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Short Research Article

Evaluation of New Insecticides Against Diamond Back Moth, *Plutella xylostella* (L.) on Red Cabbage

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Abstract

In order to study the effectiveness of rynaxypyr 18.5 SC, flubendiamide 20 WG, spinetoram 12 SC, dinotefuran 20 SG, indoxacarb 14.5 SC, novaluron 10 EC and mixed formulation of indoxacarb 4.5% and novaluron 5.25% against *Plutella xylostella*, a field trial was conducted during *rabi* season in 2010-11 at Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. Rynaxypyr 18.5 SC @ 30 g a.i. ha^{-1} was found to be the most effective in reducing larval population followed by flubendiamide 20 WG @ 40 g a.i. ha^{-1} and spinetoram 12 SC @ 50 g a.i. ha^{-1}. To determine LC_{50} values and relative toxicity of these insecticides against the target insect, leaf dip bioassay method was followed. Based on LC_{50} values, rynaxypyr was the most toxic insecticide followed by flubendiamide, spinetoram, indoxacarb and dinotefuran. Rynaxypyr showed highest acute toxicity with the lowest LC_{50} value (6.32 ppm), whereas novaluron showed lowest acute toxicity with the highest LC_{50} value (208.6 ppm).

1. Introduction

India being blessed with the unique gift of nature of diverse soil and climatic condition, a large number of vegetables is grown throughout the year. The red cabbage, *Brassica oleracea* L. var. *capitata* f. *rubra* is an important one among those. A wide number of insect pests have been reported to infest cabbage of which the diamondback moth (DBM), *Plutella xylostella* (L.) is the most serious one. DBM is the most destructive insect pest of crucifers throughout the world and the annual cost for managing it is estimated to be US $ 1 billion (Talekar and Shelton, 1993). It is believed to be the most universally distributed of all lepidoptera (Meyrick, 1928).

Over the years, this pest has developed resistance to almost all the recommended insecticides belonging to major groups in many parts of the world (Yu and Nguyen, 1992; Talekar and Shelton, 1993) and becoming increasingly difficult to control. In India, resistance to different insecticides has been reported from several states like Punjab, Haryana, Tamilnadu, Karnataka and Andhra Pradesh (Mehrotra and Phokela, 2000). The problem is acute in areas where vegetables are grown extensively throughout the year (Joia et al., 2005). Consequently the farmers intensively spray the crops with insecticides either singly or in combinations throughout the growing season of the crop (Joia et al., 2000). This practice generally leads to worsening the problem of insecticides resistance through increased selection pressure on the pest. Moreover, it also leaves excessive residues on vegetables and increases insecticide load in the environment that may prove hazardous in the long run. Keeping all these facts in mind, the present experiments were undertaken to evaluate of some new molecules having novel mode of action against *P. xylostella* on red cabbage under both field and laboratory conditions.

2. Materials and Methods

The field experiment was conducted during *rabi* season of 2010-2011 at the Instructional farm of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. The crop (red cabbage, cultivar: Primero) was raised with appropriate agronomic practices in Randomised Block Design (RBD) with three replications for each treatment. Altogether eight treatments comprising of seven insecticides and an untreated check were evaluated. The net area of each plot size was 3×3 m^2.

The seedlings were transplanted at a spacing of 60×60 cm^2 in each plot after final land preparation. After establishment of seedlings, the experiment was left for natural infestation of DBM. When infestation of *P. xylostella* reached Economic Threshold Level (ETL:5 larvae $plant^{-1}$ at heading stage), insecticides *viz.* chlorantraniliprole 18.5 SC (30 g a.i. ha^{-1}) , flubendiamide 20 WG (40 g a.i. ha^{-1}), spinetoram 12 SC (50 g a.i. ha^{-1}), dinotefuran 20 SG (40 g a.i. ha^{-1}), indoxacarb 14.5 SC (60 g a.i. ha^{-1}), novaluron 10 EC (75 g a.i. ha^{-1}) and mixed formulation of indoxacarb 4.5% and novaluron 5.25% (80 g a.i. ha^{-1}) were sprayed with pneumatic knapsack sprayer with 500 liters ha^{-1} of spray volume. Each insecticide was sprayed twice at fifteen days interval. Pest population was recorded before each spray and then two consecutive observations were taken at the interval of 5 and 10 days after each spray. Population of diamond back moth was recorded from randomly selected five pre-tagged plants $plot^{-1}$. Percent reduction or increase of diamond back moth was estimated using the following formula-

% reduction or increase (+) of population

$$= \frac{\text{population in pretreatment-population in treatment}}{\text{population in treatment}} \times 100$$

The critical difference (CD) at 5% level of significance was worked out from the data of mean pest population $plant^{-1}$ before treatment and various days interval after each treatment of two consecutive sprays.

