OnLine Journal of Biological Sciences 1(11): 1043-1045, 2001

Toxicity of Nine Insecticides to Adult *Tribolium castaneum* (Herbst)

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Abstract: Nine insecticides were used in a toxicity test on adult red flour beetle, *Tribolium castaneum* (Herbst). Mortality tests were done by applying different doses of insecticide following residual-film method in a petridish on laboratory reared 3 to 7 days adults and the data was recorded after 24 hours of treatment. The calculated LD_{50} values were 13.8221, 53.8803, 8.0592, 424.1043, 223.2351, 8.1755, 920.1590, 243.3920 and 0.2416 $\mu g/cm^2$ for chlorpyrifos, fenitrothion, malathion, monocrotophos, phosphamidon, carbosulfan, propoxur, cypermethrin and lambda-cyhalothrin respectively. The results indicate that lambda-cyhalothrin was the most toxic and propoxur was least toxic to adult red flour beetles when applied singly. The order of toxicity of the insecticides was lambda-cyhalothrin > malathion > carbosulfan > chlorpyrifos > fenitrothion > phosphamidon > cypermethrin > monocrotophos > propoxur. Lambda-cyhalothrin, malathion, carbosulfan and chlorpyrifos can be used to control red flour beetle in storage and other insecticides can control them moderately.

Key words: Insecticide, LD_{50}, *Tribolium castaneum*

Introduction

The chemical control method of insect is very effective and rapid in curative action. It has been considered as the most important and powerful tool in controlling insect pests both in the field and under storage conditions for the past few decades, even the method is, in general, ecologically unsound and has many serious limitation as insect pest resistance, outbreaks of secondary pests, adverse effects on the non-target organisms, objectionable pesticide residues, and direct hazards to the user (Smith, 1970), elimination of economically beneficial insects and the several predators of the pests (Smith and Van den Bosch, 1967). Insecticide resistance, pest resurgence and pest replacement can occur following repetition applications of these compounds (Pedigo, 1989).

If we consider the alternatives, the benefits of insecticides probably outweigh the risks. But the goal of insecticide use to obtain maximum benefits with minimal risks has not yet been achieved in most situations. Therefore, it is important that a good understanding of these chemical tools and the consequences of their use be acquired if this approach is to be improved. Given the tremendous difficulty and investment associated with the development of new, safe and cost-effective insecticides, there is a grave need to preserve the efficacy of current insecticides. This may be achieved by proper use of pesticide and dose selection, to follow the rules of pesticide application. A developmental program for chemical pesticides should involve a thorough examination of the physical, biological and environmental factors that can affect pesticide toxicity (Zettler and Arthur, 2000).

A suitable insect species for use in bioassays is *Tribolium castaneum*, which exhibits moderate tolerance to most insecticides (Champ and Campbell-Brown, 1970). In this investigation nine insecticides, such as, chlorpyrifos, fenitrothion, malathion, monocrotophos, phosphamidon, carbosulfan, propoxur, cypermethrin and lambda-cyhalothrin were used to evaluate their action on the flour beetle, *Tribolium castaneum* (Herbst).

Materials and Methods

Test insect: Different strains of *T. castaneum* (Herbst) cultures were maintained for about 15 years in the Crop protection and Toxicology Laboratory, Department of Zoology, Rajshahi University. The strains were previously collected from the Crop Protection Laboratory, Department of Agricultural and Environmental Science, University of Newcastle Upon Tyne, England. From the cultures a standard strain of the beetles was collected for the present study. Mass cultures were maintained in jars (1000 ml) and subcultures were in beakers (500 ml) with food medium and kept in an incubator at 30 ± 0.5°C. A standard mixture of whole-wheat flour with powdered dry yeast in a ratio of 19:1 (Park and Frank, 1948; Park, 1962; Zyromska-Rudzka, 1966) was used as food medium throughout the experimental period.

