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Toxicity of Some Insect Growth Regulator and Neonicotinoid Insecticides to Cotton Mealybug Predator, *Cheilomenes sexmaculata*

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The toxicity of insect growth regulators and neonicotinoid-based insecticides recommended for the management of cotton mealy bug, *Phenacoccus solenopsis* Tinsley were compared and tested for their toxicity against different developmental stages of predatory coccinellid *Cheilomenes sexmaculata* (Fabricius). Buprofezin recorded significantly higher (76.66%) hatching of eggs of *C. sexmaculata*, followed by endosulfan (73.33%), imidacloprid (70.00%) and chlorpyriphos (63.33%). The cumulative mortality of second instar grubs and adults were found to be highest in clothianidin, profenophos, imidacloprid, chlorpyriphos, acephate and thiodicarb. The emergence of adults from the treated pupae was highest in buprofezin (83.33%), endosulfan (76.67%) and profenophos (53.33%). Buprofezin was found to be the safest insecticide, followed by endosulfan to all the stages of *C. sexmaculata* and pupae were found to be resistant to the insecticides as compared to the eggs.

Key words: *Cheilomenes sexmaculata*, cotton, toxicity, buprofezin.

Bt cotton officially entered Punjab in 2005 and by 2007 almost 100 percent farmers began cultivating Bt cotton in the four cotton-producing districts. In 2005, an introduced species of *Phenacoccus* (Sternorrhyncha: Coccoidea: Pseudococcidae) was found causing serious damage to cotton in Punjab and Sindh provinces of Pakistan (Abbas *et al*., 2005). Thereafter, during the years 2006 and 2007, *Phenacoccus solenopsis* Tinsley caused widespread and serious damage to cotton crop in the Indian subcontinent (Saini and Ram, 2008). To control this pest, different insecticides have been recommended but complete reliance on insecticides may result in development of resistance, insect resurgence and environmental hazards (Mascarenhas *et al*., 1998). Pesticides often interfere with the activity of parasitoids and predators in the ecosystem. So understanding the acute toxicity of insecticides to natural enemies is important and relevant to develop a sound pest management programme. Predatory coccinellids occupy all the habitats and niches of their preys and distributed worldwide. Among them *Cheilomenes sexmaculata* are known to prey on about 39 arthropod species (Gautam, 1989). Considering the potential of mealy bugs to cause extensive damage to this crop and little information available on the toxicity of insect growth regulators and neonicotinoid-based insecticides to *C. sexmaculata*, a laboratory experiment was conducted during 2009 at Punjab Agricultural University, Ludhiana.

Materials and Methods

Toxicity to the eggs and pupae

The lethal effects of eight newer and already recommended insecticides as listed in Table 1 were tested for their toxic effects against egg and pupal stages of *C. sexmaculata*. Insecticides were used as foliar sprays in all the experiments. Two-day-old eggs and three-day-old pupae were tested at the rate of ten per treatment and replicated three times. The eggs and pupae of the predator were spread on glass plate and sprayed directly with insecticides. After drying in shade, the eggs and pupae of these treatments were kept separately in glass vials. These vials were observed daily for hatching of eggs, emergence of adults from treated pupae, survival of grubs 24 hrs after hatching of eggs and survival of adults emerged from the treated pupae, and per cent values were worked out.

Toxicity to the grubs and adults

Fifteen mealy bugs of varying ages were placed on green cotton leaf in a Petriplate (100 x 20 mm) with moistened Whatman No.1 filter paper beneath the leaf. Ten second instar grubs of the predator were released in this Petriplate with a moistened camel hair brush. The grubs were then allowed to acclimatize for 2 hrs. After this, the insecticidal treatments were applied using a hand atmoizer with a spray volume that was sufficient to thoroughly moisten the grubs, mealy bugs and cotton leaf. Ten beetles (3 days old) were placed in the petriplate

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and treated as before. Mortalities of second instar grubs and adults were recorded after 24 hr of exposure. After these observations, the grubs and adults were transferred to glass vials containing untreated food and observed for 15 days to evaluate their toxic effects.

Results and Discussion

Toxicity to eggs

Data on percent hatching of the eggs and per cent survival of the hatched out grubs after 24 hr are presented in Table 1. The insecticides tested showed a wide range of toxicity to eggs of *C. sexmaculata* as the mean per cent hatching of treated eggs varied from 0.00 to 76.67 per cent. Significant higher egg hatching (80%) and larval survival (76.67%) was observed in untreated control, while buprofezin appeared to be safe with 76.67 per cent egg hatching, followed by endosulfan (73.33%) and imidacloprid (70%). No egg hatching was observed in case of profenophos, clothianidin and acephate. The survival percentage of the grubs 24 hrs after egg hatching was the highest in case of buprofezin (66.67%) followed by endosulfan (63.33%). Clothianidin, imidacloprid, profenophos, acephate and chlorpyriphos were found to be extremely toxic as no grubs survived 24 hrs after hatching of eggs. Untreated control recorded the highest grub survival (76.67%).