To evaluate the relative toxicity of these insecticides, the experiment was conducted in the laboratory of Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. The test insect was collected from red cabbage field and reared on the red cabbage leaves under controlled condition (Temperature=25±2 °C and RH=70±5%). Rearing was done in cages (40×40×60 cm^3) where seedlings of mustard were provided for egg laying. After hatching, the larvae were transferred to fresh cabbage leaves. Cabbage leaves were kept in conical flask containing water for preventing desiccation of leaves. The larvae were provided with fresh cabbage leaves every day. After becoming full grown, the pupation takes place in loose silken cocoon spun by the caterpillars mainly on undersurface of leaves. The adults emerging from the pupae were collected and released in mating chamber. A cotton swab soaked with sugar: water (1:9) was hung as the food for the adults. After getting huge population, only third instar larvae of same age, weight and generation were selected for bioassay test.

Among different methods of bioassay studies, the leaf dip bioassay method was followed as suggested by Vastard et al. (2004) and Insecticide Resistance Action Committee (Anonymous, 1990) with slight modification. Five concentrations for each insecticide were tested with four replications. Leaf discs of approximately 4 cm diameter were cut from the cabbage and were dipped in the insecticide solutions for 20 seconds with gentle agitation and then air dried. The treated leaves were kept in plastic container (diameter-6 cm and height-9 cm), then single larva was released in each container. Twenty randomly selected third instar larvae were used for each replication. Larvae were kept for six hours without food before releasing on treated leaves. For untreated control the leaf discs were dipped in distilled water and the same methodology was followed. Mortality was recorded 24, 48 and 72 hours after treatment. The moribund larvae were considered as dead. The corrected mortality of larvae was calculated using the Abbott's formula (Abbott, 1925).

$$\text{\% Corrected Mortality} = \frac{\text{\% Kill in treated-\% kill in control}}{\text{100-\% kill in control}} \times 100$$

The data were subjected to Probit analysis followed by the method modified by Finney (1971) for the mathematical estimation of median lethal concentration (LC_{50}) and Probit regression line (Finney, 1964; Finney, 1971). The order of relative toxicity of different insecticides was then determined by comparison of the LC_{50} values by taking the insecticide possessing the highest LC_{50} value as unit.

The percent reduction or increase (+) of predatory population viz., *Menochilus* sp. and *Coccinella* sp. was worked out based on their number on five heads from five randomly selected plants. Observations on the incidence of natural enemies were taken on 10th day after application. The data collected thus were subjected to analysis of variance after necessary transformation wherever required.

3. Results and Discussion

3.1. Field experiment

The pretreatment count of DBM larval population was varied from 5.33 to 6.67 and 1.33 to 11.33 larvae $plant^{-1}$ before the first and second sprays respectively (Table 1). The maximum reduction of larval population (five days after first spray) was found in rynaxypyr @ 30 g a.i. ha^{-1} (95.4%) treated plots followed by flubendiamide @ 40 g a.i. ha^{-1} (93.2%), mixed formulation of indoxacarb and novaluron @ 80 g a.i. ha^{-1} (92.8%), spinetoram @ 50 g a.i. ha^{-1} (89.4%), dinotefuran @ 40 g a.i. ha^{-1} (86.4%), novaluron @ 75 g a.i. ha^{-1} (83.6%) and indoxacarb @ 60 g a.i. ha^{-1} (81.6%). However, even 10 days after first application, the maximum larval reduction (92.3%) was recorded in the plots treated with rynaxypyr which was at par with novaluron (90.7%), spinetoram (90.6%), mixed formulation of indoxacarb and novaluron (90.5%) and flubendiamide (89.7%).

After first spray, highest mean percent reduction of DBM population was in rynaxypyr (93.85%) treated plots followed by mixed formulation of indoxacarb and novaluron (91.65%) which was at par with the flubendiamide (91.45%). Indoxacarb showed the lowest reduction of DBM population (82.55%)

whereas in control plots the DBM population increased by 29.30% after first spray.

On the 5th day after second spray, 100% reduction of DBM population was recorded both in rynaxypyr and flubendiamide treated plots which were at par with Spinetoram (96.3%). Similar trend of population reduction was found in all treatments after ten days of application.

The overall percent reduction of DBM population after two sprays was noted highest in rynaxypyr treated plots (96.25%) followed by flubendiamide (94.82%), spinetoram (92.77%) and mixed formulation of indoxacarb and novaluron (92.32%). Whereas, dinotefuran (88.05%), indoxacarb (85.65%) and novaluron (87.80%) were not as effective as other treatments but were highly significant over untreated control.