Mortality tests: The experiment was conducted from March to July 2000. Residual film method (Busvine, 1971) was used to test the mortality of adult *T. castaneum*. The insecticides tested were chlorpyrifos (Dursban 20EC of Dow Chemical Co., USA), fenitrothion (Sovathion 50EC of Sumitomo Chemical Co., Japan), malathion (Limithon 57EC of ACI Ltd.), monocrotophos (Megafos 40LC of MacDonald Bangladesh Ltd.), phosphamidon (Phosphamidon 100SCW of Novartis Bangladesh Ltd.), carbosulfan (Marshal 20EC of FMC Corp. USA), propoxur (Acekro 20 EC of MacDonald Bangladesh Ltd.), cypermethrin (Cymbush 10EC of ACI Ltd.) and lambda-cyhalothrin (Karate 25 EC of ACI Ltd.). The insecticide was diluted in acetone and different doses were made. One ml of liquid from each dose was dropped on petridishes (90 mm) separately, covering uniformly the whole area of the petridish. They were then kept open for sometimes to dry-up. Four plastic rings (30 mm) were placed inside a petridish and 10 adult beetles were released within each ring. The rings within the petridish were served as replications. The doses were calculated by measuring the actual amount of active ingredient (μg) in one ml of the liquid divided by the surface area of the petridish. A control batch was maintained in which only acetone was applied. The mortality of the beetle was recorded after 24 hours. The mortality percentage was corrected using Abbott's formula (Abbott, 1925) and observed data was subjected to probit analysis according to Finney (1947) and Busvine (1971).

Results and Discussion

Different doses of the chlorpyrifos, fenitrothion, malathion, monocrotophos, phosphamidon, carbosulfan, propoxur, cypermethrin and lambda-cyhalothrin were applied by the method of residual film method on 3-7 days old adult *T. castaneum*. The mortality was recorded primarily after 30 minutes to see if there is any rapid activity exhibited by the treated beetles and final mortality was recorded after 24 hours

Table 1: Dose mortality data and LD_{50} of tested insecticides on adult *T. castaneum*

Insecticides	Dose ($\mu g/cm^2$)	No. used	No. killed	Mortality (%)	LD_{50} ($\mu g/cm^2$)
	12.575	90	48	53.33	
	6.287	90	39	43.33	
	3.144	90	30	33.33	
Chlorpyrifos	1.572	90	25	27.77	13.8221
	0.986	90	20	22.22	
	0.393	90	18	20.00	
	Control	90	3	3.33	
	70.736	90	66	73.33	
	58.946	90	52	57.77	
Fenitrothion	47.157	90	40	44.44	53.8803
	35.368	90	26	28.88	
	Control	90	6	6.66	
	17.920	90	56	62.22	
	8.960	90	48	53.33	
	4.480	90	43	47.77	
Malathion	2.240	90	30	33.33	8.0592
	1.120	90	27	30.00	
	Control	90	5	5.55	
	472.000	90	56	62.22	
	393.000	90	46	51.11	
Monocrotophos	319.000	90	30	33.33	424.1043
	240.000	90	27	30.00	
	Control	90	8	8.88	
	240.000	90	51	56.66	
	200.000	90	43	47.77	
Phosphamidon	160.000	90	35	38.88	233.2351
	120.000	90	27	30.00	
	Control	90	6	6.66	
	14.147	90	54	60.00	
	7.0740	90	47	52.22	
	3.5370	90	40	44.44	
Carbosulfan	1.7690	90	32	35.55	8.17545
	0.884	90	25	27.77	
	0.443	90	20	22.22	
	Control	90	6	6.66	
	940.000	90	49	54.44	
	790.000	90	39	43.33	
Propoxur	630.000	90	31	34.44	920.1590
	470.000	90	24	26.66	
	Control	90	3	3.33	
	354.000	90	68	75.55	
	292.000	90	60	66.66	
Cypermethrin	236.000	90	43	47.77	243.3920
	178.000	90	33	36.66	
	Control	90	6	6.66	
	0.393	90	71	78.88	
	0.327	90	62	68.88	
λ-Cyhalothrin	0.262	90	53	58.88	0.2416
	0.196	90	38	42.22	
	Control	90	6	6.66	

Table 2: LD_{50}, 95% confidence limits and regression equations of tested insecticides to adult *T. castaneum*