Table 1. Toxicity of insecticides to eggs of *C. sexmaculata*

Treatments	Concentration (% a.i)	Per cent hatching of treated eggs*	Per cent grub survival 24 hrs after hatching
Buprofezin 25 EC	0.13	76.67 (61.19)	66.67 (54.76)
Clothianidin 50 WDG	0.01	0.00 (0.90)	0.00 (0.90)
Imidacloprid 70 WG	0.04	70.00 (56.77)	0.00 (0.90)
Profenophos 50 EC	0.25	0.00 (0.90)	0.00 (0.90)
Acephate 75 WP	0.60	0.00 (0.90)	0.00 (0.90)
Chlorpyriphos 20 EC	0.40	63.33 (52.75)	0.00 (0.90)
Thiodicarb 75 WP	0.19	43.33 (41.14)	23.33 (28.77)
Endosulfan 35 EC	0.35	73.33 (58.98)	63.33 (52.75)
Untreated control	-	80.00 (63.40)	76.67 (61.19)
CD (P=0.05)		(4.14)	(4.18)

* Each figure is a mean of three replications
Observations started 72 hrs after spraying
Figures in parentheses are arc sine percentage transformations

Mali *et al*. (2008) reported 90 per cent egg hatching in the coccinellid beetle, *S. coccivora* treated with imidacloprid followed by chlorpyriphos (73.3%) but no grubs survived in both the treatments 24 hrs after their hatching and these results are in agreement with the present findings. Tank *et al*. (2007) showed that endosulfan (0.035%) caused 10.55 per cent egg mortality of *C. sexmaculata* and was safer compared to other insecticides. The insecticides viz. phosphamidon, dimethi oate and quinalphos belonging to organophosphates group showed egg mortality of 55.26, 42.18 and 44.34 per cent, respectively. Whereas in the present study the insecticides profenophos and acephate belonging to organophosphate group showed 100 per cent mortality of eggs of *C. sexmaculata* which indicating that these two insecticides have acute ovicidal action against coccinellid predators.

Toxicity to second instar grubs

In the present investigations all the insecticides tested were highly toxic, while buprofezin followed by endosulfan were least toxic to the second instar grubs of *C. sexmaculata* (Table 2). After 24 hrs of insecticidal treatment, there was 10 per cent grub mortality in buprofezin that was significantly low as compared to endosulfan (13.33%). In contrast, clothianidin, imidacloprid, chlorpyriphos, profenophos

Table 2. Toxicity of insecticides to 2nd instar grubs of *C. sexmaculata*

Insecticide	Concentration (% a.i)	Cumulative per cent mortality* of 2nd instar grubs of *C. sexmaculata* (days after treatment)						
		1	3	5	7	9	12	15
Buprofezin 25 EC	0.13	10.00	13.34	30.00	43.33	43.33	43.33	43.33
		(18.43)	(18.00)	(33.20)	(41.14)	(41.14)	(41.14)	(41.14)
Clothianidin 50 WDG	0.01	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Imidacloprid 70 WG	0.04	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Profenophos 50 EC	0.25	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Acephate 75 WP	0.60	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Chlorpyriphos 20 EC	0.40	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Thiodicarb 75 WP	0.19	90.00	100.0	100.0	100.0	100.0	100.0	100.0
		(71.54)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Endosulfan 35 EC	0.35	13.33	26.67	53.33	60.00	66.67	66.67	66.67
		(21.14)	(30.98)	(46.90)	(50.74)	(54.76)	(54.76)	(54.76)
Untreated control	-	0.00	3.35	3.35	3.35	3.35	6.67	6.67
		(0.90)	(6.74)	(6.74)	(6.74)	(6.74)	(12.59)	(12.59)
CD (P=0.05)		(2.68)	(8.74)	(1.90)	(6.08)	(6.40)	(6.40)	(6.40)

*Each figure is a mean of three replications

Figures in parentheses are arc sine percentage transformations

Zero value was replaced with 1/4n and hundred value was replaced with 100- 1/4n (n=10)

and acephate resulted in 100 per cent mortality of the grubs, whereas thiodicarb recorded 90 per cent grub mortality at this stage and reached to 100 per cent on third day after treatment. After 15 days of treatment the cumulative grub mortality was significantly lower in buprofezin (43.33%) and endosulfan 960.0 %) while it ranges from 43.33 to 100 per cent in different treatments. The mortality in

Table 3.Toxicity of insecticides to pupae of *C. sexmaculata*

Treatments	Concentration(% a.i)	Adult emergence (%)*	Adult survival after 24 hrs of emergence (%)*
Buprofezin 25 EC	0.13	83.33	76.67
		(66.11)	(61.19)
Clothianidin 50 WDG	0.01	60.00	6.67
		(50.83)	(12.29)
Imidacloprid 70 WG	0.04	63.33	13.33
		(52.84)	(21.14)
Profenophos 50 EC	0.25	53.33	16.67
		(46.90)	(23.85)
Acephate 75 WP	0.60	63.33	20.00
		(52.75)	(26.06)
Chlorpyriphos 20 EC	0.40	66.67	23.33
		(54.76)	(28.77)
Thiodicarb 75 WP	0.19	70.00	46.67
		(56.77)	(43.06)
Endosulfan 35 EC	0.35	76.67	60.00
		(61.19)	(50.79)
Untreated control	-	96.67	96.67
		(83.82)	(83.82)
CD (p=0.05)		(9.41)	(9.93)

* Each figure is a mean of three replications

Figures in parentheses are arc sine percentage transformations

control treatment was probably due to handling or other unknown causes.

