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Efficacy of novel insecticides against cutworms (Lepidoptera: Noctuidae) infesting cabbage

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Abstract
Persistence toxicity of seven new insecticides *viz*; bifenthrin, chlorantraniliprole, cypermethrin, emamectin benzoate, flubendiamide, novaluron and spinosad was evaluated against third instar larvae of *Agrotis ipsilon* (Hufnagel) and *A. segetum* (Denis & Schiffermuller) under laboratory conditions. The result revealed that all the selected insecticides caused mortality of third instar larvae of both the species upto 15th day of spray except emamectin benzoate and cypermethrin where the mortality was recorded upto 10th and 7th day of spray, respectively. Flubendiamide 0.004% showed highest PT value of 1099.975 and 1125 against the third instar larvae of *A. ipsilon* and *A. segetum*, respectively.

Keywords: *Agrotis* spp., flubendiamide, persistence toxicity, cutworm, cabbage

Introduction

Cutworms are notorious agricultural and garden pests. They get their name from the habit of “cutting” off a seedling at ground level by chewing through the stem. The cutworms typically coil up tightly into ‘C’ shape when disturbed. The cutworms usually remain hidden during the day and feed mostly at night. However, some feeding may occur during the day, but the cutworms generally remain concealed below the ground at that time. The larvae usually hide in cracks and crevices in the soil or under the clods or debris around the plants during day time and come out of these places of hiding at night and cut the young plants at ground level and eat only the tender parts by Butani and Jotwani (1984) [5]. Cutworms are a large, diverse group of nocturnal moths. They cause considerable damage to a number of crops, often severing the stems of seedling plants and producing more damage than actual feeding.

The economically important cutworms are lepidopterans belonging to genera *Agrotis*, *Euxoa*, *Discestra* and *Peridroma* of family Noctuidae. The genus *Agrotis* includes number of species of cutworms which cause extensive damage to vegetable and cereal crops in India and most of these species look very similar especially as larvae. Cutworms are highly polyphagous and attack a large number of crops worldwide including India (Ram *et al*., 2001; Mrowczynski *et al*., 2003 and Napiorkowska and Gawowska 2004) [13, 7, 8]. The larvae feed on variety of hosts viz., potato, barley, oats, mustard, linseed, cabbage, peas, gram, tobacco etc. However, they prefer gram over pea, potato and cabbage (Ram and Mishra, 2002) [12]. The common cutworm, *Agrotis segetum* (Denis & Schiffermuller), is distributed throughout the temperate regions of Europe, Africa and Asia whereas, greasy or black cutworm, *Agrotis ipsilon* (Hufnagel) is commonly found in Asia and North America.

Common cutworm, *Agrotis segetum* and greasy or black cutworm, *A. ipsilon* are two predominant cutworm species causing extensive damage in vegetables, ornamentals and field crops in Himachal Pradesh. In vegetables, the summer crops, viz. tomato, brinjal, capsicum, okra, cucurbits and off-season crops *viz.* cabbage, cauliflower and peas are extensively damaged. The infestation of these two species ranges from 1.5 to 23.8 percent in different vegetables/ field crops (Pathania, 2010) [9]. The *A. ipsilon* is prevalent in low and mid-hills, whereas *A. segetum* is more abundant in higher elevations.

Various methods such as deep ploughing, flooding and manual collection of larvae are adopted for the control of cutworms. The microbial insecticides have also been tried under field conditions in Himachal Pradesh for the control of *A. segetum* and *A. ipsilon* in cabbage, but were not found promising for the management of this pest (Anonymous, 2004) [1]. Thus, only the viable alternative to manage this pest appears to be the chemical control.

