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Relative toxicity of newer insecticides against *Spodoptera litura* and *Pieris brassicae* infesting Cole crops in Punjab

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ABSTRACT

Present studies were conducted to estimate the relative toxicity of six new generation insecticides *viz*., emamectin benzoate, indoxacarb, flubendiamide, novaluron, chloratraniliprole and spinosad to *Spodoptera litura* and *Pieris brassicae* on Cole crops. The relative toxicity estimates revealed that chlorantraniliprole, spinosad, flubendiamide, novaluron, emamectin benzoate were 52.0, 52.0, 17.33, 2.74 and 2.60 times toxic to third instar larvae of *S. litura*, while *P. brassicae* was observed to be relatively more sensitive to these insecticides with relative toxicity to emamectin benzoate, indoxacarb, flubendiamide, novaluron, chloratraniliprole being 85.71, 42.86, 6.0, 3.0 and 3.0, respectively. The LT_{50} values of these insecticides varied from 62.36 (indoxacarb) to 78.12 hours (flubendiamide) against *S. litura* and 67.11 (spinosad) to 82.57 hours (flubendiamide) against *P. brassicae*.

Key words: Bioassay, tobacco caterpillar, cabbage caterpillar, *Brassica oleracea*, toxicity.

INTRODUCTION

Cabbage and cauliflower are important winter vegetable crops of northern India. The tobacco caterpillar, *Spodoptera litura* (Fabricius) is an economically important polyphagous pest, distributed worldwide on plant species belonging to 25 genera and 14 families of cultivated crops, weeds, vegetables, fruits and ornamental plants (Ahmed *et al.,* 3). This pest has been reported to have significant migration capability allowing its population outbreaks over a large area (Ahmed *et al.,* 3). It is known to attack wheat, peas, rice and other cruciferous vegetables but cole crops are one of the preferred hosts of *S. litura*. The cabbage butterfly, *Pieris brassicae* Linnaeus is also one of the major pests of cole crops, which is abundant in north India. It is a known destructive cosmopolitan and the most widely distributed lepidopteran pest of crucifers (Ansari *et al.,* 4).

Indiscriminate use of insecticides has led to development of resistance in *S. litura* to all the major groups of conventional insecticides including organochlorines, organophosphates and synthetic pyrethroids (Ahmad and Arif, 2) and the resistance against new chemistry insecticides has also been reported in various parts of the world (Osorio *et al.,* 12 and Saleem *et al.*, 13) but variation in toxicity of these new generation insecticides has been reported under Indian conditions on different crops (Dhawan *et al*., 8 and Cheema *et al*., 5).

Cole crops are attacked by various insects from seedling to fruiting stage and insecticides are indiscriminately used for profitable production, hence increasing the risk of development of resistance in the pest population. It has been reported that on an average 15 sprays of pesticides are given on cauliflower during growing period (Jayanthi and Kombairaju, 10),thus predisposing insects to develop insecticide resistance. Hence, present study was planned to estimate the relative toxicity of six widely used new generation insecticides against these two important lepidopteran pests.

MATERIALS AND METHODS

S. litura larvae were collected from cabbage and cauliflower fields and reared in jars (15x10cm) under laboratory conditions on cabbage leaves at 25±2^{0}C and 65±5 per cent relative humidity for three generations to acclimatize them to laboratory conditions. The jar tops were covered with muslin cloth with the help of rubber bands. Food and blotting paper were changed daily to maintain hygiene. The full grown larvae, nearing pupation, were transferred to other jars which had 6 cm thick layer of moist soil to facilitate pupation. The pupae were surface sterilized with 0.025 per cent sodium hypochlorite solution and transferred to jars with a moistened foam disc (14 mm thick) at the bottom to prevent desiccation. Newly emerged adults of *S. litura* were kept in jars (25x15 cm) for oviposition with provision of 10 per cent sugar solution as food along with leaves for oviposition. On the other hand, newly emerged adults of *P. brassicae* were kept in net cage and provided with cabbage plants for oviposition.

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Six insecticides commonly used by vegetable growers in Punjab i.e. chlorantraniliprole 18.5 SC (Coragen, DuPont Crop Protection), flubendiamide 39.35 SC (Fame, Bayer Crop Science India Ltd.), novaluron 10 EC (Rimon, Indofil Chemicals Company), spinosad 45 EC (Tracer, Dow AgroSciences), emamectin benzoate 5 SG (Proclaim, Syngenta Crop Protection Limited) and indoxacarb 14.5 EC (Avaunt, Dupont Crop Protection) were selected for bioassay.

