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Bioefficacy of different insecticides against diamondback moth

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Abstract
In the present investigations spinosad was found to be most effective reduced up to 94.33 percent population followed by indoxacarb (91.00%) and Flubendiamide (78.66%). The insecticides, *viz*., fipronil, emamection benzoate and chlorantraniliprole were found moderately effective as they resulted in 70.66, 70.33 and 68.66 percent reduction, respectively and chlorfenapyr, pyridalyl and acephate were proved least effective reduced up to 55.33, 56.66 and 56.00 percent, respectively.

Keywords: Diamondback moth, *Plutella xylostella*, coccinellid, cabbage

Introduction
The yield of cabbage is adversely affected by many bottlenecks including insect pest, diseases, environmental stresses, nutritional imbalance etc. Among them, insect pests**,** *viz.*, tobacco caterpillar, *Spodoptera litura* (Fab.); diamondback moth, *Plutella xylostella* (L.) cabbage borer, *Hellula undalis* Fab.; cabbage looper, *Tricoplusia ni* Hub and aphid, *Lipaphis erysimi* (Kalt.) [11, 15, 17]. Out of these, aphid and diamondback moth are major pest***s*** causing significant loss in North India. The diamondback moth, *P. xylostella* was first reported on cruciferous vegetables in 1914 [6]. It is sometimes called cabbage moth, is a European moth believed to be originated in the Mediterranean region that has since spread worldwide. The moth has a short life cycle (14 days at 25 ^{0}C) is highly fecund, capable of migrating long distance, most important pest of cruciferous crops in the world that produces glucosinolates [20]. The moth has a wing span of about 15 mm and body length of 6 mm. The forewings are narrow brownish grey with fine dark speckles. A creamy coloured stripe with a wavy edge of the posterior margin is sometimes constricted to form one or more light coloured diamond shapes, which is the basis of common name of the diamondback moth. The hind wings are narrow, pointed towards the apex and light grey with a wide fringe. Moths are active usually at twilight and at night feeding on cruciferous plants but also fly in the afternoon during mass outbreak.

The larvae have four instars each with an average development time of four days. Larval body tapes at both ends have a few black short hair and are colourless in first instar but pale or emerald green with black heads in latter instars. The feeding habit of the first instar is leaf mining. The larvae emerge from the mines to moult and subsequently feed on the lower surface of the leaves. The chewing results in irregular patches of damages. The larvae damage leaves, buds, flowers and seed buds of cultivated cruciferous plants, though, the larvae are small, and they are numerous and cause complete removal of foliar tissue except leaf veins. The larvae damage the young seedlings and disrupt head formation in cabbage, cauliflower and broccoli [15]. Reported that cumulative infestation by the pest complex reached to the extent of 14 to 100 percent and consequent reduction in yield to the extent of 42 to 97 per cent.

To evolve effective management strategy it is pertinent to study the abiotic factors of environment in relation to pest population. The study was aimed in order to find out the correlation of diamondback moth population and natural enemies in cabbage ecosystem with the abiotic parameters to know the hospitable conditions for insect development. Insecticides are used widely to control the insect pests of vegetables because of the easy adoption, effectiveness and immediate control. Indiscriminate and irrational use of chemical insecticides at higher dosages results in resurgence, resistance and residual problems. The diamondback moth is a first crop pest reported to be resistant to DDT and now to almost insecticides including biopesticides. The judicious use of chemicals with novel mode of action needs to be implemented to manage this insect pest.

There are many insecticides which have different mode of action than the conventional ones. The diamide insecticides such as chlorantraniliprole and flubendiamide a new class of insecticides that selectively target insect ryanodine receptor (RyR), a distinct class of homo-tetrameric calcium release channel which play pivotal role in calcium homeostasis in numerous cell types. Similarly the pyrroles, and phenyl pyrazole insecticides block the GABA and glutamate gated chloride channels. These novel insecticides in conjuction with other IPM approaches may play a pivotal role in devising effective management strategy against diamondback moth.
A perusal of literature from all sources of information revealed that a meagre work has been done on evaluation of newer insecticides in Rajasthan.

