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Evaluate of bio-efficacy on different insecticides against diamondback moth on cauliflower

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Abstract
The field experiment was conducted during *Rabi*, 2016-17 to assess the bio-efficacy of some insecticides against diamondback moth of cauliflower, based on per cent reduction of larval population at different intervals, yield of cauliflower curds and benefit cost ratio. Total three sprays of insecticides were applied during the season. The pre-treatment larval population of diamondback moth was recorded one day before treatment and the post treatment population was recorded in all the sprays after 1, 3, 7 and 15 days of spraying of insecticides during the year.

Keywords: Bioefficacy *Coccinella septempunctata,* chlorantraniliprole, indoxacarb, flubendiamide

Introduction
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 reported that cumulative infestation by the pest complex reached to the extent of 14 to 100 per cent 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 cauliflower 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.

Materials and Methods
The experiment was laid out in a simple randomized block design (RBD) with ten treatments (insecticides) including control, each replicated four time. The plot size was 2.25 x 2.25 m^2 with row to row and plant to plant spacing of 60 x 40 cm, respectively. The recommended package of practices were followed to raise the crop.
Pre-calibrated knap sack sprayer was used for spraying insecticides on the crop. Care was taken to check the drift of insecticides by putting polythene sheet screen around each plot at the time of spraying. Total three sprays were applied, first on 16^{th} January during the year and second and third sprays were applied after rebuild of pest population at three weeks interval. The total spraying solution used in different sprays was 500 litres per hectare.

Result
One day after application of insecticides, it was observed that all the treatments were found significantly superior to untreated control in reducing the larval population of diamondback moth, however, significant difference existed among them (Table 1 and fig. 1). The maximum reduction of 77.66 per cent in the larval population was recorded in the treatment of spinosad followed by indoxacarb which resulted in 76.33 per cent reduction, however, both treatments were at par with each other in their efficacy and significantly superior to rest of the treatments.

The next effective treatment was flubendiamide (72.33%) which was at par with fipronil (70.66%) and emamectin benzoate (67.66%). The minimum reduction of 48.66 per cent was recorded in the treatment of chlorfenapyr followed by acephate and pyridalyl which resulted in 50.33 and 51.00 per cent reduction, respectively, however, these treatments were found at par with each other.

After three days of spray maximum reduction in larval population was found in spinosad (86.66%) which was at par with indoxacarb (85.66%).The next effective treatment was flubendiamide with 74.33 per cent reduction, and significant with rest of the treatments. Emamectin benzoate, chlorantraniliprole and fipronilbelongs to a moderately effective group of insecticides with 68.66, 67.66 and 67.33 per cent reduction, respectively. The chlorfenapyr with 53.66 per cent reduction in larval population was found least effective with acephate (54.33%) and pyridalyl (55.66%) and formed a least effective group of insecticides.

After seven days of spray, spinosad proved to be the most effective treatment with 85.66 per cent reduction in larval population followed by indoxacarb with 84.33 per cent reduction, these stood at par with each other in their efficacy. The next effective treatment was flubendiamide 72.33 per cent reduction which differed significantly with rest of the treatments. The minimum reduction of 50.33 per cent was noticed in chlorfenapyr, acephate (54.33%) and pyridalyl (61.33%), however, these were found statistically at par with each other.

The maximum reduction of 74.66 per cent was recorded in the treatment of spinosad even after fifteen days of spray followed by indoxacarb (74.33%), these were statistically at par with each other. The next effective non-significant group of insecticides was flubendiamide and emamectin benzoate which resulted in 70.33 and 67.33 per cent reduction, respectively. Fipronil and chlorantraniliprole found moderately effective. The minimum reduction of 52.33 per cent was recorded in chlorfenapyr and acephate, these were found at par with each other.

one day after spray of insecticides, the maximum reduction of 80.33 per cent was recorded in the treatment of spinosad followed by indoxacarb (79.33%) and flubendiamide (78.33%) and these were at par with each other in their efficacy and significantly superior to rest of the treatments. The next effective treatments were emamectin benzoate, fipronil and chlorantraniliprole with 68.66, 68.33 and 67.33 per cent reduction, respectively and formed a moderately effective group of insecticides. The minimum reduction of 54.33 per cent was recorded in chlorfenapyr closely followed by acephate (54.66%) and pyridalyl (55.33%), these were found at par with each other.