Third instar larvae were used for bioassay using leaf disc dip method under laboratory conditions at a temperature of 25 ± 2^{0}C and 65 ± 5% relative humidity in plant growth chamber. Five serial dilutions of active ingredient (1.0-0.0001 ppm) of these six insecticides were made with distilled water from a stock solution of 10 ppm. Cabbage leaves were cut into small, 9 cm diameter pieces and dipped into the insecticide solution for 20 sec. These leaf discs were air dried at ambient temperature for 15- 20 min. In case of control, leaf discs were dipped in distilled water and dried in similar way. Leaves treated with insecticides were then transferred to each petri dish lined with filter paper. The experiment had four replicates (10 larvae per replicate) and mortality was recorded after 24, 48 and 72 hrs of exposure of larvae. Larvae were considered dead if they failed to make a coordinated movement when prodded with a brush.

Mortality data obtained were corrected for control mortality using Abbott's formula (1) and subjected to probit analysis through POLO software (Le Ora software 1987 based on Finney, 9) to estimate LC_{50} values and their 95% fiducial limits. LC_{50} values were considered significantly different when their fiducial values did not overlap. LT_{50} values were also calculated through probit analysis. Chi-square values were also checked for goodness of fit of the observed values to the predicted values in the probit regression. Relative toxicity was also computed using following formula:

$$RT = \frac{LC_{50} \text{ value of the least toxic insecticide}}{LC_{50} \text{ value of the candidate insecticide}}$$

RESULTS AND DISCUSSION

Dose-mortality relationship revealed the maximum mortality of *S. litura* at 1 ppm after 72 hrs of treatment with flubendiamide (100%) followed by chlorantraniliprole (96.55%), spinosad (89.66%) and emamectin benzoate (89.66%) while, least mortality of 65.52 per cent was recorded with indoxacarb. After 72 hrs, the mortality ranged from 24.14-96.55, 37.93-89.66, 10.35-100, 6.90-89.66, 6.90-65.52 and 20.69-75.86 % respectively with chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron over different concentrations (Table 1).

The LC_{50} values of chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron were computed to be 0.001, 0.001, 0.03, 0.020, 0.052 and 0.019 ppm against third instar larva of *S. litura* (Table 2).

The median lethal time (LT_{50}) value of chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron were computed to be 75.17, 71.55, 78.12, 93.57, 62.36 and 75.74 hours against third instar larva of *S. litura* (Table 3).

In case of *P. brassicae*, dose-mortality relationship revealed cent per cent mortality with all insectides after 72 hrs of treatment at 1 ppm concentration. At 0.1 ppm, maximum mortality was recorded with emamectin benzoate (96.55%) followed by flubendiamide (93.1%), indoxacarb (93.1%), novaluron (86.21%), chlorantraniliprole (82.76%) and spinosad (82.76%). The mortality ranged from 17.24-100, 10.35-100, 20.69-100, 48.28-100, 44.83-100 and 20.69-100 % with chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron, respectively after 72 hrs of treatment across the concentrations(Table 4).

Table 1. Dose dependent mortality of different insecticides against *S. litura* after 72 hrs.

Concentration of a.i.(ppm)	Mortality (%)											
	Chlorantraniliprole		Spinosad		Flubendiamide		Emamectin benzoate		Indoxacarb		Novaluron	
	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected
1.0	96.67	96.55	90.00	89.66	100.0	100.0	90.00	89.66	66.67	65.52	76.67	75.86
0.1	90.00	89.66	86.67	86.21	90.00	89.66	70.00	68.97	63.33	62.07	66.67	65.52
0.01	80.00	79.31	63.33	62.07	63.33	62.07	36.67	34.49	40.00	37.93	43.33	41.38
0.001	46.67	44.83	53.33	51.73	40.00	37.93	26.67	24.14	26.67	24.14	30.00	27.59
0.0001	26.67	24.14	40.00	37.93	13.33	10.35	10.00	6.90	10.00	6.90	23.33	20.69

Table 2. Toxicity of insecticides to third instar larvae of *S. litura* by leaf disc dip method after 72 hrs.

