Int.J.Curr.Microbiol.App.Sci (2018) *7*(7): 2986-2998

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 07 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.707.349

Bio-efficacy of Newer Insecticides against Diamondback Moth (*Plutella xylostella* Linn.) in Cabbage at Farmers Field

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Keywords

Cabbage, *Plutella xylostella* L., Bio-efficacy, Chlorantraniliprole, Cost effectiveness

Article Info

Accepted:
20 June 2018
Available Online:
10 July 2018

ABSTRACT

Investigation was undertaken during 2015-2016 and 2016-2017on farmer's field to study the bio-efficacy of newer insecticides against *Plutella xylostella* L. infesting cabbage. The cabbage crop (var. Saint) was raised by following recommended package of practices except for plant protection measures. Treatments included of six newer insecticides along with two conventional insecticides and one synthetic pyrethroid. Results revealed that all the insecticidal treatments were significantly superior over untreated control by recording lower larval population. Among the insecticidal treatments, significantly highest per cent larval reduction of *P. xylostella* over control was recorded in chlorantraniliprole treated plots (91.30 % with 1.02 larvae plant^{-1}) followed by spinosad (87.55 % with 1.46 larvae plant^{-1}) and flubendiamide (86.61 % with 1.57 larvae plant^{-1}). The efficacy of insecticides also reflected on marketable yield of cabbage heads.The highest yield of 238.15 q ha^{-1}with 129.23% increase over control was registered in the treatment of chlorantraniliprole followed by spinosad (233.83 q ha^{-1} with 125.07% increase over control) and flubendiamide (224.98 q ha^{-1}with 116.56 % increase over control). The highest ICBR (1:16.40) was registered from chlorantraniliprole treated plots followed by flubendiamide (1:14.98) and spinosad (1:12.22).

Introduction

Cabbage (*Brassica oleracea* var. *capitata* Linn.) is the most common, popular and major annual vegetable crop. Among the winter vegetables, the cabbage is extensively cultivated crop because of its nutritional and economical values. The area under vegetable crops in India was about 9,541 thousand ha with production of 16, 8,300 MT. In Maharashtra, the corresponding figure for cabbage was 379 thousand ha with a production of8597 MT (Anon., 2015).

The cabbage crop is attacked by a number of insect pests. Diamondback moth (*P. xylostella* L) is the most destructive insect pest and is the major limiting factor for successful cultivation of cruciferous crops resulting in loss of quality and production (Patil *et al.*, 1999). *P. xylostella* has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999). Hence, farmers are compelled to use chemical insecticides in order to cultivate lucratively, as traditional and cultural practices alone cannot not give satisfactory control over the pest menace. Frequent use of chemical insecticides at higher doses results in depredation of natural enemies and development of insecticide resistance in *P. xylostella* against a wide range of insecticides in different parts of India (Talekar *et al.*, 1990). This has necessitated the use of newer insecticides to sustain the management of *P.xylostella.* Hence, the present study was undertaken for assessment of newer insecticides in managing the *P. xylostella* and their effect onyield under field conditions.

Materials and Methods

The investigations were carried out during the year 2015-16 and 2016-2017 on farmer's field at Nandur Madhyameshwar, Tq. Niphad, Dist. Nashik and at Khandgaon, Tq. Sangamner, Dist. Ahmednagar. The experiment was laid out in a randomized block design (RBD) with ten treatments including untreated control and replicated three times. The crop was raised with recommended agronomic practices with a plot size of15 sqm (3x5m) at 45 x 30cm spacing. The transplanting dates were20 December 2015 and 15 July 2016, respectively.

The insecticides evaluated were indoxacarb @ 40 g a.i.ha^{-1}, spinosad @ 17.5 g a.i.ha^{-1}, flubendiamide @18.24 g a.i. ha^{-1}, diafenthiuron @ 300 g a. i. ha^{-1},emamectin benzoate @ 10 g a. i. ha^{-1}, chlorantraniliprole @ 10 g a. i. ha^{-1}, quinalphos@ 250 g a. i. ha^{-1},triazophos@ 500 g a. i. ha^{-1} and bifenthrin@ 50 g a.i. ha^{-1}. Insecticides were applied in the form of foliar sprays when the attack of larvae of *P. xylostella* reached at ETL (2 larvae/plant). Insecticidal solutions were diluted in water (375-500 L ha^{-1}) and applied using knapsack sprayer (16 L) with hollow cone nozzle. In all, two rounds of applications were given. The larvae were counted on head and outside the head. Observations were recorded one day before spray (pre-count) and 1,3,7,14 days after spray. While recording yield data, only marketable heads were taken into account. Yield obtained from net plot was converted into per hectare. The cost:benefit ratio was determined on the basis of net income gained from yield over control.