The indiscriminate use of conventional pesticides to manage these pests has led to the development of resistance. Therefore, safer, effective and less costly alternate to chemical control are desirable as a part of an IPM. Recently, several pesticides with novel mode of action have been introduced to overcome this situation. Some of the most exciting breakthroughs in agricultural chemicals have come in the last few years with the development of several new classes of chemistry for the control of lepidopteron pests. These insecticides are very effective, relatively selective for larvae, and safe to use and apply. This has been achieved through the development of noble modes of action and type of activity of the compounds tested; most of them are new chemistry with independent modes of action (neurotoxin, metabolic and insect growth regulators). Others must be ingested to be toxic to larvae. Novaluron is a new pesticide molecule belonging to the group of insecticides termed Insect Growth Regulators (IGR) falling in to the class of diflubenzoylureas. Although the compound mainly acts by ingestion, but it still poses some contact activity. IGR are comparatively safer to beneficial insects and environment and are compatible for use in an integrated pest management system (Ayalew, 2011) [3]. The extensive and indiscriminate use of pesticide led to the development of resistance to most of the frequently used chemicals causing control failures of cutworm in India. Consequently the use of eco-friendly materials such as new chemistry insecticides emerged as a better alternatives to the conventional insecticides. Hence, the present study was initiated using cabbage as test crop.

Material and Method

Rearing of cutworms

The initial culture of *A. ipsilon* and *A. segetum* was initiated by collecting the adults on the light source during their emergence. The collected male and female moths were differentiated on the basis of antennae and transferred to glass chimneys (20 x 13 cm). In each chimney, one pair of moth was released. A crumpled paper was placed in each chimney for providing resting sites for the moths and the top of the chimney was covered with muslin cloth, which was tied with a rubber band. A piece of cotton soaked in honey solution (10%) was also kept in each chimney as food supplement to the moths in a small Petri plate. The females mostly oviposit on the muslin cloth and the crumpled paper. The eggs laid by the moths were collected daily by removing the paper and muslin cloth and later replacing with new ones. The eggs laid occasionally on the walls of the chimney were moistened before separating them with the help of camel hair brush. The papers and muslin cloth bearing egg masses were then transferred into plastic jars. The jars were examined daily for egg hatching, if any. The newly hatched larvae were then reared on cabbage leaves under controlled conditions at 25 $\pm$ 1^0C temperature and 75 $\pm$ 1 percent relative humidity under 16:8 (L:D) photoperiod. The third instar larvae (~10.08 mg) of *A. ipsilon* and *A. segetum* were used for experimentation.

Persistence toxicity of insecticides

Cabbage plants raised in pots as per requirement were sprayed with recommended dose of the insecticides in the Screen House of Department of Entomology, CSKHPKV, Palampur. For this purpose, the cabbage seedlings were transplanted in the pots (dia. 16.8 and depth 13 cm). The pots with cabbage plants (two each) were kept inside the screen house for their growth and development. In order to study the persistence toxicity of insecticides, the cabbage plants were sprayed at recommended doses. Each insecticide was sprayed on two potted plants with 3 replications with the help of hand compression sprayer.

Persistence toxicity of insecticides was evaluated against 3rd instar larvae of both *A. ipsilon* and *A. segetum*. Treated cabbage leaves were provided to 3rd instar larvae of both the species at different intervals (0, 1, 3, 7, 10 and 15 days of spray). A control experiment (with untreated leaves of cabbage) was also run simultaneously with equal number of replications. The larval mortality was recorded after 24 h of treatment and in case of novaluron after 72 h of release of test insects at different days. Moribund larvae unable to move or having uncoordinated movements were considered as dead.

Statistical analysis of data

The persistence toxicity of insecticides were analysed through CRD by CPCS software. In order to normalize or stabilize variances, the data were subjected to arcsine-square transformation. The relative efficacy of these insecticides will be worked out as per the formula given by Pradhan (1967) [10].

$$\text{Relative persistence toxicity} = P \times T$$

Where, P = Period for which toxicity persisted
T = Average residual toxicity

Result and Discussion

In case of *A. ipsilon*, the data (Table 1) revealed that all the insecticides gave 100.00 percent mortality of third instar larvae on the day of application except emamectin benzoate (93.33%) and spinosad (96.66%). After one day of spray, chlorantraniliprole @ 0.002 percent showed highest mortality (96.70%), followed by flubendiamide @ 0.004 percent (93.33%), bifenthrin @ 0.01 percent (90.00%), novaluron @ 0.01 percent (86.66%), emamectin benzoate @ 0.002 percent (83.33%) and cypermethrin @ 0.01 percent = spinosad @ 0.01 percent (80.00%) over the untreated check.

