Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 741-747

Received: 17-01-2018
Accepted: 18-02-2018

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Bio-efficacy of some newly evolved novel insecticides against diamond back moth and tobacco caterpillar in cabbage

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Abstract
For diamond back moth and tobacco caterpillar management in cabbage we selected seven treatments of newer insecticides viz., PII 8007 20 % SC, Tolfenpyrad 15% EC, Cyantraniliprole 10.26 OD and Emamectin benzoate 5% SG and one control and from which four treatments were of PII 8007 20 % SC with four different dosages viz., 15, 20, 25 and 50 a.i./ha. The total two numbers of sprays were done when diamond back moth and tobacco caterpillar were severe on cabbage to be cause economic damage. For control of diamond back moth and tobacco caterpillar PII 8007 20% SC at the dosages of 50 a.i./ha was found most effective insecticides among selected seven insecticides along with control followed by Tolfenpyrad 15% EC. The remaining insecticides was found in following order, Cyantraniliprole10.26 OD > PII 8007 20% SC @ 25 a.i./ha > Emamectin benzoate 5% SG > PII 8007 20% SC @ 15 a.i/ha > PII 8007 20% SC @ 20 a.i./ha. This kind of research will be helpful in better way cabbage lepidopteran pest management specially diamond back moth and tobacco caterpillar.

Keywords: PII 8007, cyantraniliprole, tolfenpyrad, emamectin benzoate, cabbage

Introduction
Vegetables are important source of proteins, carbohydrates, vitamins contributing a significant role in nutritionally balanced diet of predominantly vegetarian population of our country. The cabbage (*Brassica oleracia var. capitata* L.) is an important cruciferous vegetable crop grown extensively all over the country. It is the fourth most widely grown vegetable crop over country. India is the second largest cabbage producing country after China in the world. In India area under cabbage cultivation is 0.38 Million hectares with total production of 8.53 Million tones and productivity 22.6 MT ha^{-1} [1]. Cabbage crop is infested by many insect-pests but most important are diamond back moth (*Plutella xylostella* Linn.) and tobacco caterpillar (*Spodoptera litura* Fab.). Diamond back moth (*Plutella xylostella* Linn.) is widely distributed and regarded as key pest of cabbage. It is the most serious pest of the Cabbage and other cole crops and responsible for low productivity of these crops in India. It is estimated about 50% loss in marketable yield due to attack of DBM on cabbage [10]. But due to indiscriminate use of conventional pesticides including synthetic pyrethroids to manage this pest has led to the development of resistance against insect. It is because of this, it built physiological dominance of detoxifying the xenobiotics and the DBM has attained worldwide importance[4].Therefore, safer, effective and less costly alternative to chemical control are desirable as a part of IPM. Recently, several pesticides with novel mode of action have been introduced to overcome this situation. Viewing the above situation, the present experiment were planned to test the newly introduced novel insecticides.

Materials and Methods
The experiment was carried out under field conditions during the year 2016-17 at the College of Agriculture, Indore (Madhya Pradesh). The experiment plot was ploughed twice with disc plough to achieve pulverized and compact transplanting beds and leveled with heavy plank. The farm yard manure (FYM) was applied just after the first ploughing in the main field. Half of the recommended dose of nitrogen fertilizer and full dose of phosphorous and pottasic fertilizers were applied at the last ploughing and just before transplantation. The rest of nitrogen fertilizer was applied through top dressing after 40 days of transplantation.

Seedlings of Globeman variety of cabbage were procured from Krishi Vigyan Kendram, Dhar (M.P.) and were used to raise the crop. Transplantation of seedlings was done on the 9th September, 2016. Seedlings of one month old were transplanted @ one seedling per hill at a spacing of 40 x 40 cm. Gap filling was done 10 days after to ensure uniform plant population in each plot. One main irrigation channel of 1meter width prepare in the experimental field and two sub-irrigation channels of 75 cm each were made to met out the irrigation requirement. Four irrigations were given to the experimental crop at an interval of 15-20 days. First irrigation was provided 10 days after transplantation. The other recommended agronomic practices like weeding, hoeing etc. were carried out as and when needed. The experiment was laid out in Randomized Block Design with 8 treatments including control. Required numbers of plots having a size of 3.2 x 2m were prepared to accommodate all the eight treatments, each having 3 replications. One main irrigation channel of 1m width was prepared at outside in the experimental field and two sub-irrigation channels were provided in between three replications. Each plot was separated by a gap of 1 m so that drifting of chemicals during spraying was minimized.