Results and Discussion

I year

The field experiment was undertaken during January, 2016 to April, 2016 at Nandur Madhyameshwar, Tq. Niphad, Dist. Nashik.

The data (Table 1) revealed that all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the larval population of *P. xylostella* at all the days (1, 3, 7 and 14 DAS) of observations.

The overall results of first and second spray indicated that, chlorantraniliprole@ 10 g a.i. ha^{-1}recorded lowest number of larval population of *P. xylostella* (2.33, 0.30, 0.23 and 1.53 larvae plant^{-1}) with 90.59 per cent larval reduction over control and proved to be superior over all the remaining treatments at all the days of observations. Whereas, spinosad @ 17.5 g a.i. ha^{-1} with 3.20, 0.63, 0.43 and 1.83 larvae plant^{-1} (86.92 % larval reduction) was the next promising treatment. It was however at par with flubendiamide 18.24 g a.i. ha^{-1}, which recorded 3.30, 0.80, 0.53 and 1.97 larvae plant^{-1}(85.89 % larval reduction). Indoxacarb @ 40 g a.i. ha^{-1}was next in the order of effectiveness showing larval population of 4.03, 1.30, 0.83 and 2.13 larvae plant^{-1}(82.22 % larval reduction). It was followed by emamectin benzoate @ 10 g a.i.

ha^{-1} and diafenthiuron @ 300 g a.i. ha^{-1} which were recorded 4.40, 1.63, 1.23 and 2.47 larvae $plant^{-1}$(79.23 % larval reduction), 6.13, 2.37, 2.03 and 3.30 larvae $plant^{-1}$(70.43 % larval reduction), respectively. Untreated plots showed maximum number of larval population i.e. 10.27 to 13.40 larvae $plant^{-1}$.

II year

The field experiment was conducted during August, 2016 to October, 2016 at Khandgaon, Tq. Sangamner, Dist. Ahmednagar. The data (Table 2) revealed that, all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the larval population of *P. xylostella* at all the days i.e. 1, 3, 7 and 14 DAS of observations. The average number of larval population ranged between 0.90 and 3.98 as against 12.00 in untreated control.

Chlorantraniliprole@ 10 g a.i. ha^{-1} excelled over all other treatments by recording significantly least number of larvae (1.97, 0.17, 0.10 and 1.53) with 92.50 per cent reduction over control at 1, 3, 7 and 14 days after sprays, respectively. This was followed by spinosad @ 17.5 g a.i. ha^{-1} (2.90, 0.58, 0.27 and 1.83 larvae $plant^{-1}$) with 89.17 per cent larval reduction and flubendiamide18.24 g a.i. ha^{-1} (3.00, 0.63, 0.40 and 1.90 larvae $plant^{-1}$) with 88.41 per cent larval reduction but they were at par with each other. Indoxacarb @ 40 g a.i. ha^{-1}, emamectin benzoate @ 10 g a.i. ha^{-1} and diafenthiuron @ 300 g a.i. ha^{-1} were next in the order of effectiveness with 85.17, 82.17 and 76.67 per cent larval reduction over control, respectively. Untreated plots recorded maximum larval population of *P. xylostella*i.e. 9.47 to 13.23 larvae $plant^{-1}$.

Cumulative bio-efficacy of newer insecticides against *P. xylostella*during I and II year (Pooled)

The pooled analysis data of both the years (2015-16 and 2016-17) on bio-efficacy of newer insecticides against the larval population of *P. xylostella* on cabbage are presented in Table 3 and figure 1. It could be seen that, all the insecticidal treatments were significantly superior in reducing the infestation of *P. xylostella* over untreated control. The average number of larval population ranged between 1.02 and 4.42 as against 11.73 in untreated plots.

Chlorantraniliprole@ 10 g a.i. ha^{-1} consistently proved its superiority by recording least larval population (2.15 to 1.53 larvae $plant^{-1}$) with highest per cent reduction in larval population of *P. xylostella* over control (91.30 %). Next in order of effectiveness were spinosad @ 17.5 g a.i. ha^{-1} (3.05 to 1.83 larvae $plant^{-1}$) with 87.55 per cent larval reduction and flubendiamide @ 18.24 g a.i. ha^{-1} (3.15 to 1.93 larvae $plant^{-1}$)with 86.61 per cent larval reduction, but they were at par with each other at 1 and 14 days after spray. The next effective treatments were indoxacarb @ 40 g a. i. ha^{-1} (3.92 to 2.15 larvae $plant^{-1}$with 82.95 % larval reduction) followed by emamectin benzoate @ 10 g a.i. ha^{-1} (4.40 to 2.47 larvae $plant^{-1}$ with 79.88 per cent larval reduction). Maximum larval population was recorded in the untreated control (10.33 to 11.73 larvae $plant^{-1}$).