At 3 DAS, chlorantraniliprole and flubendiamide gave highest mortality of 80.00 percent, followed by novaluron (76.70%), bifenthrin (70.00%), emamectin benzoate (66.70%) and cypermethrin (63.33%), and spinosad showed least efficacy (53.33%). At 7 DAS flubendiamide (70.00%) again resulted in maximum mortality, followed by chlorantraniliprole (60.00%), novaluron (56.70%), bifenthrin (53.33%), spinosad (40.00%), emamectin benzoate (36.70%) and cypermethrin (20.00%) over the untreated check.

At 10 DAS, flubendiamide showed maximum mortality of 60.0 percent, followed by chlorantraniliprole (46.70%), novaluron (43.33%), bifenthrin (40.00%), spinosad (26.7%) and emamectin benzoate (10.00%). No mortality was observed in cypermethrin treated leaves on 10th day. At 15 DAS, flubendiamide maintained its superiority with 36.66 percent mortality, followed by chlorantraniliprole (23.33%), novaluron (20.00%), spinosad (16.66%) and bifenthrin (13.33%). No mortality was observed in cypermethrin and emamectin benzoate treatments.

On the basis of index of persistent toxicity (PT), the order of effectiveness of insecticides tested under the present investigation was flubendiamide (1099.975) > chlorantraniliprole (1016.625) > novaluron (958.275) > bifenthrin (916.65) > spinosad (783.275) > emamectin benzoate (483.3) > cypermethrin (307.218).

In case of *A. segetum*, all the insecticides gave 100.00 percent mortality on the day of spray except cypermethrin (96.70%) and emamectin benzoate (93.30%). At 1 DAS, flubendiamide gave highest mortality (100.0%), followed by chlorantraniliprole (96.7%), bifenthrin (90.00%), novaluron (86.7%), emamectin benzoate (80.0%) and spinosad = cypermethrin (70.0%).

At 3 DAS, flubendiamide and chlorantraniliprole gave the equal mortality of 80.00 percent, followed by bifenthrin (73.33%), novaluron (70.00%), emamectin benzoate (63.30%), spinosad and cypermethrin each with 50.0 percent mortality. At 7 DAS, flubendiamide (70.0%) gave the highest mortality, followed by 60.0, 56.66, 53.33 percent mortality in case of chlorantraniliprole, bifenthrin and novaluron, respectively. This was followed by emamectin benzoate (40.0%), spinosad (30.0%) and cypermethrin (13.33%).

At 10 DAS, 60.00, 50.00, 40.00, 30.00 and 20.00 percent mortality was observed in flubendiamide, chlorantraniliprole, novaluron, bifenthrin and spinosad, respectively. Emamectin benzoate gave 16.66 percent mortality. No mortality was observed in cypermethrin. At 15 DAS, flubendiamide gave highest mortality of 40.00 percent followed by chlorantraniliprole (26.70%), novaluron (20.0%) and spinosad (13.33%). The mortality in bifenthrin was only 10.0 percent. No mortality was observed in cypermethrin and emamectin benzoate.

Table 1: Residual toxicity of insecticides on cabbage leaves against third instar larvae of *A. ipsilon* and *A. segetum*

