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Bio-efficacy of spinetoram insecticide against leaf eating caterpillar (S*podoptera litura* Linn.) in cabbage

Ashithosh Mohanan, Gajendra Chandrakar, Krishna Gupta and Hemlata

Abstract
Investigation was undertaken during 2020 and 2021 on experimental field of research cum instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) to study the bio-efficacy of newer insecticide against *Spodoptera litura*. infesting cabbage. The cabbage crop was raised by following recommended package of practices except for plant protection measures. Highest Percent reduction of *Spodoptera litura* population over untreated control was observed in treatment no. (T4) i.e Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i./ha. (78.43%) followed by (T3) Spinetoram 12% SC w/v (11.7% w/w) SC@ 54 g.a.i/ha, (76.14%).There was minimum percent reduction of *Spodoptera litura* population (50.00%) over untreated control in treatment no. (T1) i.e. Spinetoram 12% SC w/v (11.7% w/w) SC @ 36 g.a.i./ha. The highest increase in yield over control was observed in treatment no. (T4) i.e Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i. /ha (73.63%) followed by treatment no. (T3) Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g.a.i./ha, (65.04%).

Keywords: Spinetoram insecticide, leaf eating caterpillar, S*podoptera litura* Linn., cabbage

Introduction
For India's primarily vegetarian population, vegetables are a major source of carbohydrates, proteins, minerals, and roughages. After China, India is the world's second-largest producer of vegetables. Low vegetable consumption may be connected to a lack of availability coupled with a high price that is out of reach for most people. Vegetarianism is becoming more popular around the world, resulting in an increase in the vegetable market. As a result, there is a lot of room for increasing vegetable production to meet domestic demand at reasonable prices while also gaining foreign cash on the international market. Cole crops are superior to other winter vegetables and are grown all around the country. Cabbage, cauliflower, Knol-khol, Brussels sprouts, sprouting broccoli, and Chinese cabbage are examples of cole crops. They are members of the Cruciferae family and the genus Brassica. Cabbage (*Brassica oleracea* var. capitata Linn.) is a popular cole vegetable that is grown on around 0.39 million hectares and produces 8.80 million tonnes. It is grown for the edible expanded terminal buds known as head, which are high in vitamins A, B1, and C, as well as minerals like as phosphorus, potassium, salt, calcium, and iron. This crop is native to West Europe and the Mediterranean's northern coastlines.
Pests such as the tobacco caterpillar, diamondback moth, painted bug, cabbage semilooper, aphids, flea beetle, and others damage the crop. In India, 37 insect pests have been identified as feeding on cabbage, with the diamondback moth, *Plutella xylostella* Linneaus, cabbage butterfly, *Pieris brassicae* Linneaus, and mustard aphid, *Lipaphis erysimi* Kaltenbach, being the most serious threats to the crop's profitability. Diamondback moth is a widespread crucifer pest, and *M. persicae* is a highly polyphagous aphid that has been recorded to feed on over 500 kinds of host plants from at least forty different families, including some major agricultural crops. Because of their versatility, effectiveness, and fast control, insecticides have been frequently employed to control pests on vegetables. The indiscriminate and illogical application of insecticides at high levels has resulted in insect pest recurrence and resistance, as well as residues in food. The indiscriminate use has increased the expense of cultivation and has resulted in certain irreversible biosphere alterations. As a result, novel pesticide molecules with high toxicity to insect pests even at low dosages are needed, which should also be safer for natural enemies in the agro-ecosystem as well as the customer.

Method and Materials
Field Studies
The studies were undertaken on the Indira Gandhi Krishi Vishwavidyalaya's research and instructional farm in Raipur in the years 2020 and 2021. (C.G.). The study used a randomised block design (RBD) with seven treatments, including an untreated control, and was duplicated three times. The crop was grown on a plot of 25 sqm (5x5m) with 60 x 60cm spacing and prescribed agronomic techniques. The insecticides evaluated were Spinetoram 12% SC 36 g a.i/ha, Spinetoram 12% SC 45 g a.i/ha, Spinetoram 12% SC 54 g a.i/ha, Spinetoram 12% SC 67.5 g a.i/ha, Emamectin benzoate 5.00% SG 7.60 g a.i/ha, Spinosad 2.5% SC 7.90 g a.i/ha. When the attack of *S. litura* larvae reached ETL, insecticides were sprayed as foliar sprays. Insecticidal treatments were diluted in water (500 L ha^{-1}) and applied with a hollow cone nozzle using a knapsack sprayer (16 L). There were two rounds of applications in all. The larvae on the head and outside the head were counted One day before the spray (pre-count) and one, three, seven, ten, and fourteen days after the spray were recorded. The "Direct Visual Counting Method" was used to estimate the *S. litura* population. Five plants were chosen at random from each repeated plot, and the larvae population on these plants was counted on a weekly basis.