Superiority of chlorantraniliprole@ 10 g a.i.ha^{-1} against *P. xylostella* as observed in the present investigation is in conformity with Venkateswarlu *et al.,* (2011) who reported 83.65 and 82.08 per cent reduction of *P. xylostella* during 2009-10 and 2010-11, respectively when cabbage crop was applied with chlorantraniliprole @ 10 g a.i.ha^{-1}. Nikam (2013) recorded mean larval population of 0.69 larvae $plant^{-1}$ with 92.12 per cent efficacy against *P. xylostella* when cabbage crop was applied with chlorantraniliprole 18.5 SC. Chlorantraniliprole @ 30 g a.i ha^{-1} recorded least larval population (0.82 larvae $plant^{-1}$) with highest per cent reduction (88.60 %) of

P. xylostella in cabbage (Sunitha, 2014). Natwick and Martin (2016) evaluated the efficacy of chlorantraniliprole against worm pests (DBM and cabbage looper) by recording 2.06 worm pests/50 plant on cabbage under desert growing conditions. Sudhendu *et al.,* (2016) recorded mean larval population of *P. xylostella* during two sprays of chlorantraniliprole 20 SC at three different doses in cabbage.

After 1st spray (10 DAS) mean larval population recorded were 0.73, 0.63 and 0.60 larvae plant^{-1} at 25, 37.5 and 50 g a.i.ha^{-1}respectively. After 2nd spray (10 DAS) there was 100 per cent reduction in larvae of *P. xylostella*. Purushotam *et al.,* (2017) recorded 65.74, 67.08 and 66.41 per cent reduction in larval population of *P. xylostella* after the application of chlorantraniliprole 18.5 SC at 1st, 2nd and 3rd spray, respectively in cabbage. Narendra (2017) reported effectiveness of different dosages of chlorantraniliprole 20 SC. The maximum reduction in larval population was recorded in chlorantraniliprole @ 50 g a.i. ha^{-1} (88.87 %) followed by chlorantraniliprole @ 25 g a.i.ha^{-1} (84.08 %).

Han *et al.,* (2012) reported chlorantraniliprole as the most effective insecticide against *P. xylostella* in radish. Selvaraj and Kennedy, (2017) recorded 86.15 and 89.95 per cent reduction in larval population of *P.xylostella* after 1st and 2nd spray, respectively when cauliflower crop was applied with chlorantraniliprole 18.5 SC. Further, effectiveness of chlorantraniliprole was demonstrated in suppressing the larval population of *P. xylostella* in cabbage by several workers (Hiromoto 2007; Vaseem *et al.,* 2014 and Chowdary *et al.,* 2015).

Marketable yield of cabbage heads(Pooled I & II Year)

Cumulative mean of two years experimental data on yield of cabbage revealed (Table 4 and Fig. 2) that, all the treated plots resulted in higher cabbage yield which ranged between 120.74 to 238.15 q ha^{-1} and proved to be significantly superior over the control (103.89 q ha^{-1}). The highest yield of 238.15 q ha^{-1} was registered chlorantraniliprole@ 10 g a.i. ha^{-1} with highest per cent increase (129.23 %) over control (Fig. 2). This was followed by spinosad @ 17.5 g a.i. ha^{-1} (233.83 q ha^{-1} with 125.07 % increase over control). Next in the order of effectiveness were flubendiamide (224.98 q ha^{-1}with 116.56 % increase over control), indoxacarb (198.17 q ha^{-1} 90.75 % increase over control) and emamectin benzoate (181.51 q ha^{-1}with 74.71 % increase over control). The lowest yield (103.89 q ha^{-1}) was recorded in the untreated plots.

Considerable yield advantages due to effective control of *P. xylostella* in cabbage, particularly with chlorantraniliprole 18.5 SC @ 10 g a.i. ha^{-1} was observed in present investigation. There was almost 129.23 per cent increase in yield over control. Superiority of chlorantraniliprole revealed in the present investigation is in agreement with several earlier reports.

Nikam (2013) recorded highest marketable yield of 230.63 q ha^{-1} cabbage heads with chlorantraniliprole 18.5 SC. Sunitha (2014) registered 230.38 q ha^{-1} marketable yield in cabbage by chlorantraniliprole 1.67 SC @ 30 g a.i.ha^{-1} treated plots.

Purushotam (2016) recorded 175.30 q ha^{-1}yield following the application of chlorantraniliprole 18.5 SC against *P. xylostella* in cabbage.

