethrins, relative toxicity values at 15°C between topical application method and foliar dipping method were almost equal. It may be the case that the amount of chemical intake at 25°C was not so different than at 15°C because of paralysing of larvae.

In other words, fenvalerate showed a negative temperature coefficient against *S. litura* by both the experiments as were pyrethrins and DDT. These three compounds also showed the negative temperature coefficient on the paralysing effect against this insect.

The lethal activity of fenvalerate against *P. xylostella* showed a negative temperature coefficient as did pyrethrins and DDT. On the other hand, salition and methomyl were more toxic to this insect at the higher temperature as well as to *S. litura*. Also the knockdown activity of fenvalerate against *L. striatellus* also showed a negative temperature coefficient as did pyrethrins and DDT. But as for MPMC and malathion, the knockdown activity against this insect at 25°C was higher than at 15°C.

Moreover, HARRIS and KINOSHITA (1977) reported that fenvalerate possessed higher lethal activity at 15°C than at 32°C against *Gryllus pennsylvanicus* as other synthetic pyrethroids. From the results, it seems that fenvalerate shows a negative temperature coefficient not only in lethal activity but also knockdown or paralysing effect against the various species of insect pests the same as pyrethroidal insecticides and DDT.

Fenvalerate, which did not possess a cyclopropane ring in the acid moiety, was similar to pyrethroids by the molecular model analysis (OHNO et al., 1976) and the mode of action on *Spodoptera litura* (HIRANO, 1977). And this compound was believed to be included in a group of synthetic pyrethroids. This study also showed one of the reasons why fenvalerate belongs to a group of pyrethroids. On the other hand, NARAHASHI (1971, 1976) reported that pyrethroid compounds showed a negative temperature coefficient of nerve-blocking action, and it was believed to be directly linked to the killing of insects. The negative temperature coefficient on efficacy of fenvalerate seemed to be related to that of nerve-blocking action.

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