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Safety of selected botanical and synthetic insecticides against braconid parasitoids of vegetable ecosystems

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ABSTRACT

Insecticides are unavoidable in pest management programmes especially when the pest crosses economic threshold level (ETL). In this context, some of the insecticides and botanicals that are used in vegetable ecosystem were test verified for their relative safety against the commonly encountered parasitoids *viz., Bracon brevicornis* Wesmael, *Chelonus blackburni* Cameronand *Cotesia plutellae* Kurdjumov. Toxicity effects of five insecticides *viz.,* Acephate 75SP, Chlorpyriphos 20EC, Cypermethrin 10EC, Profenofos 50EC, Quinalphos 25EC and NSKE 5 per cent against *B. brevicornis, C. blackburni* and Hexane extracts of *Lantana camara* var. *aculeate* tested against *C. plutellae* were evaluated under laboratory conditions. Amongst insecticides tested, Profenofos 50EC was found to be most toxic with LC_{50} value of 22.27 and 16.280 ppm; Chlorpyriphos 20EC was the least toxic with the highest LC_{50} value of 198.53 and 314.255 ppm and NSKE 5 per cent had no effect against *B. brevicornis* and *C. blackburni,* respectively. *C. plutellae* pupae were treated with hexane extracts of *L. camara* resulted of 66.67 and 76.67 per cent with reduction of adult emergence at 8 and 10 per cent, respectively. While, *C. plutellae* adults were found to be safe at all concentrations except 8 and 10 per cent and its contact toxicity of 63.33 and 96.67 per cent adult mortality recorded within 24h by dry film method. The results suggest that the Chlorpyriphos 20EC and botanical extracts can very well integrate in the management of vegetable insect pests.

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INTRODUCTION

Biological control efforts against plants and insects have different histories, with insect biological control being used for much of its first century largely against crop pests. Only in he1990s did insect biological control against environmental pests develop as an independent goal (Van Driesche, 1994). Presence of predators and parasitoids in field crops, orchards and vegetables has been a subject for many studies of reducing the insecticide usage and thereby safe to environmental pollution (Dean and Sterling, 1992) and tolerance to some pesticides (Hassan *et al.*, 1985). It has received much attention of farmers as well as researchers as a potential biological pest control agent.

A wide range of recommended chemical insecticides are being used by the farmers for controlling the pests (Priya and Misra, 2007). The chemicals are highly effective, rapid in action, adaptable to most situations and relatively economical. Despite these advantages, the use of chemical pesticides had been ecologically unsafe and harmful to natural enemies. In order to avoid adverse consequences of insecticides, it becomes necessary to minimize the use of insecticides (Kanwar and Ameta, 2007). Perera *et al*. (2000) studied the effect of feeding deterrents, azadirachtin at on 4th instar larvae of *Plutella xylostella* L. and on the parasitoid, *C. plutellae* and its results suggested that the antifeedants were effective in managing cabbage pest *P. xylostella* and could be used in integrated pest management programme and safer to the parasitoids *C. plutellae*.

The LC_{50} of *B. hebetor* and *C. blackburni* was 0.0151 and 0.0013 ppm for fluvalinate, 0.0031 and 0.0029 ppm for deltamethrin, respectively (Somasundaram and Regupathy, 1985). Mandal and Somchoudhury (1995) reported that methyl parathion was 1.62, 11.69, 14.81, 15.56 and 126.81 times more toxic than quinalphos, carbaryl, monocrotophos and phosphamidon, respectively against *B. brevicornis*. Reddy and Divakar (1998) stated that cypermethrin, fenvalerate and fluvalinate were found to be slightly harmful and malathion was moderately harmful to *B. kirkpatricki*. The mixture of abamectin + deltamethrin did not show measurable impact on the population of the natural enemies *viz., Diadegma* spp. and *Apanteles* spp. (Franca *et al*., 1998). An aqueous suspension and an ethanolic extract of *Neem* seed kernel extract (NSKE) at 0.3, 0.6, 1.2, 2.5 and 5.0 per cent concentration were tested against *B. hebetor.* Neither NSKE delivered in the food or by contact influenced the *B. hebetor* oviposition and parasitization (Raguram and Singh, 1998).

Singh (2007) stated that neem was safer with least detrimental effects on the oviposition of *C. flavipes*. Mani and Krisnamoorthy (2000) stated that botanicals appeared to be safe to the hymenopteran parasitoids. But all the conventional insecticides were found highly toxic to the adult parasitoids of Distatrixpapilionis (Vireck) against citrus butter fly. Spinosad had very little effect on the rate of parasitism of *C. plutellae* and *Brachymeria* spp. at the highest dose of 25g a.i. ha^{-1} (Dey and Somchoudhury, 2001). Mohindru and Nagalingam (2007) stated that monocrotophos, carbaryl, acephate and fenvalerate were less toxic, while cypermethrin, etofenprox and triazophos were moderately toxic and deltamethrin and profenophos were highly toxic when treated against *B. hebetor*.