The high efficiency of rynaxypyr was also reported by Lewandowski et al. (2009) where rynaxypyr was the most effective against *Pieris rapae* and *P. xylostella* (L.). Similarly, Chowdary et al. (2010 a, b) found that rynaxypyr 20 SC @ 30 g a.i. ha^{-1} was excellent in recording less larval population of *Helicoverpa armigera* (Hubner) and *Earias vitella* (Fab), that lowered fruit damage with higher fruit yield in okra. The efficacy of flubendiamide was found to be the second best in this experiment. Similar observations were also found by Hirooka et al. (2007). They revealed that flubendiamide provided excellent control of important lepidopterous insects such as, *P. xylostella, S. litura* and *H. armigera.* The high field efficacy of flubendiamide was also reported by Meena et al. (2006). They observed that flubendiamide worked well against *H. armigera* of pigeon pea. Lakshmi Narayana and Rajashri (2006) found that flubendiamide @ 50 g a.i. ha^{-1} were effective against the bollworm of cotton compared to standard checks of spinosad and indoxacarb and also recorded higher yields of cotton. Field efficacy of spinetoram against other lepidopteran pests such as spotted bollworm on cotton has already been proved by Wale et al. (2011) who reported that spinetoram 12% SC @ 56 g a.i. ha^{-1} was found most effective for the control of spotted bollworms on cotton with higher

Table 1: Effect of different insecticides on the field population of DBM, *P. xylostella* (L.) larvae on red cabbage

Treatments	Dose g a.i. ha^{-1}	Pre treatment count before 1st spray (no. of DBM plant^{-1})	First spray % reduction/ increase (+) of DBM. population		Mean% reduction/ increase (+) after 1st spray	Pretreatment count before 2nd spray (no. of DBM plant^{-1})	Second spray % reduction/ increase (+) of DBM population		Mean% reduction/ increase (+) after 2nd spray	Overall mean (%) reduction/increase (+)	Marketable yield (t ha^{-1})	% increase in yield over control
			5 DAS*	10 DAS*			5 DAS*	10 DAS*				
Rynaxypyr 18.5% SC	30	6.67	95.4 (77.62)	92.3 (73.89)	93.85	1.33	100 (90.00)	97.3 (80.54)	98.65	96.25	23.5	52.59
Flubendiamide 20% WG	40	6.00	93.2 (74.88)	89.7 (71.28)	91.45	1.67	100 (90.00)	96.4 (79.06)	98.20	94.82	23.0	49.35
Spinetoram 12% SC	50	5.67	89.4 (71.00)	90.6 (72.15)	90.00	2.00	96.3 (78.91)	94.8 (76.82)	95.55	92.77	22.3	44.80
Dinotefuran 20% SG	40	6.33	86.4 (68.36)	81.4 (64.45)	83.90	3.33	89.7 (71.28)	86.4 (68.36)	88.05	85.97	21.4	38.96
Indoxacarb 14.5 SC	60	6.67	81.6 (64.60)	83.5 (66.03)	82.55	2.00	86.8 (68.70)	84.5 (66.82)	85.65	84.10	20.4	32.47
Novaluron 10 EC	75	5.33	83.6 (66.11)	90.7 (72.24)	87.15	3.00	85.4 (67.54)	90.2 (71.76)	87.80	87.47	21.1	37.01
Indoxacarb (4.5% SC)+ Novaluron (5.25% SC)	80	6.00	92.8 (74.44)	90.5 (72.05)	91.65	1.67	93.4 (75.11)	92.6 (74.21)	93.00	92.32	22.2	44.16
Untreated control	-	5.67	(+) 23.3 (0.00)	(+) 35.3 (0.00)	(+) 29.30	11.33	(+) 24.8 (0.00)	(+) 31.4 (0.00)	(+) 28.10	(+) 28.70	15.4	-
SEm±	-	-	2.32	3.16	-	-	3.46	2.86	-	-	2.68	-
CD (*p*=0.05)	-	-	3.94	5.37	-	-	5.84	4.83	-	-	4.52	-

DAS: Days after spray; *: Significant at 5% level; Figures in the parentheses are angular transformed values yield of seed cotton.

The maximum reduction of *Menochilus* sp. population was observed in Indoxacarb 14.5 SC (5.73%) treated plots followed by Rynaxypyr 18.5 SC and similar trend was also noticed in case of *Coccinella sp.*

3.2. Laboratory experiment

In laboratory evaluation for bioassay studies, there was a proportionate increase in the mortality of larvae (3rd instar) of *Plutella xylostella* (L.) with the increased concentration of different insecticides just after 24 hrs. and onwards (Table 2 and 3). However, in all the cases the trend of increasing the% mortality varied with insecticides. The acute toxicity of rynaxypyr was relatively higher than that of other insecticides against the larvae of *Plutella xylostella* (L.) during the course of investigation. The relative toxicity values were 33.00, 30.01, 28.69, 15.50, 10.73 and 9.18 for rynaxypyr, flubendiamide, spinetoram, indoxacarb, dinotefuran and mixed formulation of indoxacarb and novaluron respectively taking novaluron as unit due to its highest LC_{50} value (208.6 ppm). Indoxacarb 14.5 SC had highest effect on natural enemies namely, *Menochilus sp*. and *Coccinella sp*. i.e. 5.73% and 6.06%, respectively followed by Rynaxypyr 18.5 SC (4.97% and 4.73%). Novaluron 10 EC was found most safe (2.42% and 2.29%) (Table 4).