Bio-efficacy of selected insecticides molecules that are known to have novel mode of action viz., PII 8007, Cyantraniliprole, Tolfenpyrad, Emamectin benzoate were tested at their respective recommended field concentrations against diamond back moth and tobacco caterpillar on cabbage. The treatments were applying five weeks after transplantation when moderate infestation was observed and total two treatments were given on 04.11.2016 and 19.11.2016. Spraying was done during morning hours using a knapsack sprayer. The sprayer and the container used for preparing the spray fluid were thoroughly cleaned with water after each spray and rinsed with the insecticides to be used next. The spraying was done to the point of run-off for ensuring through coverage of the plant surface. The quantity of spray fluid was @ 500 liters per ha. i.e., 0.6 liters per plot during first spraying and it was gradually increased and at final spraying the quantity used was @ 625 liters per ha i.e., 0.75 liters per plot. Data on the pest's population were recorded at one day before spraying as a pre treatment count and at 1, 7 and 15 days after spraying as post treatment counts. The observations were recorded on 5 randomly selected plants which were tagged in each plot leaving the border rows. The diamond back moth and tobacco caterpillar population of larvae were counted during early morning hours on leaves from each five selected and tagged plants in each plot.

The per cent reduction of diamond back moth and tobacco caterpillar over untreated check in different treatments was calculated using Henderson and Tilton's (1955) formula as given below.

$$\text{Corrected \%} = \left(1 - \frac{\text{n in Co before treatment} * \text{n in T after treatment}}{\text{n in Co after treatment} * \text{n in T before treatment}}\right) * 100$$

Where: n = Insect population, T = treated, Co = control

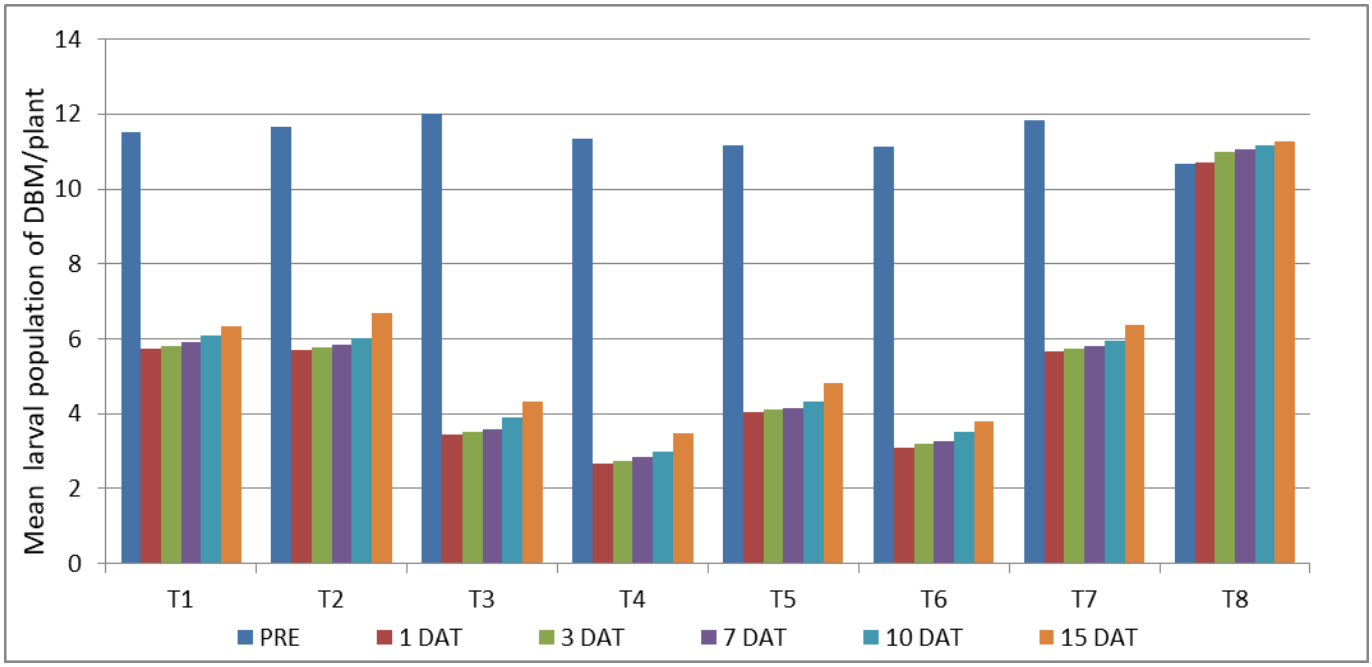

Fig 1: Effect of treatments against cabbage diamond back moth after first spray

T1-PII 8007 (20%SC)@15 g *a.i*/ha,T2-PII 8007 (20%SC)@20 g *a.i*/ha, T3-PII 8007 (20%SC)@25 g *a.i*/ha, T4-PII 8007 (20%SC)@50 g *a.i*/ha,T5-Cyantraniliprole 10.26%OD@60 g*a.i*/ha
T6-Tolfenpyrad 15%EC@150g *a.i*/ha, T7-Emamectin benzoate 5%SG @7.5 g *a.i*/ha, T8-Untreated check