Sudhendu *et al.,* (2016) recorded highest yield of 156.80, 164.80 and 177.60 q ha^{-1} by the application of chlorantraniliprole 20 SC at different dosages (25, 37.5 and 50 g a.i.ha^{-1}, respectively) in cabbage.

Table.1 Bio-efficacy of newer insecticides against *P. xylostella* during I year (2015-16)

Sr. No.	Treatment details	Dose (g a.i.ha^{-1})	Pre-count	Mean number of larvae per plant — Mean of first and second spray: 1 DAS	3 DAS	7 DAS	14 DAS	Overall larval count	%Reduction over untreated control
1	Indoxacarb14.5%SC	40	8.10 (2.93)*	4.03 (2.13)	1.30 (1.34)	0.83 (1.15)	2.13 (1.62)	2.08 (1.60)	82.22
2	Spinosad2.5%SC	17.50	8.03 (2.92)	3.20 1.92)	0.63 (1.06)	0.43 (0.97)	1.83 (1.53)	1.53 (1.42)	86.92
3	Flubendiamide39.35 % SC	18.24	8.00 (2.92)	3.30 (1.95)	0.80 (1.14)	0.53 (1.02)	1.97 (1.57)	1.65 (1.47)	85.89
4	Diafenthiuron 50% WP	300	7.83 (2.89)	6.13 (2.58)	2.37 (1.69)	2.03 (1.59)	3.30 (1.95)	3.46 (1.99)	70.43
5	Emamectin benzoate 5% SG	10	7.93 (2.90)	4.40 (2.21)	1.63 (1.46)	1.23 (1.32)	2.47 (1.72)	2.43 (1.71)	79.23
6	Chlorantraniliprole 18.5 % SC	10	7.90 (2.90)	2.33 (1.68)	0.30 (0.89)	0.23 (0.86)	1.53 (1.43)	1.10 (1.26)	90.59
7	Quinalphos 25% EC	250	7.77 (2.88)	6.23 (2.59)	2.83 (1.83)	2.43 (1.71)	3.70 (2.05)	3.80 (2.07)	67.52
8	Triazophos 40 % EC	500	8.00 (2.92)	6.50 (2.65)	3.53 (2.01)	2.77 (1.81)	4.23 (2.18)	4.26 (2.18)	63.59
9	Bifenthrin 10 % EC	50	7.83 (2.89)	6.83 (2.71)	4.00 (2.12)	3.23 (1.93)	4.67 (2.27)	4.68 (2.28)	60.00
10	Untreated control	----	10.13 (3.24)	10.27 (3.28)	11.00 (3.39)	12.13 (3.55)	13.40 (3.73)	11.70 (3.49)	---
	S.E. ±	----	NS	0.016	0.018	0.016	0.019	0.012	---
	C. D. at 5 %	----	NS	0.051	0.057	0.050	0.058	0.038	---

DAS: Days after spray
NS: Non-significant
*Figures in parentheses denote $\sqrt{n + 0.5}$ transformed values.

Table.2 Bio-efficacy of newer insecticides against *P. xylostella* during II year (2016-17)

Sr. No.	Treatment details	Dose (g a.i.ha^{-1})	Pre-count	Mean number of larvae per plant – Mean of first and Second spray: 1 DAS	3 DAS	7 DAS	14 DAS	Overall larval count	% Reduction over untreated control
1	Indoxacarb14.5%SC	40	6.97 (2.73)*	3.80 (2.07)	1.07 (1.25)	0.67 (1.08)	2.17 (1.63)	1.78 (1.51)	85.17
2	Spinosad2.5%SC	17.50	6.97 (2.73)	2.90 (1.84)	0.58 (1.04)	0.27 (0.88)	1.83 (1.53)	1.30 (1.34)	89.17
3	Flubendiamide39.35 % SC	18.24	7.07 (2.75)	3.00 (1.87)	0.63 (1.06)	0.40 (0.95)	1.90 (1.55)	1.39 (1.37)	88.41
4	Diafenthiuron 50% WP	300	7.03 (2.74)	5.53 (2.46)	2.17 (1.63)	1.57 (1.44)	2.87 (1.83)	2.80 (1.81)	76.67
5	Emamectin benzoate 5% SG	10	7.13 (2.76)	4.40 (2.21)	1.33 (1.35)	0.97 (1.21)	2.47 (1.72)	2.14 (1.62)	82.17
6	Chlorantraniliprole 18.5 % SC	10	7.07 (2.75)	1.97 (1.57)	0.17 (0.82)	0.10 (0.77)	1.53 (1.43)	0.90 (1.18)	92.50
7	Quinalphos 25% EC	250	6.90 (2.72)	5.70 (2.49)	2.60 (1.76)	1.93 (1.56)	3.27 (1.94)	3.18 (1.92)	73.50
8	Triazophos 40 % EC	500	7.20 (2.77)	6.23 (2.59)	2.87 (1.83)	2.30 (1.67)	3.77 (2.07)	3.57 (2.02)	70.25
9	Bifenthrin 10 % EC	50	7.23 (2.78)	6.60 (2.66)	3.17 (1.91)	2.70 (1.79)	4.13 (2.15)	3.98 (2.11)	66.84
10	Untreated control	---	9.47 (3.16)	10.40 (3.30)	11.10 (3.41)	12.30 (3.58)	13.23 (3.71)	12.00 (3.54)	---
	S.E. ±	---	NS	0.013	0.014	0.023	0.014	0.030	---
	C. D. at 5 %	---	NS	0.040	0.043	0.070	0.045	0.092	---