Statistical Analysis
Observation on live larvae per plant will be recorded on the following parameters: one day before application (pre-treatment an and then at 1^{st}, 3^{rd}, 7^{th} 10^{th} and 14^{th} day after each application or till until treatment effect continues. Efficacy of different treatment in controlling the insect pests was determined by calculating percent reduction with the formula given by Henderson and Tilton (1955) which is as under:

$$\text{The percent reduction in population} = 100 \times \left[1 - \frac{T_a - C_b}{T_b - C_a}\right]$$

Where,
Ta = Number of insects after treatment
Tb = Number of insects before treatment
Ca = Number of insects in untreated check after treatment
Cb = Number of insects in untreated check before treatment

The values of percent reduction will be transformed to angular values, from which analysis of variance will be calculated for determining critical difference (C.D) at 5 percent level of significance.

Result and Discussion
I Year
The data (Table 01) revealed that all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the larval population of *S. litura* at all the days (1, 3, 7, 10 and 14 DAS) of observations. The overall results of first and second spray indicated that, Spinetoram 12% SC @ 67.5 g a.i. ha^{-1} recorded lowest number of larval population of *S. litura* and proved to be superior over all the remaining treatments (2.35 over all mean larvae). Whereas, Spinetoram 12% SC @ 54 g a.i. ha^{-1} with 2.865 over all mean no. of larvae after 1^{st} and 2^{nd} spray was the next promising treatment. It was however at nearly at par with Spinetoram 12% SC @ 67.5 g a.i ha^{-1}. Emamectin benzoate 5.00% SG @ 10 g a.i. ha^{-1} was next in the order of effectiveness showing over all mean larval population of 3.358 larvae. It was followed by Spinosad 2.5% SC @ 17.50 g a.i. ha^{-1} and Spinetoram 12% SC @ 45 g a.i. ha^{-1} which were recorded with 3.567 larvae and 4.056 over all mean larvae after 1^{st} and 2^{nd} spray respectively. Untreated plots showed maximum over all mean number of larval population i.e. 8.666 after 1^{st} and 2^{nd} spray.

II year
The data (Table: 02) revealed that, all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the larval population of *S. litura* at all the days i.e. 1, 3, 7, 10 and 14 DAS of observations. The over all mean number of larval population ranged between 1.11 and 3.28 as against 7.93 in untreated control. The overall results of first and second spray indicated that, Spinetoram 12% SC @ 54 g a.i. ha^{-1} recorded lowest number of larval population of *S. litura* and proved to be superior over all the remaining treatments (1.115 over all mean no. of larvae). Whereas, Spinetoram 12% SC @ 67.5 g a.i. ha^{-1} with 1.235 over all mean no. of larvae after 1^{st} and 2^{nd} spray data was the next promising treatment. It was however at nearly at par with Spinetoram 12% SC @ 67.5 g a.i/ha. Emamectin benzoate 5.00% SG @ 10 g a.i. ha^{-1} was next in the order of effectiveness showing over all mean larval population of 1.608 larvae. It was followed by Spinosad 2.5% SC @ 17.50 g a.i. ha^{-1} and Spinetoram 12% SC @ 45 g a.i. ha^{-1} which were recorded with 1.817 larvae and 2.306 over all mean no. larvae after 1st and 2nd spray data respectively. Untreated plots showed maximum over all mean number of larval population i.e. 7.938 after 1st and 2nd spray.