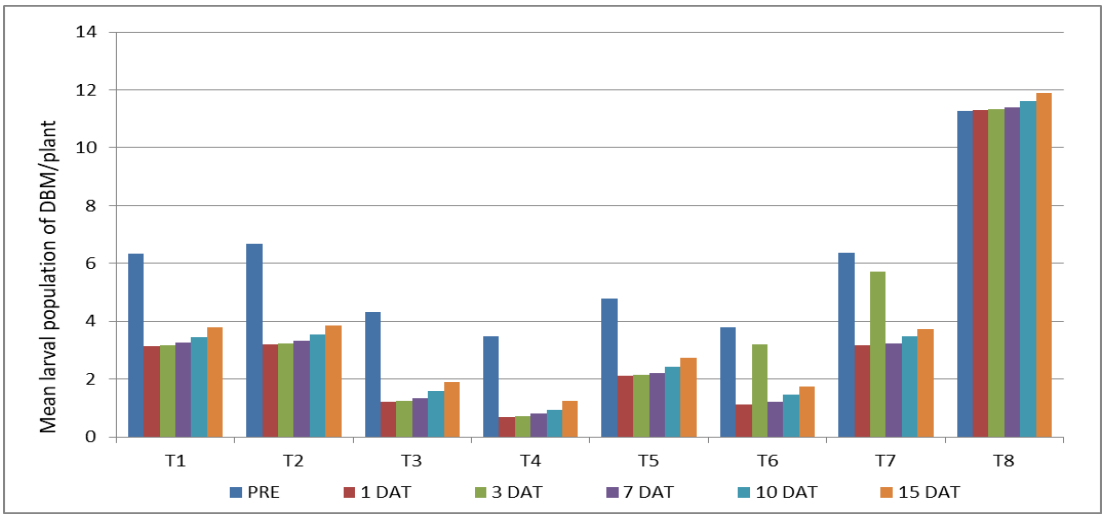

Fig 2: Effect of treatments against cabbage diamond back moth after second spray

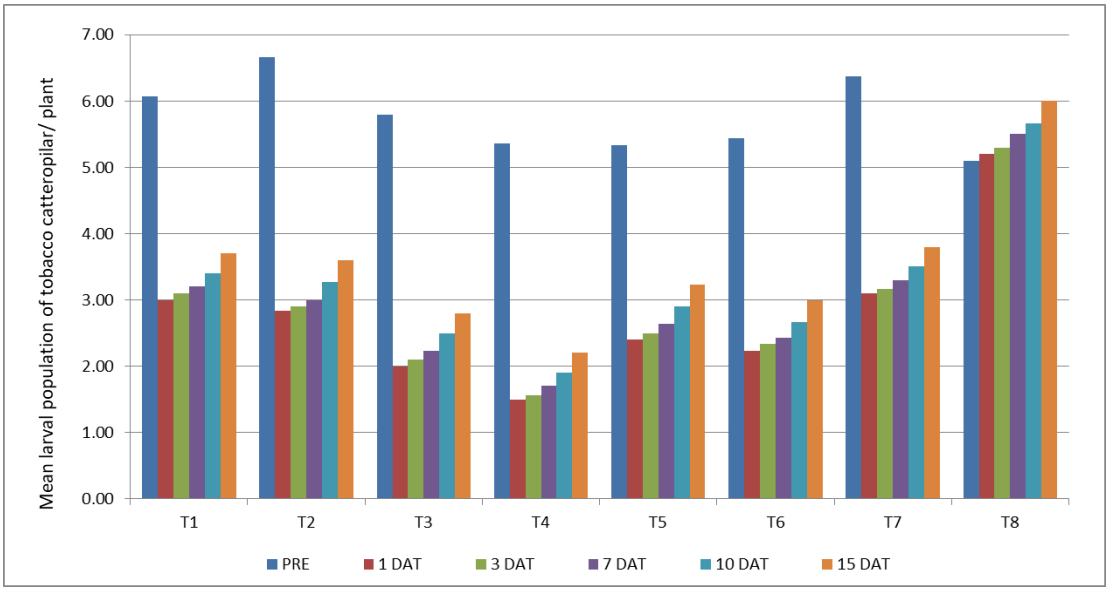

Fig 3: Effect of treatments against tobacco caterpillar after first spray

T1-PII 8007 (20%SC)@15 g *a.i*/ha,T2-PII 8007 (20%SC)@20 g *a.i*/ha, T3-PII 8007 (20%SC)@25 g *a.i*/ha, T4-PII 8007 (20%SC)@50 g *a.i*/ha,T5-Cyantraniliprole 10.26%OD@60 g*a.i*/ha T6-Tolfenpyrad 15%EC@150g *a.i*/ha, T7-Emamectin benzoate 5%SG @7.5 g *a.i*/ha, T8-Untreated check