DAS: Days after spray
NS: Non-significant
*Figures in parentheses denote $\sqrt{n+0.5}$ transformed values

Table.3 Bio-efficacy of newer insecticides against *P. xylostella* during I & II year (Pooled data of 2015-16 and 2016-17)

Sr. No.	Treatment details	Dose (g a.i.ha^{-1})	Pre-count	Mean number of larvae per plant Mean of first and second year				Overall larval count	% Reduction over untreated control
				1 DAS	3 DAS	7 DAS	14 DAS		
1	Indoxacarb14.5%SC	40	7.53 (2.83)*	3.92 (2.10)	1.18 (1.30)	0.75 (1.12)	2.15 (1.63)	2.00 (1.58)	82.95
2	Spinosad2.5%SC	17.50	7.50 (2.83)	3.05 (1.88)	0.61 (1.05)	0.35 (0.92)	1.83 (1.53)	1.46 (1.40)	87.55
3	Flubendiamide39.35 % SC	18.24	7.53 (2.83)	3.15 (1.91)	0.72 (1.10)	0.47 (0.98)	1.93 (1.56)	1.57 (1.44)	86.61
4	Diafenthiuron 50% WP	300	7.43 (2.82)	5.83 (2.52)	2.27 (1.66)	1.80 (1.52)	3.08 (1.89)	3.25 (1.94)	72.29
5	Emamectine benzoate 5% SG	10	7.53 (2.83)	4.40 (2.21)	1.48 (1.41)	1.10 (1.26)	2.47 (1.72)	2.36 (1.69)	79.88
6	Chlorantraniliprole 18.5 % SC	10	7.48 (2.83)	2.15 (1.63)	0.23 (0.86)	0.17 (0.82)	1.53 (1.43)	1.02 (1.23)	91.30
7	Quinalphos 25% EC	250	7.33 (2.80)	5.97 (2.54)	2.72 (1.79)	2.18 (1.64)	3.48 (2.00)	3.59 (2.02)	69.39
8	Triazophos 40 % EC	500	7.60 (2.85)	6.37 (2.62)	3.20 (1.92)	2.53 (1.74)	4.00 (2.12)	4.03 (2.13)	65.64
9	Bifenthrin 10 % EC	50	7.53 (2.83)	6.72 (2.69)	3.58 (2.02)	2.97 (1.86)	4.40 (2.21)	4.42 (2.22)	62.31
10	Untreated control	---	9.80 (3.20)	10.33 (3.29)	11.05 (3.40)	12.22 (3.57)	13.32 (3.72)	11.73 (3.50)	---
	S.E. +	---	NS	0.011	0.009	0.011	0.011	0.006	---
	C. D. at 5%	---	NS	0.033	0.029	0.034	0.033	0.019	---

DAS: Days after spray
NS: Non-significant
*Figures in parentheses denote $\sqrt{n+0.5}$ transformed values

Table.4 Influence of newer insecticides on the marketable yield of cabbage in I and II year (Pooled data of 2015-16 &2016-17)

Sr. No.	Treatment details	Marketable yield of cabbage heads		Per cent increase over control
		Kg/plot	**qt/ha**	
1	Indoxacarb14.5%SC	29.73	198.17	90.75
2	Spinosad2.5%SC	35.08	233.83	125.07
3	Flubendiamide39.35 % SC	33.75	224.98	116.56
4	Diafenthiuron 50% WP	26.18	174.51	67.98
5	Emamectin benzoate 5% SG	27.23	181.51	74.71
6	Chlorantraniliprole 18.5 % SC	35.72	238.15	129.23
7	Quinalphos 25% EC	23.05	153.64	47.88
8	Triazophos 40 % EC	20.07	133.77	28.76
9	Bifenthrin 10 % EC	18.11	120.74	16.21
10	Untreated control	15.58	103.89	----
	S.E. +	0.037	0.247	
	C. D. at 5%	0.114	0.761	