MATERIAL AND METHODS

Laboratory experiments were carried out to find the toxicity of synthetic and botanicals insecticide on braconids. The parasitoids for the bioassay study were taken from Biocontrol Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Cultures of the host insect and parasitoids :

Rice moth, *Corcyra cephalonica* Stain. an important laboratory host for the braconid parasitoids, were obtained from the Biocontrol Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore and procedure described by Singh and Jalali (1994).

The larval parasitoid *B. brevicornis* and *C. plutellae* were cultured on the larvae of *C. cephalonica* by sandwich methodas per procedure developed by Jhansi (1984). *C. blackburni*, an egg larval parasitoid was cultured on the eggs of *C. cephalonica* as described by Swamiappan and Balasubramanian (1979). Braconid species of parasitoid used in the bioassays were reared for three to six generations in the laboratory and progenies were used for the experiments. All bioassays were conducted atambient temperature of 26 (±2) ^{0}C with 70 (±5) per cent RH.

Safety of commonly used insecticides to adult braconid parasitoids :

Dry film method - contact toxicity :

Laboratory experiments were carried out to determine the safety of commonly used synthetic and botanical insecticides against adults of *B. brevicornis*, *C. blackburni* and *C. plutellae* of pupae and adults.

Experiments were carried out to determine the LC_{50} values of commonly used insecticides like acephate 75 SP, cypermethrin 10 EC, chlorpyriphos 20 EC, endosulfan 35 EC, profenofos 50 EC, quinalphos 25 EC, NSKE 5 per cent against *B. brevicornis* and *C. blackburni*; hexane crude extract of *Lantana camara var. aculeata* different concentration (Fig. 1) tested against *C. plutellae* by dry film method. All the studies were carried out with commercial formulations of insecticides.

A preliminary range finding test was conducted to have a narrow insecticide concentration. Differential concentrations were prepared from commercial formulation with hexane for the safety study. Test insecticides @ 0.5ml and botanicals @ 1.0ml was pipetted out into a glass scintillation vial of 20 ml capacity and rotated by hand to have a uniform coating of the insecticides all over the inner surface (Jalali and Singh, 1993 and Zh *et al*., 2004). Then, the vials were air dried to leave a thin film of the insecticide. Thirty unsexed adults (1–2 days post-emergence) braconid emerged from the parasitized larvae were released into the glass tube and covered with muslin cloth secured with a rubber band and provided with a small cotton ball saturated with 20 per cent honey solution as food and the LC_{50} was worked out. Each treatment was replicated thrice and each replicate involved 10 adults.

Statistical analysis :

The adult parasitoid mortality in control was corrected using Abbott's formula (Abbott, 1925). The concentration and time mortality responses of various experiments were subjected to probit analysis was done to calculate median lethal concentration (LC_{50}) using SPSS v16.0 version software package (Finney, 1962). The corrected per cent mortalities were transformed to arcsine percentage and subjected to statistical analysis adopting Completely Randomized Design.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Safety of commonly used insecticides and NSKE to *C. blackburni*

Profenofos 50 EC was the most toxic insecticide with LC_{50} value of 22.266 ppm followed by cypermethrin 10 EC (LC_{50} - 28.202 ppm). Chlorpyriphos 20 EC was observed to be less toxic to *C. blackburni* with a value of 198.523 ppm; NSKE 5 per cent recorded no toxic effect presented in Table 1.

Table 1 : Safety of commonly used insecticides against *C. blackburni*

Insecticide	Regression equation	$\chi^{2*}_{(n-2)}$	LC_{50} (ppm)	Fiducial limits	
				LL	UL
Acephate 75 SP	Y= 1.668 x + 2.088	2.647	55.640	40.657	76.145
Chlorpyriphos 20 EC	Y= 1.856 x + 0.733	0.808	198.523	150.359	262.115
Cypermethrin 10 EC	Y= 1.687 x + 2.552	0.973	28.202	20.691	38.440
Profenofos 50 EC	Y= 1.646 x + 2.783	1.318	22.266	16.374	30.278
Quinalphos 25 EC	Y= 2.069 x + 0.285	0.285	62.831	45.789	86.230
NSKE (Aqueous 5%)		No toxic effect			

* All lines are significantly a good fit ($P \leq 0.05$) ;No. of insects used per treatment was 30