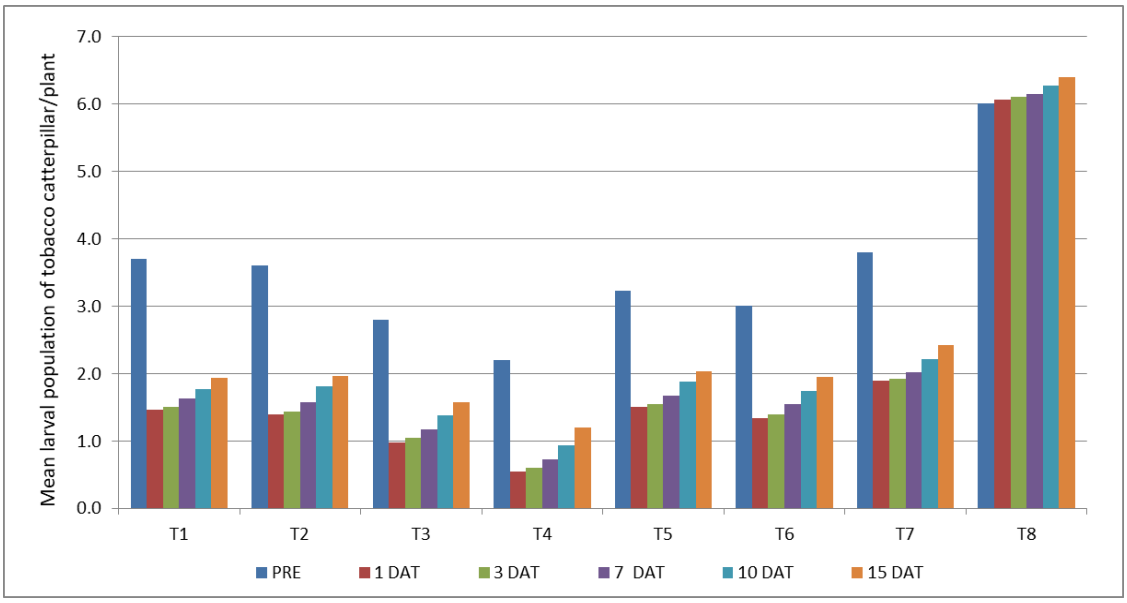

Fig 4: Effect of treatments against tobacco caterpillar after second spray

T1-PII 8007 (20%SC)@15 g *a.i*/ha,T2-PII 8007 (20%SC)@20 g *a.i*/ha, T3-PII 8007 (20%SC)@25 g *a.i*/ha, T4-PII 8007 (20%SC)@50 g *a.i*/ha,T5-Cyantraniliprole 10.26%OD@60 g*a.i*/ha
T6-Tolfenpyrad 15%EC@150g *a.i*/ha, T7-Emamectin benzoate 5%SG @7.5 g *a.i*/ha, T8-Untreated check

Effects of treatments against diamond back moth on cabbage after first spray

Pre-treatment observation was revealed that the larval population ranged from 10.67 to 12.00 One day after treatments all the treatments differed significantly with untreated check. The larval population ranged from 2.67 to 10.70. The minimum larval count was recorded in T_4 (2.67) which was at par with T_6 (3.10) and T_3 (3.43) and differed significantly with rest of the treatments. The maximum incidence was recorded in untreated T_8 (10.70). Three days after first insecticidal spray the insect population ranged from 2.73 to 11.00. The treatment T_4 (2.73) showed its superiority over all the treatments but found at par with T_6 (3.20), T3 (3.50) and T_5 (4.10) and followed with T_7 (5.73), T2 (5.77) and T_1 (5.80). The maximum count of larvae was recorded in T_8 (11.00). All the treatments showed significant difference with untreated check.

Seven Days after the least larval population was noted in T_4 (2.83) and showed non-significant different with T_6 (3.27), T_3 (3.57) and T_5 (4.13) followed by T_7 (5.80), T_2 (5.83) and T_1 (5.90). The maximum population was observed in T_8 (11.07). All the treatments exhibited significant difference with untreated check. Ten days after first spray the insect population ranged from 3.00 to 11.17. The treatment T_4 (3.00) showed its superiority over all the treatments but found at par with T_6 (3.50), T_3 (3.90) and T_5 (4.33) and followed with T_7 (5.93), T_2 (6.00) and T_1 (6.07). The maximum count of larvae was recorded in untreated check T_8 (11.17). All the treatments were significantly superior over untreated check. Fifteen Days after spray the minimum larval number was observed in treatment T_4 (3.47) and found at par with T_6 (3.80), T_3 (4.33) and T_5 (4.80) followed by T_1 (6.33), T_7 (6.37) and T_2 (6.67). The maximum larval count of was observed in T_8 (11.27). The performance of all the treatments was significantly better over untreated check.

Per cent larval population reduction

The maximum reduction in larval number was recorded in T_4-PII 8007 20% SC @ 250 mlha^{-1} (69.37%) followed by T_6-tolfenpyrad 15% EC @ 1000 mlha^{-1} (65.86%), T_3-PII 8007 20 % SC @ 125 mlha^{-1} (63.91%), T_5-cyantraniliprole 10.26 OD @ 600 mlha^{-1} (57.02%), T_7-emamectin benzoate 5 % SG @ 150 gmha^{-1} (46.15%), T_1-PII 8007 20% SC @75 mlha^{-1} (44.95%) and T_2-PII 8007 20% SC 100 mlha^{-1} (42.84%).