Table.5 Incremental cost benefit ratio of different insecticides used against *P. xylostella* in cabbage during I and II year (pooled I.C.B.R of 2015-16 & 2016-17)

Treatments	Yield (q ha^{-1})	Increased yield over control (q ha^{-1})	Cost of insecticides for 2 sprays ($Rs.ha^{-1}$)	Labour charges for 2 sprays ($Rs.ha^{-1}$)	Total cost ($Rs.ha^{-1}$)	Value of additional yield over untreated control ($Rs.ha^{-1}$)	Incremental benefit ($Rs.ha^{-1}$)	I.C.B.R.	Rank
Indoxacarb14.5%SC	198.17	94.28	1740	1600	3340	39833.3	36493.3	1:10.92	4
Spinosad2.5%SC	233.83	129.94	2550	1600	4150	54899.6	50749.6	1:12.22	3
Flubendiamide39.35 % SC	224.98	121.09	1600	1600	3200	51160.5	47960.5	1:14.98	2
Diafenthiuron 50% WP	174.51	70.62	5640	1600	7240	29836.9	22596.9	1:3.10	8
Emamectin benzoate 5% SG	181.51	77.62	2880	1600	4480	32794.4	28314.4	1:6.32	5
Chlorantranaliprole 18.5 % SC	238.15	134.26	1660	1600	3260	56724.8	53464.8	1:16.40	1
Quinalphos 25% EC	153.64	49.75	1360	1600	2960	21019.3	18059.3	1:6.10	6
Triazophos 40 % EC	133.77	29.88	1400	1600	3000	12624.3	9624.3	1:3.20	7
Bifenthrin 10 % EC	120.74	16.85	960	1600	2560	7119.1	4559.1	1:1.78	9
Untreated control	103.89	----	---	---	---	----	---	---	---

Note: 1. Labour+ Sprayer charges:1600/-, 2. Labour required: 2/ha, 3.Market price of cabbage: Rs. 422.5/-per quintal

Cost of insecticides(Rs./lit/kg.) :

Indoxacarb14.5%SC: 2175/-, Spinosad2.5%SC: 1700/-, Flubendiamide39.35 % SC: 16000/-, Diafenthiuron 50% WP: 3760/-,Emamectin benzoate 5% SG:7200/- Chlorantraniliprole 18.5%SC: 14110/-, Quinalphos 25% EC: 680/-, Triazophos 40 % EC:560/-, and Bifenthrin 10 % EC:960/-

Fig.1 Per cent larval reduction of *P. xylostella* due to different insecticidal treatments (Pooled I & II Year)