Treatment	LC_{50} (ppm)	Fiducial limits LC_{50}	Slope	Heterogeneity	Chi square	Regression equation
Chlorantraniliprole	0.001	0.00-0.003	0.666±0.11	0.26	0.76	y = 41.96x + 57.57
Spinosad	0.001	0.00-0.003	0.417±0.088	0.35	1.01	y = 34.27x + 57.90
Flubendiamide	0.003	0.001-0.007	0.860±0.13	0.33	1.00	y = 56.28x + 47.49
Emamectin benzoate	0.020	0.006-0.052	0.675±0.12	0.40	1.20	y = 61.73x + 31.11
Indoxacarb	0.052	0.014-0.254	0.447±0.09	0.53	1.58	y = 61.73x + 31.11
Novaluron	0.019	0.004-0.087	0.410±0.09	0.21	0.61	y = 41.29x + 37.03

Table 3. Duration–mortality response of insecticides to third instars larvae of *S. litura*.

Treatment	LT_{50} (hrs)	Fiducial limits 95%	Slope	Heterogeneity
Chlorantraniliprole	75.17	58.73-143.78	2.949±0.87	0.07
Spinosad	71.55	57.81-114.06	3.392±0.91	0.50
Flubendiamide	78.12	68.49-118.71	7.123±2.33	0.00
Emamectin benzoate	93.57	70.01-273.12	3.181±1.04	0.05
Indoxacarb	62.36	55.03-73.99	6.154±1.50	0.29
Novaluron	75.74	67.24-104.33	7.593±2.35	0.01

Table 4. Dose dependent mortality of different insecticides against *P. brassicae* after 72 hrs.

Concentration of a.i. (ppm)	Mortality (%)											
	Chlorantraniliprole		Spinosad		Flubendiamide		Emamectin benzoate		Indoxacarb		Novaluron	
	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected	Observed	Corrected
1.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.1	83.33	82.76	83.33	82.76	93.33	93.10	96.67	96.55	93.3	93.10	86.7	86.21
0.01	66.7	65.52	56.7	55.17	80.00	79.31	93.33	93.10	86.67	86.21	63.33	62.07
0.001	46.67	44.83	26.67	24.14	43.33	41.38	86.67	86.21	73.33	72.41	40.00	37.93
0.0001	20.00	17.24	13.33	10.35	23.33	20.69	50.00	48.28	46.67	44.83	23.33	20.69

The LC_{50} values of chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron were computed to be 0.002, 0.006, 0.01, 0.00007, 0.00014 and 0.002 ppm against third instar larva of *P. brassicae* (Table 5).

The median lethal time (LT_{50}) value of chlorantraniliprole, spinosad, flubendiamide, emamectin benzoate, indoxacarb and novaluron were computed to be 73.95, 67.11, 82.59, 73.23, 71.39 and 75.00 hours against third instar larva of *P. brassicae* (Table 6).

The relative toxicity ratios of these insecticides against *S. litura* were worked out to be 2.6, 2.74, 17.33, 52.0 and 52.0 for emamectin benzoate, novaluron, fluebndiamide, spinosad and chlorantraniliprole, respectively (Table 5). This shows that chlorantraniliprole and spinosad proved more than 50 times more toxic than indoxacarb to *S. litura* larvae. In contrast, the relative toxicity ratios of these insecticides to were observed to be 3, 3, 6, 42.86 and 85.71, respectively for chlorantraniliprole, novaluron, flubendiamide, indoxacarb and emamectin benzoate (Table 7) indicating that emamectin benzoate proved more than 85 times more toxic than spinosad to *P. brassicae*.

Different reports are available in literature regarding the susceptibility of *S. litura* against insecticides which may be due to the differential extent of exposure of *S. litura* populations to these insecticides. In a recent study, very low resistance against spinosad and emamectin benzoate has been reported and these insecticides have proved effective tools in managing

Table 5. Toxicity of insecticides to third instar larvae of *P. brassicae* by leaf disc dip method after 72 hrs.

Treatment	LC_{50} (ppm)	Fiducial limits LC_{50}	Slope	Heterogeneity	Chi square	Regression equation
Chlorantraniliprole	0.002	0.001-0.005	0.698±0.11	0.62	1.87	y = 52.42x + 50.42
Spinosad	0.006	0.002-0.014	0.879±0.16	0.51	1.53	y = 63.30x + 40.41
Flubendiamide	0.001	0.0005-0.003	0.840±0.13	0.27	0.81	y = 46.93x + 56.46
Emamectin benzoate	0.00007	0.00001-0.00020	0.696±0.15	0.74	2.21	y = 21.52x + 80.04
Indoxacarb	0.00014	0.00003-0.00039	0.596±0.12	0.29	0.87	y = 28.99x + 72.86
Novaluron	0.002	0.001-0.006	0.720±0.12	0.56	1.69	y = 53.82x + 49.41

Table 6. Duration–mortality response of insecticides to third instars larvae of *P. brassicae.*