After second spray

One Day after second insecticidal spray the insect population ranged from 0.70 to 11.30. The treatment T_4 (0.70) showed its superiority over all the treatments but found at par with T_6 (1.13). The next best treatment was noted as T_3 (1.23) which differed significantly with remaining treatments followed as, T_5 (2.13), T1 (3.15), T_7 (3.16), T_2 (3.20). The maximum larval count was recorded in T_8 (11.30). All the treatments showed significant difference with untreated check. Three Days after treatments larval population ranged from 0.73 to 11.33. The minimum larval count was recorded in T_4 (0.73) which was at par with T_6 (1.15) and differed significantly with rest of the treatments. The maximum insect population was recorded in untreated check T_8 (11.33). Seven Days after second insecticidal spray the minimum larval number was noticed in treatment T_4 (0.80) and found at par with T_6 (1.23) and differed significantly with remaining treatments followed by T_3 (1.35), T_5 (2.22), T_7 (3.24), T_1 (3.26) and T_2 (3.32). The maximum larval count was observed in T_8 (11.40). The performance of all the treatments was significantly better over untreated check. Ten Days after treatment the least larval population was noted in T_4 (0.95) and showed non-significant different with T_6 (1.45) and T_3 (1.60) followed by T_5 (2.42), T_7 (3.47), T_1 (3.44) and T_2 (3.53). The maximum population was observed in T_8 (11.60). All the treatments exhibited significant difference with untreated check. Fifteen Days after second spray the insect population ranged from 1.26 to 11.90. The treatment T_4 (1.26) found superior over all the treatments but exhibited non-significant difference with T_6 (1.73) and T_3 (1.91) and followed with T_5 (2.75), T_7 (3.72), T_1 (3.78), T_2 (3.85). The maximum count of larvae was recorded in untreated check T_8 (11.90). All the treatments were significantly superior over untreated check.

Per cent larval population reduction

The maximum reduction in larval number was recorded in T_4-PII 8007 20% SC @ 250 mlha^{-1} (63.68%) followed by T_3-PII 8007 20% SC @ 125 mlha^{-1}(55.88%), T_6-tolfenpyrad 15% EC @ 1000 ml ha^{-1}(54.47%), T_5-cynantraniliprole10.26OD @600mlha^{-1} (42.70%), T_2-PII8007 20% SC 100 mlha^{-1} (42.27%), T_7-emamectin benzoate 5 % SG @ 150 gm ha^{-1}(41.60%) and T_1-PII 8007 20% SC @ 75 mlha^{-1} (40.28%).

Overall Per cent larval population reduction

The maximum reduction in larval number was calculated in T_4-PII 8007 20% SC @ 250 mlha^{-1} (88.87%) followed by T_6-tolfenpyrad15% EC @ 1000 mlha^{-1} (84.45%), T_3-PII 8007 20 % SC @ 125 mlha^{-1}(84.08%), T_5-cyantraniliprole 10.26 OD @ 600 mlha^{-1} (75.38%), T_7-emamectin benzoate 5% SG @ 150 gmha^{-1}(68.55%), T_1-PII 8007 20% SC @ 75 mlha^{-1} (67.82%) and T_2-PII 8007 20 % SC 100 mlha^{-1}(67.00%).

The effects of tolfenpyrad 15% EC against *Plutella xylostella* L. which was 97.9%, 97.8% and 92.3% at 1150.0, 862.5 and 575.0 mlha^{-1} after seven days of treatment in field experiment [6]. It was also noticed maximum reduction in larval population of DBM by tolfenpyrad @ 150 g *a.i*.ha^{-1} which ranged from 25.01 to 96.39% [2]. Two workers reported the effectiveness of cyantraniliprole and chlorantraniliprole against diamond back moth (*Plutella xylostella* L) on cabbage [13] and [3]. Various workers reported the effectiveness of emamectin benzoate against diamond back moth (*Plutella xylostella* L.) on cabbage [8, 10, 11, 12]. The findings of these researchers were in partial agreement with the present investigations as the highly effective insecticide in the study is a new chemical of novel insecticide group. Further they found the association with other tested insecticides and supported the present study.

Table 1: Effect of treatments against cabbage diamond back moth after first spray