Cumulative bio-efficacy of newer insecticides against P. xylostella during I and II year (Pooled)
The pooled analysis data of both the years 2020 and 2021 on bio-efficacy of newer insecticides against the larval population of *S. litura* on cabbage are presented in Table 3. It could be seen that, all the insecticidal treatments were significantly superior in reducing the infestation of *S. litura* over untreated control. The overall mean number of larval population ranged between 1.794 and 8.302. Spinetoram 12% SC @ 67.5 g a.i. ha^{-1} consistently proved its superiority by recording least larval population 1.794 with highest per cent reduction in larval population of *S. litura* over control (78.43%). Next in order of effectiveness was Spinetoram 12% SC @ 54 g a.i. ha^{-1} (1.99 over all mean no. of larvae in both year) with 76.14 per cent larval reduction and Emamectin benzoate 5.00% SG @ 10 g a.i. ha^{-1} (2.483 over all mean no. of larvae in both year) with 70.24 per cent larval reduction, The next effective treatments were Spinosad 2.5% SC @ 17.50 g a.i. ha^{-1} (2.692 larvae with 67.70% larval reduction) followed by Spinetoram 12% SC @ 45 g a.i. ha^{-1} (3.181 larvae $plant^{-1}$ with 61.80 per cent larval reduction). Maximum larval population was recorded in the untreated control (8.302 larvae).

Yield
The two years mean data of total head yield of cabbage showed that all the treatments ware significantly superior over untreated control. The yield of cabbage head presented in table no. 03, ranged between 153.06 to 265.76. Minimum cabbage head yield was recorded under treatment (T7)

untreated control, (153.06 q/ha.). The maximum head yield of cabbage was recorded under treatment no. (T4) i.e. Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i/ha (265.76 q/ha) followed by treatment no. (T3) i.e Spinetoram 12% SC w/v (11.7% w/w) SC@ 54 g.a.i/ha (253.21q/ha). The yield from both treatment T3 and T4 was found statistically on par.

Table 1: Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against Leaf eating caterpillar (*Spodoptera litura*) on cabbage during rabi 2020

S.N.	Treatments	Dose g a.i./ha	Pre-treatment population/ 5 plants	Average no. of caterpillar/5 plants										Over all mean
				I Spray					II Spray					
				1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	9.26 (8.12)	4.86 (3.35)	5.07 (4.25)	5.06 (4.12)	5.59 (4.39)	5.51 (4.4)	4.59 (3.75)	4.44 (4.0)	4.15 (3.9)	5.15 (4.08)	5.95 (4.40)	5.037
T2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	9.45 (8.25)	3.52 (2.49)	3.97 (2.9)	4.49 (3.90)	3.7 (2.7)	4.00 (3.7)	3.69 (2.47)	3.78 (2.51)	4.14 (3.45)	4.65 (3.56)	4.62 (3.52)	4.056
T3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	9.45 (8.25)	2.15 (1.04)	2.80 (1.83)	2.66 (1.70)	3.45 (2.88)	3.65 (2.91)	2.16 (1.64)	2.22 (1.58)	.2.74 (1.38)	3.26 (2.85)	3.56 (2.90)	2.865
T4	* Spinetoram 12% SC w/v (11.7% w/w) SC	67.5	10.25 (9.01)	2.10 (1.00)	2.50 (1.50)	0.79 (1.70)	2.43 (3.75)	3.42 (1.98)	2.10 (1.8)	3.17 (2.75)	2.70 (1.66)	0.79 (1.81)	3.53 (2.02)	2.353
T5	Emamectin benzoate 5.00% SG	10	10.56 (9.20)	3.40 (2.00)	3.45 (2.99)	3.49 (2.84)	3.40 (2.97)	3.42 (1.98)	2.83 (1.82)	2.90 (1.75)	3.00 (1.66)	3.79 (1.99)	3.90 (2.02)	3.358
T6	Spinosad 2.5% SC	17.50	10.43 (9.16)	3.50 (2.01)	3.61 (1.88)	2.37 (1.66)	3.57 (1.43)	4.00 (1.89)	2.44 (1.70)	3.95 (2.55)	3.62 (2.43)	4.01 (1.81)	4.60 (3.88)	3.567
T7	Untreated control		15.73 (14.02)	7.74 (6.01)	7.54 (6.00)	9.50 (8.23)	8.89 (7.79)	8.34 (7.45)	7.67 (6.54)	8.93 (7.34)	8.65 (7.23)	9.67 (8.34)	9.73 (8.59)	8.666
SEm±			NS	0.090	0.080	0.264	0.153	0.097	0.093	0.064	0.074	0.090	0.094	
CD at 5%			NS	0.270	0.242	0.794	0.461	0.292	0.281	0.193	0.223	0.272	0.284	

DAS= Days after spray () Figures in parentheses are square root transformed, NS= Non significant,*treatment for residue studies only (1.25X DOSE)

Table 2: Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against Leaf eating caterpillar (*Spodoptera litura*) on cabbage during summer 2021