Treatment	LT_{50} (hrs)	Fiducial limits 95%	Slope	Heterogeneity
Chlorantraniliprole	73.95	64.49-104.51	6.090±1.84	0.06
Spinosad	67.11	55.12-97.91	3.551±0.89	0.31
Flubendiamide	82.59	61.33-234.80	2.555±0.85	0.86
Emamectin benzoate	73.23	57.43-135.95	2.927±0.86	0.33
Indoxacarb	71.39	62.36-96.07	5.898±1.69	0.12
Novaluron	75.00	67.95-94.54	9.462±2.82	0.01

this pest (Saleem *et al.,* 13). In comparison to the baseline susceptibility of *S. litura* to some of these insecticides, it was observed that the susceptibility to indoxacarb and chlorantraniliprole in present study are in conformity with those of Cheema *et al.* (5) who have reported LC_{50} value of indoxacarb and chlorantraniliprole to be 0.0000132 and 0.0000005 per cent, respectively. In present study also, the LC_{50} values of these insecticides were 0.052 ppm (0.052 $\times 10^{-4}$ %) and 0.01 ppm (0.01 $\times 10^{-4}$ %), respectively. In contrast, Sharma and Pathania (14) studied the toxicity of insecticides against *S. litura* and reported the LC_{50} value of 4.23×10^{-6}, 1.04×10^{-2}, 25×10^{-6}, 9.80×10^{-3} and 6.39×10^{-3} per cent for emamectin benzote, flubendiamide, indoxacarb, novaluron and spinosad, respectively.

The LC_{50} and LC_{90} values of flubendiamide 20WG have been reported to be 0.0145 and 0.3765 per cent, respectively, against *S. litura* by leaf dip method (Karuppaiah and Srivastava, 11). Earlier also, the LC_{50} values of this insecticide against different strains of *S. litura* in Punjab were reported to be 0.0060, 0.0050, 0.0050 and 0.0055 per cent for Abohar, Mansa, Muktsar and Sangrur strains, respectively (Dhawan *et al.,* 7) which could be attributed to the differences in the insecticide use pattern.

Table 7. Relative toxicity of different insecticides against *S. litura* and *P. brassicae.*

Treatment	Relative toxicity (RT)	
	S. litura	*P. brassicae*
Chlorantraniliprole	52.00	3.00
Spinosad	52.00	1.00
Flubendiamide	17.33	6.00
Emamectin benzoate	2.60	85.71
Indoxacarb	1.00	42.86
Novaluron	2.74	3.00

Present results corroborate the earlier findings of Dhawan *et al.* (6) who reported LC_{50} of emamectin, indoxacarb, spinosad against *S. litura* to be 0.000004, 0.00001 and 0.0006 per cent respectively indicating a good bioefficacy of indoxacarb and emamectin benzoate. However, in present study indoxacarb proved most toxic followed by emamectin benzoate and novaluron, while, spinosad and chlorantraniliprole proved least effective against *S. litura*. In contrast to present findings, Sharma and Pathiana (14) have found emamectin benzoate to be least toxic followed by indoxacarb, whereas maximum toxicity was reported with endosulfan, followed by flubendiamide and novaluron.

Very little information is available in literature on relative toxicity of new generation insecticides against *P. brassicae*. Su *et al.* (15) found chlorantraniliprole, indoxacarb and spinosad to be the most effective insecticides against *P. rapae* on cabbage and chlorantraniliprole exhibited high level contact toxicity on *P. rapae* larvae. These findings are similar to those of present study, in which these novel insecticides were found to be effective against *P.*

brassicae. Similarly, studies on relative toxicity of novel insecticides viz. spinosad, chlorantraniliprole, novaluron and indoxacarb revealed chlorantraniliprole and spinosad to be more toxic as compared to endosulfan and azadirachtin (Dhawan *et al.* 8) which are in accordance with the present study. Differences in toxicity among both pests could be because *S. litura* is a polyphagous pest and exposed to various insecticides on different crops as compared to *P. brassicae*

It can thus be concluded from present studies that third instar larvae of *S. litura* were highly susceptible to chlorantraniliprole and spinosad, whereas emamectin benzoate was highly toxic to *P. brassicae* larvae. The LT_{50} values of these insecticides varied from 62.36 (indoxacarb) to 78.12 (flubendiamide) against *S. litura* and 67.11 (spinosad) to 82.57 (flubendiamide) against *P. brassicae.* Hence, these new generation insecticides could be integrated in pest management on Cole crops for effective management of *S. litura* and *P. brassicae.*

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