Treatments	Dosage g. *a i*. ha^{-1}	Dose form ha^{-1}(gm/ml)	Pre-treatment	Number of DBM larvae/plant					% reduction
				1DAT	3DAT	7DAT	10DAT	15DAT	
T_1- PII 8007(20%SC)	15	75	11.50 (3.45)	5.73 (2.50)	5.80 (2.51)	5.90 (2.53)	6.07 (2.56)	6.33 (2.61)	44.95
T_2- PII 8007(20%SC)	20	100	11.67 (3.48)	5.70 (2.49)	5.77 (2.50)	5.83 (2.52)	6.00 (2.55)	6.67 (2.68)	42.84
T_3- PII 8007(20%SC)	25	125	12.00 (3.53)	3.43 (1.98)	3.50 (2.00)	3.57 (2.02)	3.90 (2.10)	4.33 (2.20)	63.91
T_4- PII 8007(20%SC)	50	250	11.33 (3.44)	2.67 (1.78)	2.73 (1.80)	2.83 (1.82)	3.00 (1.87)	3.47 (1.99)	69.37
T_5-Cyantraniliprole10.26 OD	60	600	11.17 (3.41)	4.03 (2.13)	4.10 (2.14)	4.13 (2.15)	4.33 (2.20)	4.80 (2.30)	57.02
T_6-Tolfenpyrad 15%EC	150	1000	11.13 (3.67)	3.10 (1.89)	3.20 (1.92)	3.27 (1.94)	3.50 (2.00)	3.80 (2.07)	65.86
T_7-Emamectin benzoate 5%SG	7.5	150	11.83 (3.47)	5.67 (2.48)	5.73 (2.50)	5.80 (2.51)	5.93 (2.54)	6.37 (2.62)	46.15
T_8-Untreated control			10.67 (3.33)	10.70 (3.32)	11.00 (3.36)	11.07 (3.37)	11.17 (3.38)	11.27 (3.40)	-----
S Em			--	0.11	0.12	0.13	0.12	0.13	
CD at 5 %			NS	0.34	0.38	0.40	0.37	0.40	
CV %			--	8.46	9.18	9.61	8.85	9.31	

Table 2: Effect of treatments against cabbage diamond back moth after second spray

Treatments	Dosage g *a i* ha^{-1}	Dose form ha^{-1}(ml/gm)	Pre-treatment	Number of DBM larvae/plant					% reduction	% overall reduction
				1DAT	3DAT	7DAT	10DAT	15DAT		
T_1- PII 8007(20%SC)	15	75	6.33 (2.61)	3.15 (1.90)	3.18 (1.92)	3.26 (1.94)	3.44 (1.98)	3.78 (2.07)	40.28	67.82
T_2- PII 8007(20%SC)	20	100	6.67 (2.68)	3.20 (1.92)	3.23 (1.93)	3.32 (1.95)	3.53 (2.01)	3.85 (2.09)	42.27	67.00
T_3- PII 8007(20%SC)	25	125	4.33 (2.20)	1.23 (1.32)	1.26 (1.33)	1.35 (1.36)	1.60 (1.45)	1.91 (1.55)	55.88	84.08
T_4- PII 8007(20%SC)	50	250	3.47 (1.99)	0.70 (1.09)	0.73 (1.11)	0.80 (1.14)	0.95 (1.20)	1.26 (1.33)	63.68	88.87
T_5-Cyantraniliprole10.26 OD	60	600	4.80 (2.30)	2.13 (1.62)	2.16 (1.63)	2.22 (1.65)	2.42 (1.71)	2.75 (1.80)	42.70	75.38
T_6-Tolfenpyrad 15%EC	150	1000	3.80 (2.07)	1.13 (1.28)	1.15 (1.29)	1.23 (1.32)	1.45 (1.40)	1.73 (1.49)	54.47	84.45
T_7 Emamectin benzoate 5%SG	7.5	150	6.37 (2.62)	3.16 (1.91)	3.20 (1.92)	3.24 (1.93)	3.47 (1.99)	3.72 (2.06)	41.60	68.55
T_8-Untreated control			11.27 (3.40)	11.30 (3.43)	11.33 (3.44)	11.40 (3.44)	11.60 (3.46)	11.90 (3.50)	-----	-----
S Em			--	0.07	0.06	0.06	0.10	0.09		
CD at 5 %			NS	0.20	0.19	0.19	0.29	0.28		
CV %			--	6.40	5.84	5.93	8.75	7.94		

Table 3: Effect of treatments against tobacco caterpillar after first spray

Treatments	Dosage g *a i* ha^{-1}	Dose form ha^{-1} (ml/gm)	Pre-treatment	Number of tobacco caterpillar larvae/plant					% reduction
				1DAT	3 DAT	7 DAT	10 DAT	15DAT	
T_1- PII 8007(20%SC)	15	75	6.07 (2.56)	3.00 (1.87)	3.10 (1.90)	3.20 (1.92)	3.40 (1.97)	3.70 (2.05)	39.04
T_2- PII 8007(20%SC)	20	100	6.67 (2.68)	2.83 (1.82)	2.90 (1.84)	3.00 (1.87)	3.27 (1.94)	3.60 (2.02)	46.02
T_3- PII 8007(20%SC)	25	125	5.80 (2.51)	2.00 (1.58)	2.10 (1.61)	2.23 (1.65)	2.50 (1.73)	2.80 (1.82)	51.72
T_4- PII 8007(20%SC)	50	250	5.37 (2.42)	1.50 (1.41)	1.57 (1.44)	1.70 (1.48)	1.90 (1.55)	2.20 (1.64)	59.03
T_5-Cyantraniliprole10.26 OD	60	600	5.33 (2.41)	2.40 (1.70)	2.50 (1.73)	2.63 (1.77)	2.90 (1.84)	3.23 (1.93)	39.39
T_6-Tolfenpyrad 15%EC	150	1000	5.43 (2.43)	2.23 (1.65)	2.33 (1.68)	2.43 (1.71)	2.67 (1.78)	3.00 (1.87)	44.75
T_7-Emamectin benzoate5%SG	7.5	150	6.37 (2.62)	3.10 (1.90)	3.17 (1.91)	3.30 (1.95)	3.50 (2.00)	3.80 (2.07)	40.34
T_8-Untreated control			5.10 (2.37)	5.20 (2.38)	5.30 (2.39)	5.50 (3.20)	5.67 (2.43)	6.00 (2.51)	------
S Em			--	0.07	0.08	0.10	0.13	0.11	
CD at 5 %			NS	0.20	0.25	0.32	0.40	0.34	
CV %			--	6.44	7.83	9.81	11.98	9.89	