Toxicity to pupae of C. sexmaculata

The effect of insecticides against the adult emergence from pupae of *C. sexmaculata* treated with chemicals is presented in Table 3. The percentage of emerged adults from the treated pupae with all the insecticidal treatments varied from 53.33 to 83.33 per cent but the survival percentage of emerged adults was very poor. Among all the insecticidal treatments, the per cent emergence was highest in buprofezin (83.33%) followed by endosulfan (76.67%) and thiodicarb (70%). After 24 hrs of adult emergence, buprofezin was found to be safest with 76.67 per cent adult survival followed by endosulfan (60%) and thiodicarb (46.67%) while rest of the insecticides proved toxic to pupae of *C. sexmaculata*. Satyanaryanan and Murthy (1991) reported that chlorpyriphos (100% survival) was safe to *C. montrouzieri* but the present findings did not support them as chlorpyriphos, acephate and profenophos proved detrimental. The present findings got support from Mali *et al*. (2008) who observed that in imidacloprid (0.045%) though there was 90 per cent emergence of *S. coccivora* adults from treated pupae only 3.30 per cent survived 24 hrs after emergence.

Toxicity to beetles

The insecticides tested showed a wide range of toxicity (56.67 to 100 per cent cumulative mortality) to the adults of *C. sexmaculata* (Table 4). Clothianidin, imidacloprid, profenophos and chlorpyriphos recorded 100 per cent adult mortality within 24 hrs of insecticidal treatment and it was significantly higher than acephate (76.67%) and thiodicarb (73.33%). The per cent mortality in buprofezin and endosulfan was 13.33 per cent, which was significantly lower than any other chemical treatment. Clothianidin, imidacloprid, profenophos, chlorpyriphos and acephate were found to be highly toxic followed by endosulfan that was found to be moderately toxic and buprofezin maintained its superiority as safest insecticide to the adults of *C. sexmaculata*.

Table 4. Toxicity of insecticides to adults of *C. sexmaculata*

Insecticide	Concentration (% a.i)	Cumulative per cent mortality* of 2nd instar grubs of *C. sexmaculata* (days after treatment)						
		1	3	5	7	9	12	15
Buprofezin 25 EC	0.13	13.33	33.33	43.33	50.00	56.67	56.67	56.67
		(21.14)	(35.20)	(41.14)	(44.98)	(48.83)	(48.83)	(48.83)
Clothianidin 50 WDG	0.01	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Imidacloprid 70 WG	0.04	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Profenophos 50 EC	0.25	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Acephate 75 WP	0.60	76.67	100.0	100.0	100.0	100.0	100.0	100.0
		(61.19)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Chlorpyriphos 20 EC	0.40	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Thiodicarb 75 WP	0.19	73.33	100.0	100.0	100.0	100.0	100.0	100.0
		(58.98)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)	(89.15)
Endosulfan 35 EC	0.35	13.33	40.00	56.67	63.33	70.00	76.67	76.67
		(21.14)	(39.21)	(48.82)	(52.75)	(56.77)	(61.20)	(61.20)
Untreated control	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		(0.90)	(0.90)	(0.90)	(0.90)	(0.90)	(0.90)	(0.90)
CD (p=0.05)		(4.90)	(3.34)	(2.69)	(1.99)	(1.90)	(2.90)	(2.90)

*Each figure is a mean of three replications

Figures in parentheses are arc sine percentage transformations

Zero value was replaced with 1/4n and hundred value was replaced with 100- 1/4n (n=10)

Further, the results revealed that *C. sexmaculata* adults were more sensitive to the insecticides than the larvae as significantly higher mortality was observed. The present findings got support from Rathod and Bapodra (2002) who revealed that endosulfan was significantly safe to the coccinellids including *C. sexmaculata* as compared to profenophos and imidacloprid. Babu and Sharma

(2003) found that chlorpyriphos, profenophos and imidacloprid caused 100 per cent mortality in coccinellids within 2 hrs of their exposure. The present findings are in conformity with the results obtained by Cloyd and Dickinson (2006) who revealed that acetamiprid and clothianidin caused 70 and 100 per cent mortality of *C. montrouzieri* adults after 24 and 72 hrs of their exposure where as buprofezin and treatment with other IGR's caused only 20 per cent or less mortality after 48 hrs of their treatments. The present investigations are in agreement with their results except chlorpyriphos, which was observed toxic to both grubs and adults of *C. sexmaculata*. Among the different insecticides tested, buprofezin was found to be the safest insecticide, followed by endosulfan to all the stages (eggs, larvae, pupae and adults) of *C. sexmaculata*. Pupae were found to be resistant to the insecticides as compared to the eggs.

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