S.N.	Treatments	Dose g a.i./ ha	Pre-treatment population/ 5 plants	Average no. of caterpillar/5 plants										Over all mean
				I Spray					II Spray					
				1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	8.75	3.11 (1.6)	3.32 (2.5)	3.31 (2.37)	3.84 (2.64)	3.76 (2.65)	2.84 (2)	2.69 (2.05)	2.4 (2.15)	3.4 (2.33)	4.2 (2.65)	3.287
T2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	7.64	1.77 (0.74)	2.22 (1.15)	2.74 (2.15)	1.95 (0.95)	2.25 (1.95)	1.94 (0.72)	2.03 (0.76)	2.39 (1.70)	2.9 (1.81)	2.87 (1.77)	2.306
T3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	8.54	0.4 (0.02)	1.05 (0.08)	0.91 (0.05)	1.7 (1.13)	1.9 (1.16)	0.41 (0.11)	0.47 (0.17)	0.99 (0.37)	1.51 (1.1)	1.81 (1.15)	1.115
T4	*Spinetoram 12% SC w/v (11.7% w/w) SC	67.5	8.89	0.35 (0.01)	0.75 (0.03)	0.82 (0.05)	0.87 (0.22)	1.67 (0.23)	1.69 (0.28)	1.70 (0.28)	1.67 (0.07)	1.03 (0.09)	1.78 (0.27)	1.235
T5	Emamectin benzoate 5.00% SG	10	7.65	1.65 (0.25)	1.7 (1.24)	1.74 (1.09)	1.65 (1.22)	1.67 (0.23)	1.08 (0.07)	1.15 (0.34)	1.25 (0.09)	2.04 (0.24)	2.15 (0.27)	1.608
T6	Spinosad 2.5% SC	17.50	7.90	1.75 (0.26)	1.86 (0.13)	0.62 (0.09)	1.82 (0.32)	2.25 (0.14)	0.69 (0.05)	2.2 (0.8)	1.87 (0.68)	2.26 (0.06)	2.85 (2.13)	1.817
T7	Untreated control		9.00	7.75 (6.46)	7.45 (6.71)	7.67 (6.74)	7.32 (6.81)	8.64 (7.07)	7.75 (6.72)	8.84 (7.60)	8.72 (7.57)	7.56 (6.71)	7.68 (6.59)	7.938
SEm±			NS	0.084	0.075	0.259	0.148	0.091	0.088	0.058	0.068	0.085	0.089	
CD at 5%			NS	0.253	0.225	0.777	0.444	0.275	0.264	0.176	0.206	0.255	0.267	

DAS= Days after spray ( ) Figures in parentheses are square root transformed, NS= Non significant,

Table 3: Bio-efficacy of spinetoram 12% SC w/v (11.7% w/w) SC against Leaf eating caterpillar (*Spodoptera litura*) in cabbage two year mean data during rabi 2020 and summer 2021

S. No.	Treatments	Dose g a.i./ha	Pre-treatment population	Average no. of caterpillar/ plant										Over all mean
				I Spray					II Spray					
				1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	9.005	3.985	4.195	4.185	4.715	4.635	3.715	3.565	3.275	4.275	5.075	4.162
T2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	8.545	2.645	3.095	3.615	2.825	3.125	2.815	2.905	3.265	3.775	3.745	3.181
T3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	8.995	1.275	1.925	1.785	2.575	2.775	1.285	1.345	1.865	2.385	2.685	1.99
T4	Spinetoram 12% SC w/v (11.7% w/w) SC	67.5	9.57	1.225	1.625	0.805	1.65	2.545	1.895	2.435	2.185	0.91	2.655	1.794
T5	Emamectin benzoate 5.00% SG	10	9.105	2.525	2.575	2.615	2.525	2.545	1.955	2.025	2.125	2.915	3.025	2.483
T6	Spinosad 2.5% SC	17.50	9.165	2.625	2.735	1.495	2.695	3.125	1.565	3.075	2.745	3.135	3.725	2.692
T7	Untreated control		12.365	7.745	7.495	8.585	8.105	8.49	7.71	8.885	8.685	8.615	8.705	8.302
SEm±			NS	0.087	0.077	0.261	0.150	0.094	0.090	0.061	0.071	0.087	0.091	
CD at 5%			NS	0.261	0.233	0.785	0.452	0.283	0.272	0.184	0.214	0.263	0.275	
DAS= Days after spray ( ) Figures in parentheses are square root transformed, NS= Non significant,														