The per cent reduction in larval population of diamondback moth after three days of spray was maximum in spinosad (94.33%) and indoxacarb (91.00%), and these were found statistically at par with each other. The flubendiamide (71.66% reduction), emamectin benzoate (70.33% reduction), chlorantraniliprole (68.00% reduction) and fipronil (67.00% reduction), formed the next moderately effective non significant group of insecticides. The minimum reduction of 51.66 per cent was registered in chlorfenapyr, pyridalyl (52.00%) and acephate (52.66%), these were at par with each other.

After seven days of insecticidal spray, the maximum reduction of 85.66 per cent was recorded in the treatment of the spinosad and indoxacarb were statistically at par with each other after 7 days of insecticidal spray and exhibited 85.66 and85.33 per cent reduction, respectively. The next moderately effective group of insecticides comprised chlorantraniliprole (67.66%), flubendiamide (67.33%), emamectin benzoate (65.66%) and fipronil (65.33%). The minimum reduction (49.66%) was registered in acephate followed by chlorfenapyr (50.33%) and pyridalyl (51.33%) and these were at par with each other.

The treatment of spinosad and indoxacarb with 77.00 and 75.33 per cent reduction respectively in the larval population of diamondback moth proved most effective even after fifteen days of spray and these were at par with each other. The next effective non-significant group of insecticides was flubendiamide, chlorantraniliprole and emamectin benzoate which registered, 66.66, 65.33 and 63.66 per cent reduction, respectively, however, fipronil (61.66%) was also found at par with emamectin benzoate.The minimum reduction of 43.66 per cent was recorded in acephate followed by chlorfenapyr (49.00%) and pyridalyl (49.66%), these were non-significantly to each other.

The maximum reduction of 80.33, 79.33 and 78.33 per cent in the larval population of diamondback moth was recorded in the treatments of spinosad,indoxacarb and flubendiamide,these treatments were at par with each other in their efficacy and significantly superior to rest of the treatments. The next effective treatment was emamectin benzoate (69.66%), which was at par with fipronil (67.66%) and chlorantraniliprole (66.00%). The minimum reduction of larval population was recorded in the treatment of chlorfenapyr, acephate and pyridalyl which resulted in 54.33, 55.33 and 56.66 per cent reduction, respectively, these were found at par with each other.

After three days of spray maximum reduction in larval population (90.33%) was found in spinosad which was at par with indoxacarb (88.66%), these treatments were followed by emamectin benzoate with 70.33 per cent reduction and significant with rest of the treatments. Flubendiamide, chlorantraniliprole and fipronil formed a moderately effective group of insecticides with 68.66, 68.66 and 68.00 per cent reduction respectively. The chlorfenapyr with 55.33 per cent reduction in larval population was found least effective with acephate (56.00%) and pyridalyl (56.66%) and formed a least effective group of insecticides.

After seven days of spray, spinosad proved to be the most effective treatment with 87.66 per cent reduction in larval population and had non significant with indoxacarb (86.33% reduction). The next moderately effective treatments were flubendiamide (69.00%), chlorantraniliprole (67.33%), emamectin benzoate (66.33%) and fipronil (65.33%) reduction, however, these were at par with each other. The minimum reduction of 52.66 per cent was registered in chlorfenapyr, acephate (53.33%) and pyridalyl (53.66%), which were found statistically at par with each other.

The reduction of 75.33 per cent was recorded in the treatment of spinosad even after fifteen days of spray followed by indoxacarb (74.33%) and these were statistically non significant with each other. The next effective group of insecticides was comprised chlorantraniliprole, flubendiamide, emamectin benzoate and fipronil, which resulted in 63.66, 63.00, 62.33 and 61.33 per cent reduction, respectively. However, pyridalyl (60.33%) was found at par with fipronil. The minimum reduction of 49.00 per cent was recorded in chlorfenapyr and acephate (49.33%) and these were found at par with each other.

Discussion

In the present investigation the bio-efficacy of insecticides was assessed on the basis of reduction of pest population, yield of cauliflower curds and economics of the treatments.

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 cauliflower which was found at par with Indoxacarb (85.66-91.00%) The present results are in close conformity with the findings of Pramanik and chatterjee (2003) [11], shukla and Kumar (2004) [13], Paliwal and Oommen (2005) [9], Ameta and Bunker (2007) [1], Gill *et al*. (2008) [4] and Meena and Singh (2010) [8], Kikuchi *et al.* (2013) [7], who found spinosad as the most effective insecticide against diamondback moth.