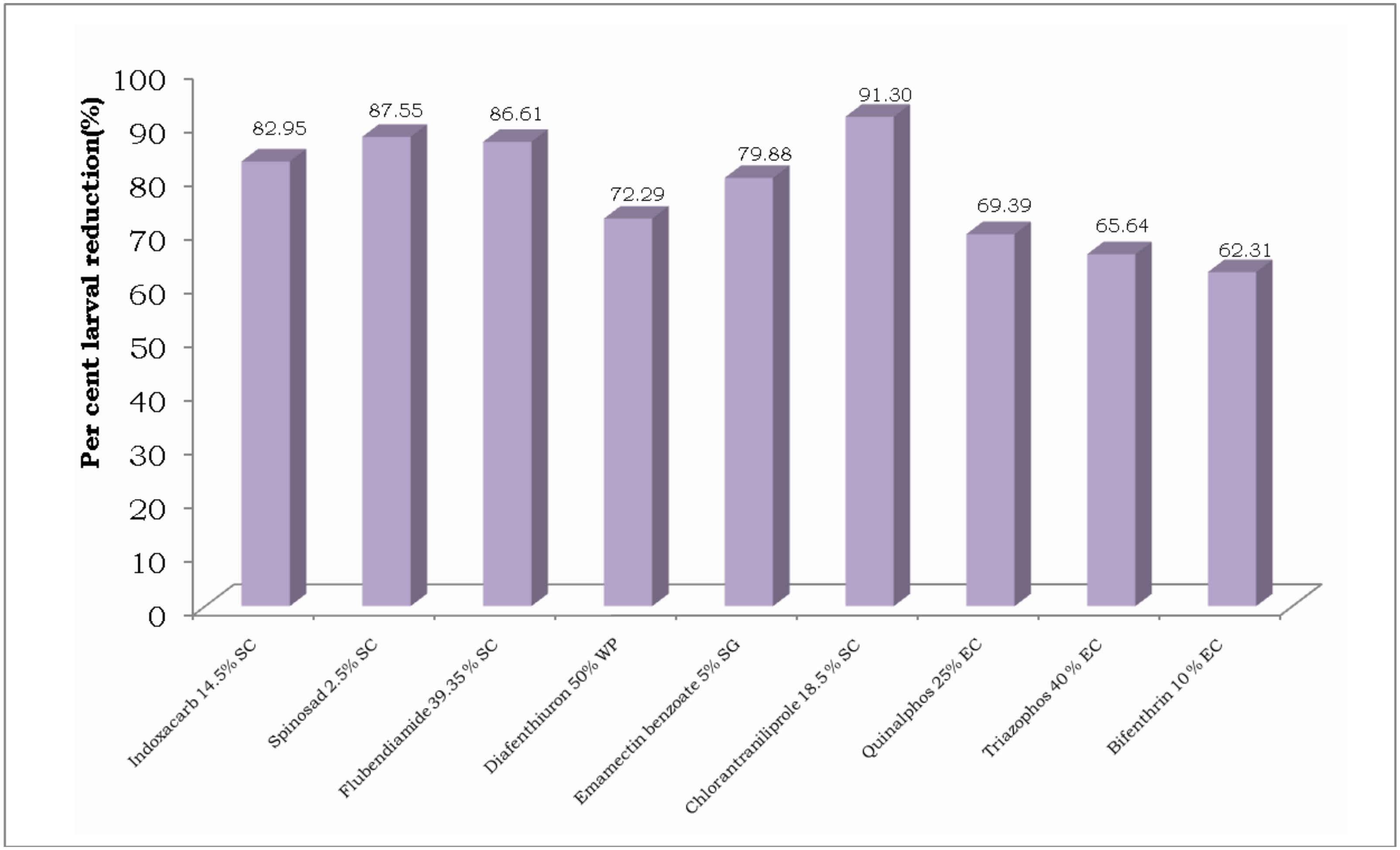
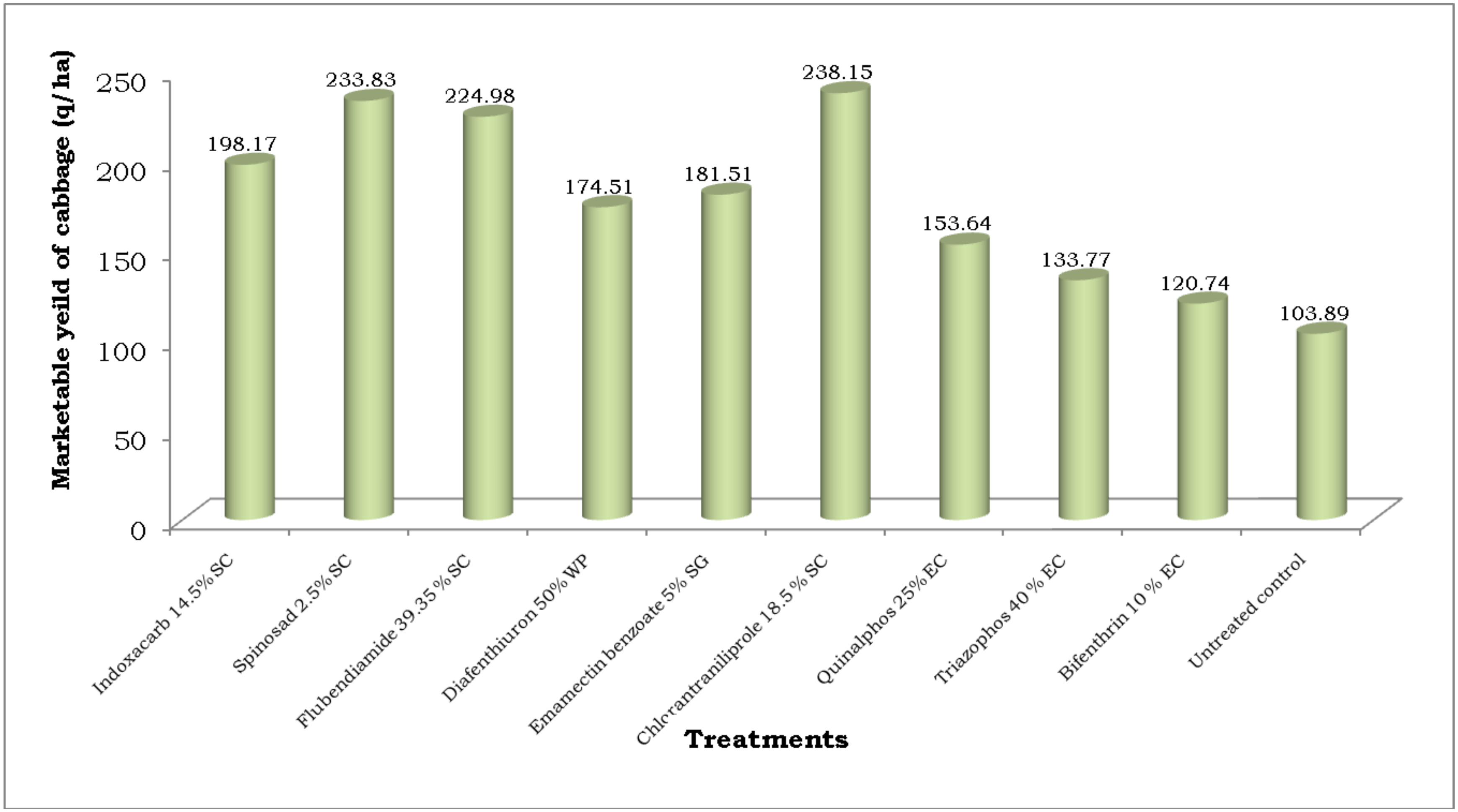