Table 3: Bio-efficacy of spinetoram 12% SC w/v (11.7% w/w) SC against Leaf eating caterpillar (*Spodoptera litura*) in cabbage crop, % reduction over control yield of cabbage, mean data during *rabi* 2020 and summer 2021

S.N.	Treatments	Dose		Late summer 2020			Early Summer 2021				Percent reduction of caterpillar over untreated control	Cabbage head yield (q/ha)	Increase in yield over control (q/ha)	% Increase in yield over control
		g a.i./ha.	Formulation (ml)/ha.	Mean population 5 plants after 1st sprey	Mean population 5 plants after 2nd spray)	Mean of 1st and 2nd sprays	Mean population 5 plants after 1st spray)	Mean population 5 plants after 2nd spray)	Mean of 1st and 2nd sprays	Over all mean				
T1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	300	5.21	4.85	5.03	3.46	3.10	3.28	4.15	50.00	164.15	11.09	7.2
T2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	375	3.93	4.17	4.05	2.18	2.42	2.3	3.17	61.80	183.94	30.88	20.17
T3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	450	2.94	2.78	2.86	1.19	1.03	1.11	1.98	76.14	253.21	99.56	65.04
T4	*Spinetoram 12% SC w/v (11.7% w/w) SC	67.5	562.5	2.80	2.65	2.72	1.05	0.90	0.97	1.79	78.43	265.76	112.70	73.63
T5	Emamectin benzoate 5.00% SG	10	375	3.43	3.28	3.35	1.68	1.53	1.60	2.47	70.24	181.995	28.93	18.90
T6	Spinosad 2.5% SC	17.50	700	3.41	3.72	3.56	1.66	1.97	1.81	2.68	67.70	172.475	19.41	12.68
T7	Untreated control			8.402	8.93	8.66	7.76	8.11	7.93	8.30		153.065		
This table show mean data and percent reduction values so no need of transformed values														

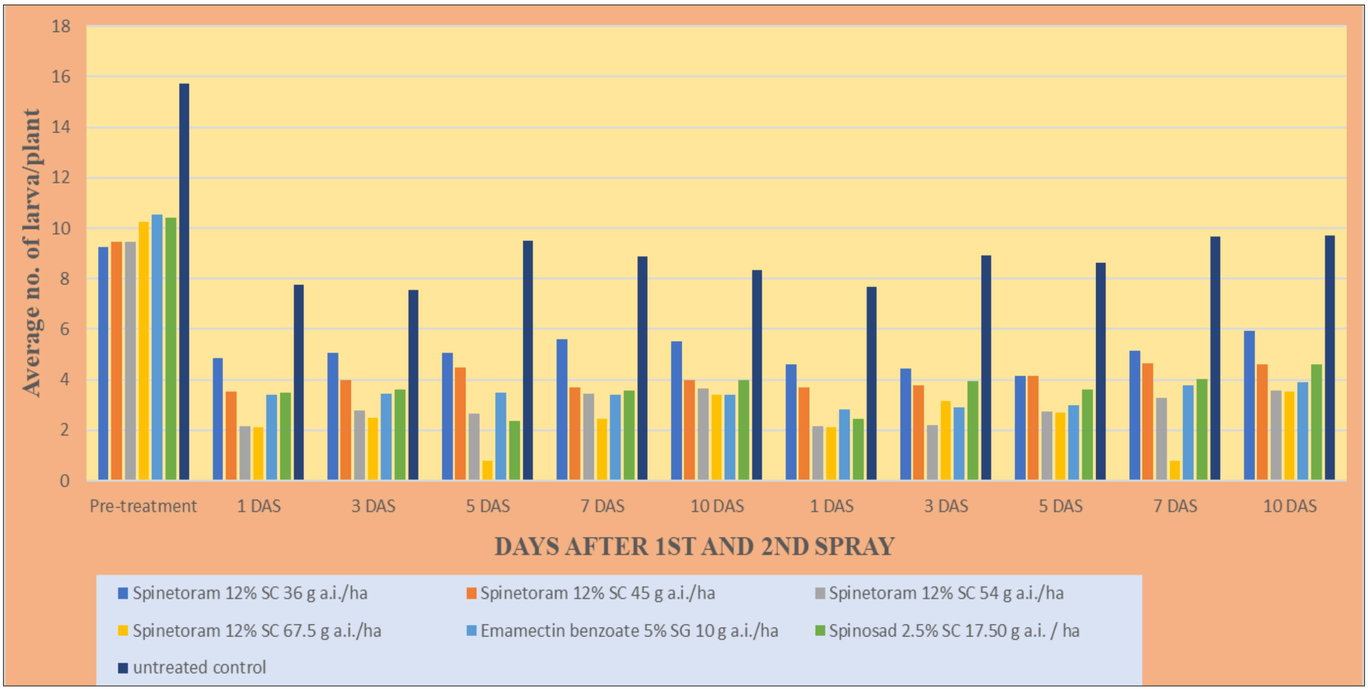

Fig 1: Bio-efficacy Evaluation of Spinetoram insecticide against larval population of *S. litura* Rabi 2020