The present results also got partial support from the findings of John *et al*. and Gupta (2000) [6] who reported results in favour of in controlling *P. xylostella* on cabbage. The treatment of indoxacarb was found at par for the control of *P. xylostella* on cauliflower, the findings are in conformity by Sannaveerappanavar *et al*. (2003) [12], Patel *et al*. (2005) [10], Ameta and bunker (2007) [1], Gill *et al*. (2008) [4] and Meena and Sharma (2010) [8]. The effectiveness of flubendiamide was supported by Ameta and Bunker (2007) [1] who reported flubendiamide most effective in controlling the diamondback moth on cabbage. The results of present investigation are also in conformity with Kikuchi *et al*. (2013) [7], 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 Deivendran *et al*. (2007) [3], Kikuchi *et al.* (2013) [7], Gill *et al.* (2008) [4], Sannaveerappanvar *et al.* (2003) [12], 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 Kikuchi *et al*. (2013) [7] 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 Sannaveerappanvar (2005) [12], Deivendran *et al.* (2007) [3], Kikuchi *et al.* (2013) [7]. 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 per cent reduction, respectively of the larval population of *P. xylostella* on cauliflower. The present findings are in agreement with Chakraborty and Somchoudhary (2011) [2] who reported that pyridalyl was least effective against *P. xylostella* on cabbage. Likewise, Kikuchi *et al.* (2013) [7] reported pyridalyl as least effective insecticide in controlling, *P. xylostella* which fully supported the present findings.

Table 1: Bioefficacy of insecticides against diamond back moth, *Plutella xylostella* (L.) on cauliflower crop during *Rabi*, 2016-17

S. No. Treatments Conc. (%)			Per cent 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 (61.87)	86.66 (68.58)	85.66 (67.76)	74.66 (59.78)	81.16	80.33 (63.71)	94.33 (75.37)	85.66 (67.89)	77.00 (61.35)	84.33	80.33 (63.69)	90.33 (71.95)	87.66 (69.49)	75.33 (60.23)	83.41
2.	Indoxacarb	0.01	76.33 (60.89)	85.66 (67.77)	84.33 (66.69)	74.33 (59.58)	80.16	79.33 (63.03)	91.00 (72.79)	85.33 (67.48)	75.33 (60.23)	82.75	79.33 (62.99)	88.66 (70.38)	86.33 (68.33)	73.66 (59.13)	81.49
3.	Chlorantra Niliprole	0.005	66.33 (54.53)	67.66 (55.35)	65.33 (53.93)	63.66 (52.93)	65.74	67.33 (55.15)	68.00 (55.56)	67.66 (55.35)	65.33 (53.93)	67.08	66.00 (54.33)	68.66 (55.97)	67.33 (55.15)	63.66 (52.94)	66.41
4.	Emamectin benzoate	0.005	67.66 (55.34)	68.66 (55.96)	65.66 (54.14)	67.33 (55.15)	67.32	68.66 (55.98)	70.33 (57.00)	65.66 (54.13)	63.66 (52.94)	67.07	69.66 (56.58)	70.33 (57.00)	66.33 (54.54)	62.33 (52.14)	67.16
5.	Chlorfenapyr	0.01	48.66 (44.23)	53.66 (47.10)	51.33 (45.76)	52.33 (46.33)	50.74	54.33 (47.49)	51.66 (45.95)	50.33 (45.19)	49.00 (44.43)	51.33	54.33 (47.49)	55.33 (48.06)	52.66 (46.53)	49.00 (44.43)	52.83
6.	Fipronil	0.01	70.66 (57.21)	67.33 (55.14)	65.33 (53.93)	63.66 (52.94)	66.74	68.33 (55.77)	67.00 (54.94)	65.33 (53.93)	61.66 (51.75)	65.58	67.66 (55.34)	68.00 (56.55)	65.33 (53.93)	61.33 (51.55)	65.58
7.	flubendiamide	0.01	*72.33 (58.26)*	*74.33 (59.59)*	*72.33 (58.27)*	*70.33 (57.00)*	*72.33*	*78.33 (62.27)*	*71.66 (57.86)*	*67.33 (55.15)*	*66.66 (54.74)*	*71.00*	*78.66 (62.52)*	*68.66 (55.96)*	*69.00 (56.18)*	*63.00 (52.54)*	*69.83*
8.	Acephate	0.05	50.33 (45.19)	54.33 (47.48)	54.33 (47.48)	52.33 (46.33)	52.83	54.66 (47.67)	52.66 (46.52)	49.66 (44.80)	47.66 (43.66)	51.16	55.33 (48.06)	56.00 (48.44)	53.33 (46.91)	49.33 (44.62)	53.50
9.	Pyridalyl	0.015	51.00 (45.57)	55.66 (48.25)	61.33 (51.55)	56.66 (48.83)	56.16	55.33 (48.06)	52.00 (46.14)	51.33 (45.76)	49.66 (44.80)	52.08	56.66 (48.33)	56.66 (48.83)	53.66 (47.10)	49.66 (44.80)	54.16
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 angulartransformation values. Mean of three replications