Insecticides (Conc. %)	*Agrotis* species	Mean corrected percent mortality (days)*						Relative efficacy	
		0	1	3	7	10	15	PT	X
Bifenthrin (0.01)	*A. ipsilon*	100.00(89.96)	90.00 (71.53)	70.00(56.97)	53.33(46.89)	40.00 (39.13)	13.33(21.13)	916.65	2.983
	A. segtum	100.00(89.96)	90.00 (71.53)	73.33(58.98)	56.66 (48.82	30.00 (32.98)	10.00(14.99)	899.975	3.354
Chlorantraniliprole (0.002)	*A. ipsilon*	100.00(89.96)	96.66 (83.82)	80.00(63.90)	60.00(50.83)	46.66 (43.06)	23.33(28.76)	1016.625	3.309
	A. segetum	100.00(89.96)	96.66 (83.82)	80.00(63.90)	60.00(50.83)	50 (44.98)	26.70(30.98)	1033.30	3.85
Cypermethrin (0.01)	*A. ipsilon*	100.00(89.96)	80.00 (63.90)	63.33(52.75)	20.00(26.55)	00.00 (00.00)	00.00(00.00)	307.2183	1.000
	A. segetum	96.66 (83.82)	70.00 (56.97)	50.00(44.98)	13.33(21.13)	00.00 (00.00)	00.00(00.00)	268.3217	1.000
Emamectin benzoate (0.002)	*A. ipsilon*	93.33 (77.68)	83.33 (66.11)	66.66(55.05)	36.66(37.24)	10.00 (14.99)	00.00(00.00)	483.3	1.573
	A. segetum	93.33 (77.68)	80.00 (63.90)	63.33(52.75)	40.00(39.13)	16.66 (23.84)	00.00(00.00)	488.8667	1.821
Flubendiamide (0.004)	*A. ipsilon*	100.00(89.96)	93.33 (77.67)	80.00(63.90)	70.00(56.97)	60.00 (50.83)	36.66(37.12)	1099.975	3.580
	A. segetum	100.00(89.96)	100.00(89.96)	80.00(63.90)	70.00(56.97)	60.00 (50.83)	40.00(39.13)	1125	4.192
Novaluron (0.01)	*A. ipsilon*	100.00(89.96)	86.66 (68.82)	76.66(61.19)	56.66(48.81)	43.33 (41.14)	20.00(26.55)	958.275	3.199
	A segetum	100.00(89.96)	86.66 (68.82)	70.00(56.97)	53.33(46.89)	40.00 (39.13)	20.00(26.55)	924.975	3.447
Spinosad (0.01)	*A. ipsilon*	96.66 (83.62)	80.00 (63.90)	53.33(46.90)	40.00(39.21)	26.70 (30.98)	16.66(23.84)	783.275	2.549
	A. segetum	100.00(89.96)	70.00 (56.97)	50.00(44.98)	30.00(32.98)	20.00 (26.55)	13.33(21.13)	708.325	2.639
CD (P=0.05)	*A. ipsilon*	NS	(12.90)	(10.97)	(10.08)	(11.30)	(6.78)	-	-
	A. segetum	NS	(14.12)	(11.69)	(9.22)	(11.63)	(13.42)	-	-

* Average of three replications

Figures in parentheses are the arc sine transformed value

On the basis of index of persistent toxicity (PT), the order of effectiveness of insecticides tested under the present investigation was flubendiamide (1125) > chlorantraniliprole (1033.30) > novaluron (924.975) > bifenthrin (899.975) > spinosad (708.325) > emamectin benzoate (488.867) > cypermethrin (268.322).

The persistence toxicity (PT) values of insecticides varied widely between 307.218 to 1099.975 for *A. ipsilon* and 268.322 to 1125.000 for *A. segetum* (Table 1). The value was maximum in case of flubendiamide (1099.975 and 1125.000) and lowest being (307.218 and 268.322) for cypermethrin. On the basis of average PT values of both the species, the descending order of toxicity of insecticides against third instar larvae of *A. ipsilon* and *A. segetum* was flubendiamide > chlorantraniliprole > novaluron > bifenthrin > spinosad > emamectin benzoate > cypermethrin at recommended concentrations.

Singh and Singh (1994) [14] tested the persistence toxicity of seven insecticides against larvae of the noctuid on soyabean in field-cum-laboratory trials and result indicated that amongst insecticides cypermethrin was not persistent upto 15 DAS, which corroborate the results of present study. Liu *et al*., (2003) [6] found that spinosad was more persistent than emamectin benzoate against five day old larvae of *Plutella xylostella*, which substantiate our results. Bandral (2005) [4] found that amongst insecticides, cypermethrin dissipated almost its persistency on 7 day after spray which is similar to the results of present study. Prasad *et al*., (2009) [11] found that spinosad caused the larval mortality (6.67 to 13.33) of *H. armigera* upto 12 days after spray while in the present study spinosad cause 13.33 percent mortality of *A. segetum* larvae up to 15 days after spray. In the present study, 50 percent of larval mortality was observed at 5 days after spray of emamectin benzoate which is almost similar to the results of Wankhede and Kale (2010) [16] and Abdu-allah (2010) [2]. The present study results i.e. chlorantraniliprole was more persistent than bifenthrin and spinosad against third instar larvae of *A. ipsilon* and *A. segetum*, are similar to the findings of Tofangsazi *et al*., (2015) [15].

Conclusion

From the above results, the persistence toxicity studies revealed that flubendiamide was the most effective with highest PT values followed by chlorantraniliprole and novaluron against both the *A. ipsilon* and *A. segetum* third instar larvae.

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