Experimental

Materials and methods

The experiment was laid out in a simple randomized block design (RBD) with ten treatments (insecticides) including control, each replicated thrice. The plot size was 2.25 x 2.25 m^2 with row to row and plant to plant spacing of 45 x 45 cm, respectively. The larval population of diamondback moth was recorded one day before and one, three, seven and fifteen days after the application of insecticides in all the sprays. The data of insect population were subjected for calculation of percent reduction (percent control) as suggested by [1];

$$\text{Percent control (Reduction)} = \frac{X - Y}{X} \times 100$$

Where
X = Percent living in check (Untreated control)
Y = Percent living in treated plots
X – Y = Percent killed by the treatment

The data on percentage reduction of larval population of diamondback moth were transformed into angular values [3] and population of natural enemies into $\sqrt{X + 0.5}$ values [8] and subjected to analysis of variance.

Details of insecticides used

The details of insecticides used for testing their effectiveness against diamondback moth in cabbage were given in table.

Table 1: Details of insecticides used and there concentrations

S. No.	Insecticides	Formulations	Trade Name	Conc. (%)
1.	Spinosad	45 SC	Tracer	0.01
2.	Indoxacarb	14.5 SC	Avaunt	0.01
3.	Chlorantraniliprole	18.5 SC	Coragen	0.005
4.	Emamectin benzoate	5 SG	Proclaim	0.005
5.	Chlorfenapyr	10 SC	Lepido	0.01
6.	Fipronil	5 SC	Regent	0.01
7.	Flubendiamide	39.35 SC	Fame	0.01
8.	Acephate	75 SP	Asataf	0.05
9.	Pyridalyl	10 EC	Pleo	0.015
10.	Control (Plain water)			

Results and discussion

In the present study the spinosad was found to be most effective in reducing the larval population of diamondback moth (86.66-94.33%) on cabbage which was found at par with Indoxacarb (85.66-91.00%) The present results are in close conformity with the findings of [2, 7, 9, 10, 12, 14, 19] who found spinosad as the most effective insecticide against diamondback moth.
the treatment of indoxacarb was found at par for the control of *P. xylostella* on cabbage, the findings are in conformity by [2, 7, 10, 13, 18]. The effectiveness of flubendiamide was supported by [2], who reported flubendiamide most effective in controlling the diamondback moth on cabbage. The results of present investigation are also in conformity with [9], who reported flubendiamide most effective in reducing the larval population of diamondback moth.
The data revealed that the insecticides, *viz*., emamectin benzoate (68.66-70.33%) chlorantraniliprole (67.66-68.66%) and fipronil (67.00-67.66%) were moderately effective against the larval population of diamondback moth The present findings are corroborated with the findings of [5, 7, 9, 18] who reported that the treatment of emamectin benzoate was moderately effective in reducing the larval population of diamondback moth. The effectiveness of chlorantraniliprole was supported with the finding of [9] who reported chlorantraniliprole effective against larval population of diamondback moth on cabbage. The treatment of fipronil existed in moderately effective groups of insecticides in the present investigation which corroborate with the findings of [5, 7, 18]. Reported that fipronil found moderately effective against the larval population of diamondback moth.
The treatment of chlorfenapyr, acephate and pyridalyl proved less effective and resulted in 51.66-55.33, 52.66-56.00 and 52.00-56.66 percent reduction, respectively of the larval population of *P. xylostella* on cabbage. The present findings are in agreement with [4] who reported that pyridalyl was least effective against *P. xylostella* on cabbage. Likewise, [9] reported pyridalyl as least effective insecticide in controlling, *P. xylostella* which fully supported the present findings.