Table 3: Effect of treatments against tobacco caterpillar after second spray

Treatments	Doses g.*a i* ha^{-1}	Form. ml or gm ha^{-1}	Pre-treatment	Number of tobacco caterpillar larvae/plant					% reduction	Overall reduction %
				1 DAT	3 DAT	7 DAT	10DAT	15DAT		
T_1- PII 8007(20%SC)	15	75	3.70 (2.05)	1.46 (1.40)	1.50 (1.42)	1.63 (1.46)	1.76 (1.50)	1.93 (1.56)	47.83	68.20
T_2- PII 8007(20%SC)	20	100	3.60 (2.02)	1.40 (1.38)	1.44 (1.39)	1.58 (1.44)	1.81 (1.52)	1.97 (1.57)	45.27	70.46
T_3- PII 8007(20%SC)	25	125	2.80 (1.82)	0.98 (1.22)	1.05 (1.25)	1.18 (1.29)	1.38 (1.37)	1.58 (1.44)	43.57	72.75
T_4- PII 8007(20%SC)	50	250	2.20 (1.64)	0.55 (1.02)	0.61 (1.05)	0.73 (1.11)	0.94 (1.20)	1.20 (1.30)	45.45	77.65
T_5-Cyantraniliprole10.26 OD	60	600	3.23 (1.93)	1.50 (1.41)	1.55 (1.43)	1.67 (1.47)	1.88 (1.54)	2.04 (1.59)	36.84	61.72
T_6-Tolfenpyrad 15%EC	150	1000	3.00 (1.87)	1.34 (1.36)	1.40 (1.38)	1.54 (1.43)	1.75 (1.50)	1.95 (1.57)	35.00	64.08
T_7-Emamectin benzoate5%SG	7.5	150	3.80 (2.07)	1.90 (1.55)	1.93 (1.56)	2.02 (1.59)	2.22 (1.65)	2.43 (1.71)	63.94	61.85
T_8-Untreated control			6.00 (2.51)	6.07 (2.56)	6.10 (2.56)	6.15 (2.57)	6.27 (2.59)	6.40 (2.60)	-----	
S Em			--	0.09	0.08	0.08	0.10	0.11		
CD at 5 %			NS	0.26	0.24	0.23	0.31	0.33		
CV %			--	10.15	9.15	8.67	10.85	11.42		

Effects of treatments after first spray against Tobacco caterpillar on cabbage

Pre treatment larval population was ranged from 5.10 and 6.67. One day after the larval population ranged from 1.50 to 5.20. The minimum larval count was recorded in T_4 (1.50) which was at par withT_3 (2.00) and differed significantly with rest of the treatments. The maximum larval population was recorded in untreated T_8 (5.20). Three days after the treatments insect population ranged from 1.57 to 5.30. The treatment T_4 (1.57) showed its superiority over all the treatments but found at par with T_3 (2.10) and T_6 (2.33). Among the remaining treatments the better performance was noted in T_5 (2.50) followed by T_2 (2.90), T_1 (3.10) and T_7 (3.17). The maximum count of larvae was recorded in T_8 (5.30). Seven days after the first spray the least larval count was noted in T_4 (1.70) and showed its superiority over all the treatments but found at par with T_3 (2.23), T_6 (2.43) and T_5 (2.63) followed by T_2 (3.00), T_1 (3.20) and T_7 (3.30). The maximum count of larvae was recorded in T_8 (5.50). All the treatments exhibited significant difference with untreated check. Ten days after first insecticidal spray the larval count was recorded in the range of 1.90 to 5.67. The treatment T_4 (1.90) showed best performance with least larval number but found at par with T_3 (2.50), T_6 (2.67) and T_5 (2.90) followed by T_2 (3.27), T_1 (3.40) and T_7 (3.50). The maximum number of larvae was recorded in T_8 (5.67). All the treatments differed significantly with untreated check. Fifteen days after the insect population ranged from 2.20 to 6.00. The treatment T_4 (2.20) showed its superiority over all the treatments but found at par with T_3 (2.80), T_6 (3.00) and T_5 (3.23) and followed with T_2 (3.60), T_1 (3.70) and T_7 (3.80). The maximum count of larvae was recorded in T_8 (6.00).The effect of all the treatments was significantly different with untreated check.