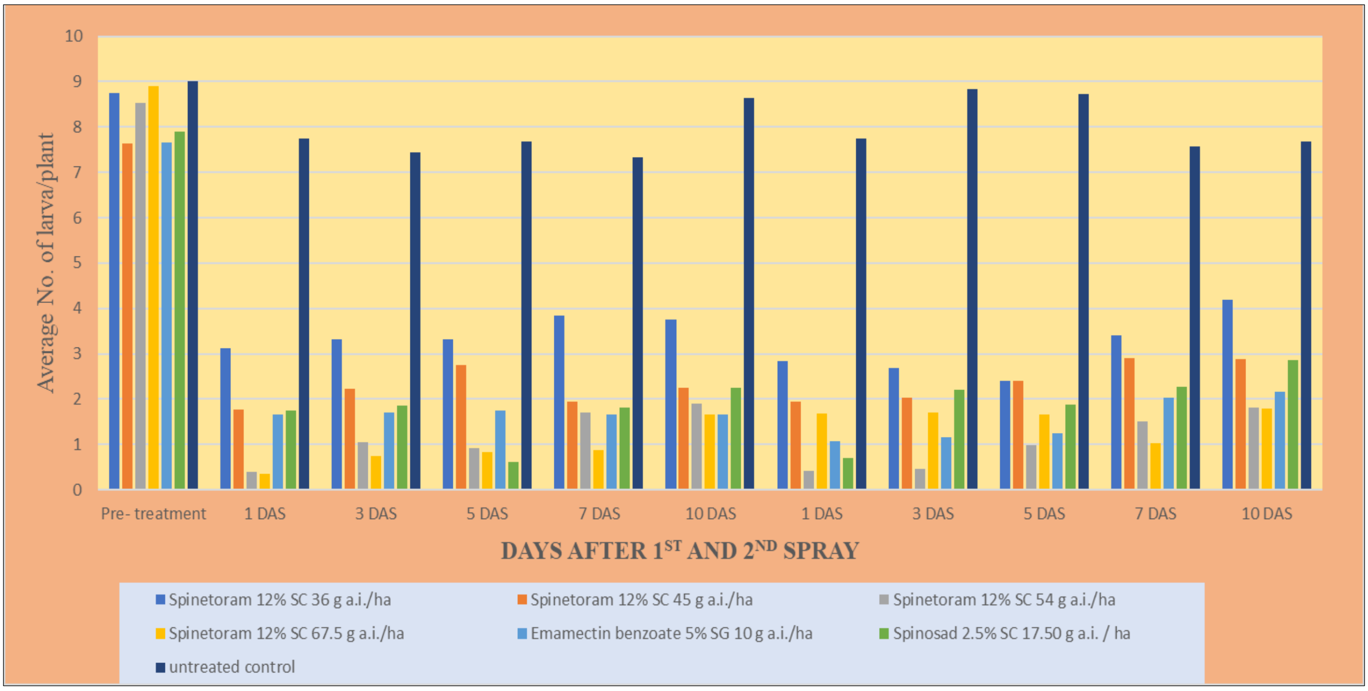

Fig 2: Bio-efficacy Evaluation of Spinetoram insecticide against larval population of *S. litura* Rabi 2021

Conclusion

Different doses of test insecticide Spinetoram 12% SC w/v (11.7% w/w) SC along with reference insecticides and untreated control were evaluated for bio -efficacy, at the research farm of IGKV, Raipur during rabi 2020 and summer 2021.

The treatment number (T4) Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i/ha was found superior in reducing population as compared to rest of the insecticidal treatments during both the season of study. The highest fruit yield of 255.75 q/ha and 250.67 q/ha. were observed during rabi 2020 and Summer 2021 season respectively were recorded under (T4) i.e Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5g.a.i/ha.

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