Table 2 : Safety of commonly used insecticides against *B. brevicornis*

Insecticide	Regression equation	$\chi^{2*}_{(n-2)}$	LC_{50} (ppm)	Fiducial limits	
				LL	UL
Acephate 75 SP	Y= 1.730 x + 2.062	0.237	49.811	37.165	66.761
Chlorpyriphos 20 EC	Y= 1.655 x + 0.877	0.454	314.255	229.158	430.954
Cypermethrin 10 EC	Y= 1.939 x + 2.087	0.186	32.210	24.659	42.073
Profenofos 50 EC	Y= 1.301 x + 3.417	0.172	16.280	11.107	23.860
Quinalphos 25 EC	Y= 0.875 x + 0.364	1.147	305.172	231.184	402.838
NSKE (Aqueous 5%)		No toxic effect			

* All lines are significantly a good fit ($P \leq 0.05$) ;No. of insects used per treatment was 30

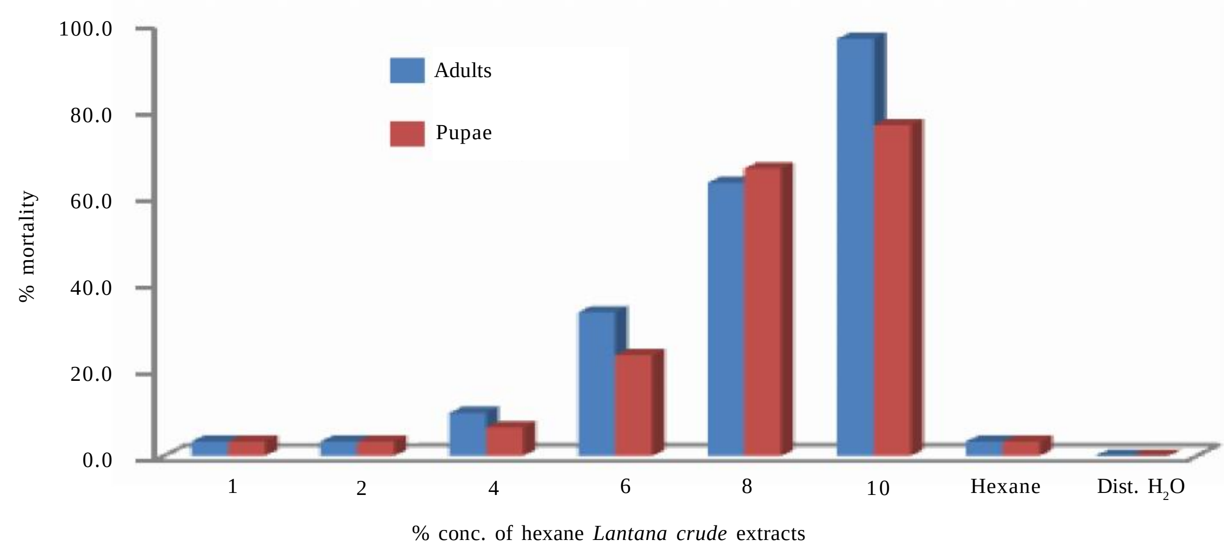

Fig. 1 : Toxicity of *Lantana crude* extract to *Cotesia plutellae* Kurdjumov-dry film method

Safety of commonly used insecticides and NSKE to *B. brevicornis* :

All the insecticides tested for safety to *B. brevicornis* were found to be toxic. Among the synthetic insecticides, Profenofos 50 EC (LC_{50}- 16.280 ppm) was the most toxic followed by cypermethrin 10 EC (LC_{50}- 32.210 ppm). Chlorpyriphos 20 EC was found to be less toxic with highest LC_{50} value of 314.255 ppm. NSKE 5 per cent recorded no toxic effect on *B. brevicornis* presented in Table 2.

Safety of *L. camara* hexane crude extract to *C. plutellae* :

Mortalities of the *Cotesia* adults and pupae after exposure to *Lantana crude* extracts at different concentrations are presented in Fig.1. Concentrations 8 and 10 per cent killed almost all adults of the parasitoids within 24h, but showed less toxicity at 1, 2, 4 and 6 per cent concentrations to *C. plutellae* pupae and adults. However, no significant difference in the mortality of *C. plutellae* at 24h was detected between the hexane and distilled water. The adults and pupae exposure to *Lantana crude* extract upto 6 per cent recorded no toxic effect on *C. plutellae* (Fig. 1).

Results of the safety studies showed that all the insecticides were toxic to *B. brevicornis* and *C. blackburni*. The order of toxicity was; profenofos> cypermethrin> acephate>quinalphos> chlorpyriphos. Several other studies also revealed the toxicity of cypermethrin and quinalphos to *B. kirkpatricki*, *Bracon* spp. and *C. blackburni* (Chaturvedi, 2005 and Samanta *et al*., 2007). But, Mani *et al*. (1985) and Reddy and Divakar (1998) reported cypermethrin was less toxic to *Bracon* spp. These variations, perhaps, could be attributed to the difference in technical or adjuvant used in the formulations.