Table 2: Dosage mortality response and LC_{50} values of different insecticides for the laboratory rearing larvae (3rd instar) of *P. xylostella* (L.) (Leaf dip bioassay and 24 hrs exposure)

Insecticides	Df	Heterogeneity χ^2 (4)	Regression equations	LC_{50} (ppm)	Fiducial limits		Relative toxicity	Order of relative toxicity
					Lower	Upper		
Rynaxypyr 18.5% SC	4	2.74	Y=3.23x+1.44	6.32	2.44	10.86	33.00	1
Flubendiamide 20% WG	4	3.87	Y=4.28x+0.95	6.95	3.15	11.28	30.01	2
Spinetoram 12% SC	4	2.18	Y=5.30x+1.96	7.27	2.18	12.82	28.69	3
Dinotefuran 20% SG	4	4.42	Y=4.62x+2.49	19.43	11.64	23.70	10.73	5
Indoxacarb 14.5 SC	4	1.87	Y=2.42x+0.87	13.45	8.57	19.44	15.50	4
Novaluron 10 EC	4	2.74	Y=5.34x-1.23	208.6	139.00	558.00	1.00	7
Indoxacarb (4.5% SC)+Novaluron (5.25% SC)	4	3.46	Y=5.12x+0.85	22.72	9.75	26.54	9.18	6

Y: Probit kill; x: Log concentration; LC_{50}: Median lethal concentration

Table 3: LC_{50} values of insecticides (a.i.) against third instar larvae of diamondback moth, *P. xylostella* (L.) at different exposure hours

Insecticides	LC_{50} values (ppm) at different exposure hours		
	24 hours	48 hours	72 hours
Rynaxypyr 18.5% SC	6.32	0.94	0.22
Flubendiamide 20% WG	6.95	1.87	0.64
Spinetoram 12% SC	7.27	3.66	1.21
Dinotefuran 20% SG	19.43	4.27	2.94
Indoxacarb 14.5 SC	13.45	3.94	2.14
Novaluron 10 EC	208.6	46.5	17.5
Indoxacarb(4.5% SC)+Novaluron (5.25% SC)	22.72	10.74	3.18

Table 4: Effect of insecticides on two important natural enemies on red cabbage

Treatments	Dose g a.i. ha^{-1}	% reduction/increase (+) of natural enemies on 10th day after application.	
		Menochilus sp.	*Coccinella* sp.
Rynaxypyr 18.5 SC	30	4.97(12.88)	4.73(12.55)
Flubendiamide 20% WG	40	3.81(11.25)	3.47(10.73)
Spinetoram 12% SC	50	3.90(11.39)	4.17(11.78)
Dintoefuran 20% SG	40	3.53(10.80)	3.19(10.29)
Indoxacarb 14.5 SC	60	5.73(13.84)	6.06(14.25)
Novaluron 10 EC	75	2.42(8.95)	2.29(8.71)

Continue...

Treatments	Dose g a.i. ha^{-1}	% reduction/increase (+) of natural enemies on 10^{th} day after application.	
		Menochilus sp.	*Coccinella* sp.
Indoxacarb(4.5% SC)+Novaluron (5.25% SC)	80	2.90 (9.80)	2.81(9.61)
Untreated control	-	(+)70.58 (0.00)	(+)52.54 (0.00)
CD (p=0.05)	-	1.05	1.07

N.B. Figures in the parentheses are angular transformed values

4. Conclusion

Rynaxypyr 18.5 SC @ 30 g a.i. ha^{-1} provides satisfactory control of diamond back moth in red cabbage with maximum yield and less adverse effect on Menochilus sp and Coccinella sp. Flubendiamide 20 WG @ 40 g a.i. ha^{-1} stands second in order of efficacy in controlling diamond back moth. In laboratory experiment, rynaxypyr showed highest acute toxicity with the lowest LC50 value, whereas novaluron showed lowest acute toxicity with the highest LC50 value. The present findings show that rynaxypyr 18.5 SC @ 30 g a.i. ha^{-1} may be considered in the integrated pest management schedule of diamond back moth in red cabbage.

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