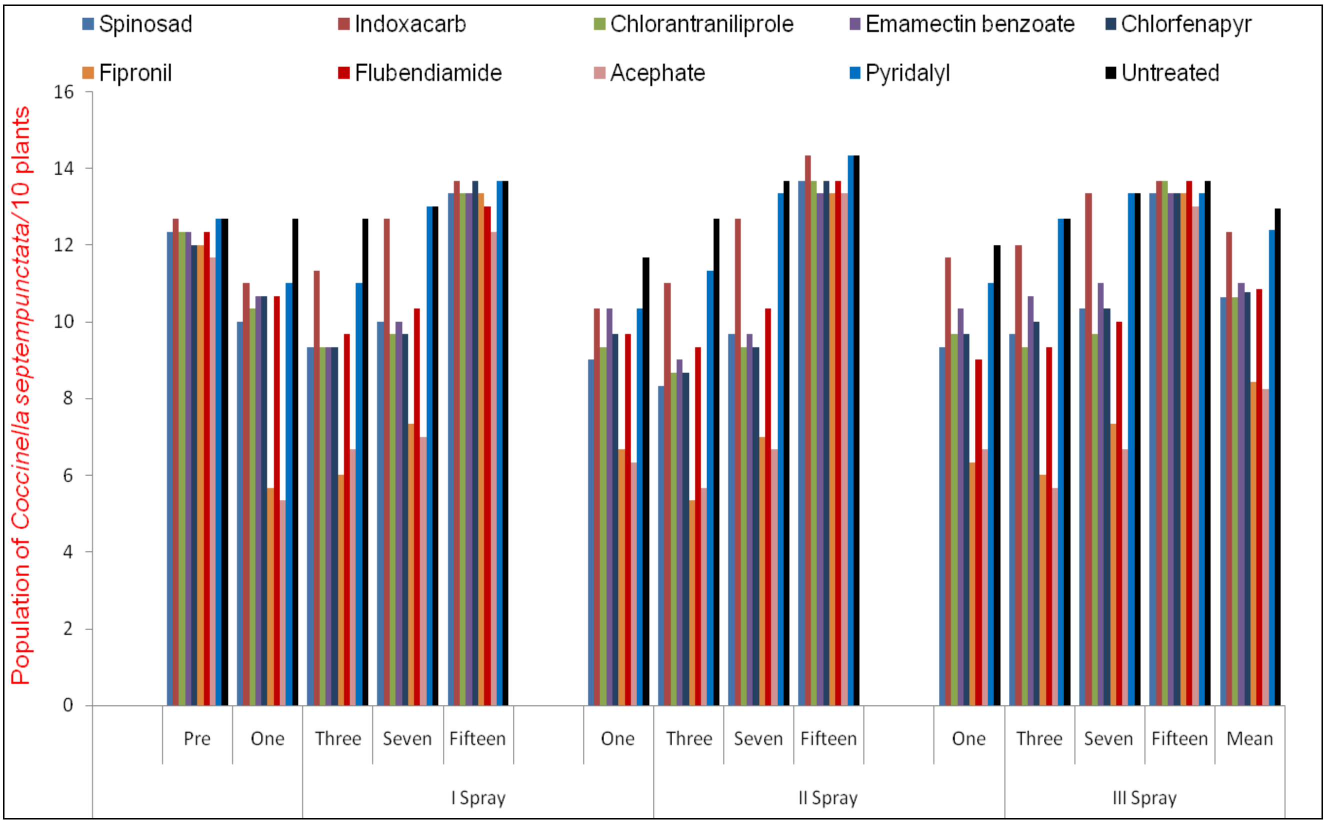

Fig 1: Effect of insecticides on the population of *Coccinella Septempunctata* L. (per ten plants) on cauliflower crop during Rabi, 2016-17

Conclusion

All the insecticides tested against diamondback moth of cauliflower were found effective over untreated control in reducing the larval population of diamondback moth. On the basis of mean per cent reduction of diamondback moth, spinosad was found to be most effective reduced up to 82.96 per cent population followed by indoxacarb (81.46%) and Flubendiamide (71.05%). The insecticides, *viz.*, fipronil, emamection benzoate and chlorantraniliprole were found moderately effective reduction and chlorfenapyr, pyridalyl and acephate were proved least effective reduction.

The indoxacarb and pyridalyl were least toxic to *C. septempunctata* and maximum toxicity was observed in the treatments of acephate and fipronil.

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