Profenofos observed to be highly toxic against *B. brevicornis*, which was evident from the lowest LC_{50} values. The results corroborate with findings of Khan *et al.* (2005) and Mohindru and Nagalingam (2007) against *Bracon* spp. NSKE 5 per cent was found to be safe against *B. brevicornis* and *C. blackburni*. Jhansi and Sundara Babu (1987) reported the safety of NSKE 5 per cent against *B. hebetor.* Several other workers also documented the same against *Bracon* spp. and *C. blackburni* (Raguram and Singh, 1998 and Mani and Krishnamoorthy, 2000).

Based on the classification given by IOBC/WPRS working group on pesticides and non-target invertebrates, both chlorpyriphos 20 EC and *Lantana* camara hexane crude extract 4 per cent were classified as harmless to *C. blackburni*, *B. brevicornis* and *C. plutellae*, respectively. Since the recommended dose caused less than 50 per cent mortality in the laboratory conditions. The use of natural enemy in combination with selected insecticides and botanicals which have no effect on them is effective in depressing the population density of the insect pest.

Schneider and Mandel (1991) reported that there was no adverse effect on adults of the braconid *Diadegma semiclausum* after exposure for 3 days or during their lifetime in cages to residues of NSKE of 0.1-5 per cent.The longevity of the wasps exposed to neem residues was even prolonged but the difference between treated and untreated individuals was statistically not significant. Females of the braconid, derived from larvae developed in neem-treated larvae of *P. xylostella*, showed no reduced fecundity or activity as compared with controls. Fresh extracts showed no repellent effect. The influence of azadirachtin on *Diadegma terebrans*, parasitoid of *Ostrinia nubilalis* was investigated in the laboratory by Mccloskey *et al.* (1993). Spraying of high conc. of AZT-VR-K on adult braconids and their contact with sprayed cabbage leaves for 2 days had no obvious effect on the wasps (Schmutterer, 1992). Use of a *Neem* preparation for pest control had no effect on the rate of parasitism (Olivella and Vogt, 1997).

The success of IPM programmes depends, in part, on the optimal use of selective insecticides that are less harmful to natural enemies, which requires knowledge of their side-effects on the biological and behavioural traits of these organisms (Tillman and Mulrooney, 2000; Bozski, 2006 and Stark *et al.*, 2007).

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Table 3 : Toxicity effects of various synthetic insecticides against adults of *C. plutellae*

Insecticides and recommended concentrations (ppm)@		% Mortality after treatment*		Rating	Reference
		24 hours	48 hours		
Chlorfluazuron 5EC*	10.00	16.7	46.70	1	Zh *et al.*, 2004
Fenvalerate 20 EC*	20.00	53.3	70.00	4	Zh *et al.*, 2004
Fipronil 5 SC*	12.50	43.3	100.00	4	Zh *et al.*, 2004
Methomyl 90 SP*	405	93.3	100.00	4	Zh *et al.*, 2004
Quinalphos 25EC*	500	100	-	4	Kao and Tzeng, 1992
Acephate 75SP*	500	6.49	-	1	Kao and Tzeng, 1992
Carbofuran 40.64FP*	339	100	-	4	Kao and Tzeng, 1992
Abamectin 1.8 EC*	3.24	68	88.00	3	Miyata *et al.*, 2001
Chlorfenapyr 10 SC*	100	100	100	4	Miyata *et al.*, 2001
Diafenthiuron 25 EC*	1875	92	100	4	Miyata *et al.*, 2001
Cypermethrin 15 EC*	337.40	34	58.00	3	Miyata *et al.*, 2001
Emamectin benzoate 5 SG**	10.00	43.33	63.33	2	Thangachamy *et al.*, 2015
Imidacloprid17.8SL**	99.68	0.00	6.67	1	Thangachamy *et al.*, 2015
Lufenuron 5.4 EC**	99.90	43.33	76.67	2	
Spinosad 2.5 EC**	50.00	50.00	83.33	2	Thangachamy *et al.*, 2015
Indoxacarb 14.5 SC**	40.60	23.33	26.67	1	
Acetamiprid 20 SL**	100.00	0.00	6.67	1	Thangachamy *et al.*, 2015
Quinalphos 25EC**	500.00	0.00	3.33	1	

Based on criteria suggested by Hassan *et al.* (1985) to evaluate the toxicity of insecticide toxicity rated as; 1= Harmless (<50%).
2= Slightly harmful (50-79%). 3= Moderately harmful (80-99%). 4= Harmful (>99% mortality). @ Recommended dosage;
*Dry film method - % adult mortality; **Coccon tip method - % adult emergence.

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