Insecticides	LD_{50}, ($\mu g/cm^2$)	95% confidence limits		Regression equations	χ^2 (df)
		Lower	Upper		
Chlorpyrifos	13.8221	6.8896	27.6903	Y = 3.579198 + 0.663748X	1.014 (4)
Fenitrothion	53.8803	49.8851	58.1953	Y = -2.061879 + 4.078641X	0.278 (2)
Malathion	8.0592	5.4713	11.8713	Y = 4.266287 + 0.8095768X	1.209 (3)
Monocrotophos	424.1043	378.7038	474.9476	Y = -4.010807 + 3.429450X	3.053 (2)
Phosphamidon	223.2351	189.8362	262.5099	Y = -1.015187 + 2.561003X	0.084 (2)
Carbosulfan	8.1755	5.1813	12.8997	Y = 3.543133 + 0.7617565X	0.049 (4)
Propoxur	920.1590	772.8470	1095.5500	Y = -2.746945 + 2.6138X0.500 (2)	
Cypermethrin	243.3920	224.0779	264.3708	Y = -4.130479 + 3.826198X	0.962 (2)
λ-Cyhalothrin	0.2416	0.2173	0.2685	Y = 3.686801 + 3.42848X	0.059 (2)

of exposure. The calculated LD_{50} values were 13.8221, 53.8803, 8.0592, 424.1043, 223.2351, 8.1755, 920.1590, 243.3920 and 0.2416 $\mu g/cm^2$ for chlorpyrifos, fenitrothion, malathion, monocrotophos, phosphamidon, carbosulfan, propoxur, cypermethrin and lambda-cyhalothrin respectively (Table 1). The results indicate that lamda-cyhalothrin was the most toxic and propoxur was the least toxic to adult red flour beetles when applied singly. The order of toxicity of the insecticides was lambda-cyhalothrin > malathion > carbosulfan > chlorpyrifos > fenitrothion > phosphamidon > cypermethrin > monocrotophos > propoxur. The 95% confidence limits, regression equations of the expected probit on log dose of the tested insecticides and χ^2 -values are presented in Table 2. All χ^2 -values were found insignificant indicating no significant heterogeneity in the experiments.

Adrain *et al.* (1947) first observed the inhibition properties of organophosphorous esters against cholinesterase. Balls and Jansen (1952) found that the inhibition was attributed to the phosphorylation of the esteratic site, which was initially demonstrated, by the action of di-isopropylfluorophosphate (DFP) with chymotrypsin. In animal acetylcholine is believed to be the transmitter in the synapses of the nervous system. Generally acetylcholine inhibition interferes with the co-ordination of muscular response in the vital organs serious symptoms and eventually death Smallman and Mansingh (1969). It was hypothesized by Johnson (1975) that organophosphorus compound-induced delayed neurotoxicity is attributable to a large degree of inhibition of an enzyme characterized as neurotoxic esterase (NTE) in nervous systems, but not to inhibition of acetylcholinesterase (AchE). It was also suggested by Lotti and Johnson (1978) that measurements of the degree of inhibition of both NTE and AchE in hen brain provide a guide to the evaluation of delayed neurotoxicity of organophosphorus esters.

Pyrethroids have disruptive effects on a variety of arthropod sensory preparations. Gammon (1978) reported that allethrin-treated cockroaches developed bursts of afferent discharges in the cerci, which arose as the treated insects became restless and ataxic. Electrical or mechanical stimuli applied to the cerci produced greatly prolonged sensory responded. Repetitive discharges in the crural nerves of the housefly and cockroach resulted from topical treatment of tarsi on isolated legs (Miller and Adams, 1977). The latency from treatment to repetitive firing decreased with increasing doses, and compounds that were most potent in producing discharges were better knockdown agents.

The toxicity of most organophosphate insecticides applied as residual crack-and-crevice treatments to control insects in and around mills and processing plants is positively correlated with temperature (Johnson, 1990). Many of these compounds are older chemicals that have been registered for years, and they maybe subject to regulatory restraints based on interpretations of new legislation and requirements for reregistration (Arthur, 1999). The present study shows that lambda-cyhalothrin, malathion, carbosulfan and chlorpyrifos can be used to protect the red flour beetle in granary and storehouses. Other insecticides used can moderately control *T. castaneum*.

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