Fig.2 Influence of newer insecticides on marketable yield of cabbage (Pooled I & II Year)



Narendra (2017) recorded highest yield of cabbage in chlorantraniliprole@ 50 g a.i. ha^{-1} (27.9 tonne ha^{-1}) followed by lower doses of chlorantraniliprole. In cauliflower, highest yield of cabbage heads (27.0 tonne ha^{-1} with 87.89% increase) was registered following the application of chlorantraniliprole 18.5 SC @ 30 g a.i.ha^{-1} against *P. xylostella* (Selvaraj and Kennedy, 2017).

Cost economics and incremental cost:benefit ratio

The data generated on cost effectiveness of different insecticides applied against *P. xylostella* in cabbage during two years (2015-16 & 2016-17) are presented in Table 5. The ICBR in respect of different treatments ranged between 1.78 and 16.40. It could be seen that, chlorantraniliprole@ 10 g a.i. ha^{-1} ranked first indicating the maximum return of Rs. 16.40 per rupee invested followed byflubendiamide@ 18.24 g a.i. ha^{-1} (Rs. 14.98) and spinosad @ 17.5 g a.i. ha^{-1} (Rs.12.22).

Cost benefit analysis revealed that highest net profit (Rs.53464.8) was reaped from chlorantraniliprole 18.5 SC @ 10 g a.i.ha^{-1} with incremental cost benefit ratio of 1:16.40.The present findings are in corroboration with Ratnsari (2012) who obtained higher net profit with higher ICBR (1:11.49) from the chlorantraniliprole 18.5 SC against cabbage pests. Purushotam (2016) recorded ICBR of 1:5.60 after application of chlorantraniliprole 18.5 SC against DBM in cabbage. Narendra (2017) reported cost benefit ratio of chlorantraniliprole 20 SC at different dosages (50, 25, 15 and 10 g a.i.ha^{-1}) against *P. xylostella* in cabbage. The highest ICBR was recorded in chlorantraniliprole@ 50 g a.i. ha^{-1} (1:2.89) followed by chlorantraniliprole @ 25 g a.i.ha^{-1} (1:2.53).

Cost effectiveness of chlorantraniliprole 18.5 SC was also endorsed in other vegetable crops (Narendra *et al.,* 2017; Pawar *et al.,* 2016; Tarun *et al.,* 2016 and Sarnabati and Ray, 2017).

Hence concluded in the present investigation, chlorantraniliprole @ 10 g a.i. ha^{-1} excelled over all other insecticides for the control of diamondback moth in cabbage. The treatments recorded highest per cent reduction in larval population, highest yield of marketable cabbage heads with ICBR of 1:16.40. Flubendiamide and spinosad were the next to follow in the order of effectiveness. Thus it can be concluded that two sprays of chlorantraniliprole at ETL is the effective and economic in controlling cabbage diamondback moth.

Acknowledgements

The authors are thankful to the DST, Ministry of Science and Technology, Government of India for awarding 'INSPIRE Fellowship' for doctorial research and Pesticide Residue Laboratory, Department of Agricultural Entomology, MPKV, Rahuri for providing necessary facilities to carry out the research.

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How to cite this article:

Sawant, C.G. and Patil, C.S. 2018. Bio-efficacy of Newer Insecticides against Diamondback Moth (*Plutella xylostella* Linn.) in Cabbage at Farmers Field. *Int.J.Curr.Microbiol.App.Sci.* 7(07): 2986-2998. doi: https://doi.org/10.20546/ijcmas.2018.707.349