Table 2: Bioefficacy of insecticides against diamond back moth, *Plutella xylostella* (L.) on cabbage crop during *Rabi.*

S. No.	Treatments	Conc. (%)	Percent reduction of larval population of diamond back moth days after sprays														
			First spray					Second spray					Third spray				
			One	Three	seven	Fifteen	Mean	One	Three	seven	Fifteen	Mean	One	Three	seven	Fifteen	Mean
1.	Spinosad	0.01	77.66	86.66	85.66	74.66	81.16	80.33	94.33	85.66	77.00	84.33	80.33	90.33	87.66	75.33	83.41
			(61.87)	(68.58)	(67.76)	(59.78)		(63.71)	(75.37)	(67.89)	(61.35)		(63.69)	(71.95)	(69.49)	(60.23)	

2.	Indoxacarb	0.01	76.33	85.66	84.33	74.33	80.16	79.33	91.00	85.33	75.33	82.75	79.33	88.66	86.33	73.66	81.49
			(60.89)	(67.77)	(66.69)	(59.58)		(63.03)	(72.79)	(67.48)	(60.23)		(62.99)	(70.38)	(68.33)	(59.13)	
3.	Chlorantra	0.005	66.33	67.66	65.33	63.66	65.74	67.33	68.00	67.66	65.33	67.08	66.00	68.66	67.33	63.66	66.41
	Niliprole		(54.53)	(55.35)	(53.93)	(52.93)		(55.15)	(55.56)	(55.35)	(53.93)		(54.33)	(55.97)	(55.15)	(52.94)	
4.	Emamectin benzoate	0.005	67.66	68.66	65.66	67.33	67.32	68.66	70.33	65.66	63.66	67.07	69.66	70.33	66.33	62.33	67.16
			(55.34)	(55.96)	(54.14)	(55.15)		(55.98)	(57.00)	(54.13)	(52.94)		(56.58)	(57.00)	(54.54)	(52.14)	
5.	Chlorfenapyr	0.01	48.66	53.66	51.33	52.33	50.74	54.33	51.66	50.33	49.00	51.33	54.33	55.33	52.66	49.00	52.83
			(44.23)	(47.10)	(45.76)	(46.33)		(47.49)	(45.95)	(45.19)	(44.43)		(47.49)	(48.06)	(46.53)	(44.43)	
6.	Fipronil	0.01	70.66	67.33	65.33	63.66	66.74	68.33	67.00	65.33	61.66	65.58	67.66	68.00	65.33	61.33	65.58
			(57.21)	(55.14)	(53.93)	(52.94)		(55.77)	(54.94)	(53.93)	(51.75)		(55.34)	(56.55)	(53.93)	(51.55)	
7.	flubendiamide	0.01	72.33	74.33	72.33	70.33	72.33	78.33	71.66	67.33	66.66	71.00	78.66	68.66	69.00	63.00	69.83
			(58.26)	(59.59)	(58.27)	(57.00)		(62.27)	(57.86)	(55.15)	(54.74)		(62.52)	(55.96)	(56.18)	(52.54)	
8.	Acephate	0.05	50.33	54.33	54.33	52.33	52.83	54.66	52.66	49.66	47.66	51.16	55.33	56.00	53.33	49.33	53.50
			(45.19)	(47.48)	(47.48)	(46.33)		(47.67)	(46.52)	(44.80)	(43.66)		(48.06)	(48.44)	(46.91)	(44.62)	
9.	Pyridalyl	0.015	51.00	55.66	61.33	56.66	56.16	55.33	52.00	51.33	49.66	52.08	56.66	56.66	53.66	49.66	54.16
			(45.57)	(48.25)	(51.55)	(48.83)		(48.06)	(46.14)	(45.76)	(44.80)		(48.33)	(48.83)	(47.10)	(44.80)	
10.	Control	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.Em±		0.70	0.47	0.68	0.60	-	1.31	1.18	0.70	0.63	-	0.66	0.83	0.71	0.65	-
	C.D. (5%)		2.15	1.55	2.07	2.09	-	3.37	3.82	2.25	1.88	-	1.99	2.07	2.14	2.24	-

Figures in the parentheses are angular transformation values. Mean of three replications

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