Per cent larval population reduction

The maximum larval population reduction was calculated in T_4-PII 8007 20% SC followed by T_3-PII8007 20% SC @ 125 mlha^{-1} (51.72%), T_2-PII 8007 20% SC @ 100 mlha^{-1} (46.02%), T_6-tolfenpyrad15% EC @ 1000 mlha^{-1} (44.75%), T_7-emamectin benzoate 5% SG @150 gmha^{-1} (40.34%), T_5-cyantraniliprole 10.26OD @ 600 mlha^{-1} (39.39%) and T_1-PII 8007 20% SC @75 mlha^{-1} (39.04%).

After second spray

One day after the second spray the larval population ranged from 0.55 to 6.07. The minimum larval count was recorded in T_4 (0.55) which was at par with T_3 (0.98) and differed significantly with rest of the treatments. The maximum number was recorded in untreated check T_8 (6.07). All the treatments differed significantly with untreated check. Three days after the second spray the insect population ranged from 0.61 to 6.10. The treatment T_4 (0.61) showed the best effect over all the treatments but found at par with T_3 (1.05) and followed with T_6 (1.40), T_2 (1.44), T_1 (1.50), T_5 (1.55) and T_7 (1.93). The maximum count of larvae was recorded in T_8 (6.10). All the treatments showed significantly superior effect over untreated check. Seven days after the second insecticidal spray the least larval population was noted in T_4 (0.73) and showed non-significant different with T_3 (1.18), T_6 (1.54) and T_2 (1.58) followed by T_1 (1.63) T_5 (1.67) and T_7 (2.02).The maximum population was observed in T_8 (6.15). All the treatments exhibited significant difference with untreated check. Ten days after the second treatments the minimum larval number was noticed in treatment T_4 (0.94) and found at par with T_3 (1.38), T_6 (1.75) and T_1 (1.76) and followed by T_2 (1.81), T_5 (1.88) and T_7 (2.22). The highest larval count of was noticed in T_8 (6.27). The performance of all the treatments was significantly superior over untreated check. Fifteen days after the second spray the insect population ranged from 1.20 to 6.40. The treatment T_4 (1.20) exhibited the best performance over all the treatments but differed non-significantly with T_3 (1.58), T_1 (1.93), T_6 (1.95), T_2 (1.97), T_5 (2.04) and followed by T_7 (2.43). The maximum count of larvae was recorded in T_8 (6.40). All the treatments showed significant difference with untreated check.

Per cent larval population reduction

The maximum reduction in larval number was recorded in T_7-emamectin benzoate 5% SG @150 gmha^{-1} (63.94%) followed by T_1-PII 8007 20% SC @ 75 mlha^{-1} (47.83%), T_4-PII 8007 20% SC @ 250 mlha^{-1} (45.45%), T_2-PII8007 20% SC @ 100 mlha^{-1} (45.27%), T_3-PII 8007 20% SC @ 125 mlha^{-1}(43.57%), T_5-cyantraniliprole 10.26 OD @ 600 mlha^{-1} (36.84%) and T_6-tolfenpyrad15% EC @ 1000 mlha^{-1} (35.00%).

Overall Per cent larval population reduction

The Overall maximum reduction in larval number was recorded in T_4-PII 8007 20% SC @ 250 mlha^{-1} (77.65%) followed by T_3-PII 8007 20% SC @ 125 mlha^{-1} (72.75%), T_2-PII 8007 20% SC @ 100 mlha^{-1} (70.46%), T_1-PII 8007 20% SC @ 75 mlha^{-1} (68.20%), T_6-tolfenpyrad 15% EC @1000 mlha^{-1} (64.08%), T_7-emamectin benzoate 5% SG @ 150 gmha^{-1}(61.85%) and T_5-cyantraniliprole 10.26 OD @ 600 mlha^{-1} (61.72%).

Various workers reported the effectiveness of cyantraniliprole and chlorantraniliprole against tobacco caterpillar [5, 7, 14, 6]. The findings of these researchers were in partial association

with the present study as the insecticide was not tested on same crop as in present study.

Conclusion

1. The highest reduction in larval population of *Plutella xylostella*, was recorded in treatment T_4- PII 8007 @ 50 g *a.i.* ha^{-1} (88.87%) followed by T_6 -tolfenapyrad 15% EC @ 150 g *a.i* ha^{-1} (84.45%), T_3-PII 8007 20% SC @ 25 g *a.i* ha^{-1} (84.08%).
2. The highest tobacco caterpillar population reduction was noted in T_4-PII 8007 20% SC @ 250 ml ha^{-1} (77.65%) followed by T_3-PII 8007 20%SC @125 ml ha^{-1} (72.75%) and T_2-PII 8007 20% SC 100 ml ha^{-1} (70.46%).

Acknowledgement

I want to give acknowledgement to RVSKVV, Gwalior (College of Agriculture, Indore) for admitting me for doing Master Degree and provide such a good facilities for research.

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