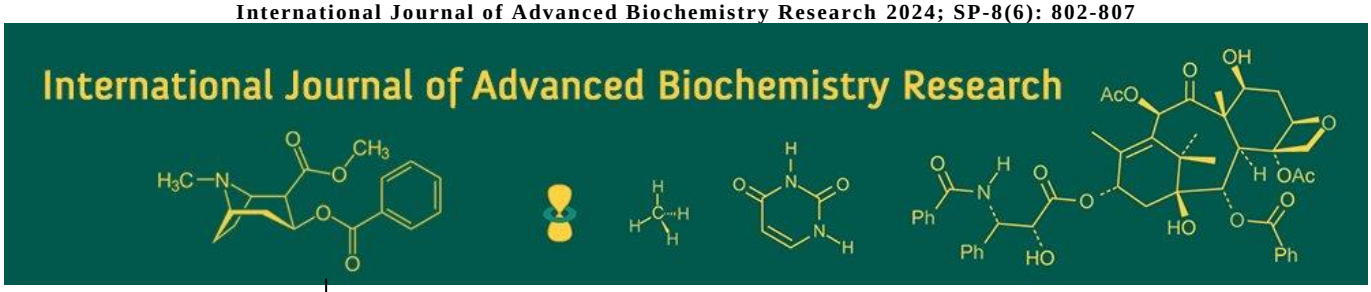

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Bio-efficacy, phytotoxicity and effect on natural enemies of spinetoram 12% SC w/v (11.7% w/w) SC against lepidopteran insect pests of cabbage

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Abstract
Lepidopteran pests of cabbage are one of the important constraints in the production and productivity of cabbage yield. Several insecticides developed resistance and lost efficacy against lepidopteran insects, in this view, a study was undertaken to evaluate the bioefficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against Lepidopteran Insect Pests of Cabbage. Lowest larval population was registered in Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha with 1.58 and 1.89 larvae per plant 14 days after first and second treatment imposition, respectively. Similarly, significantly lowest larval population was recorded in the treatment Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha with 0.62 and 0.69 larvae/plant respectively. Paper cent head damage revealed that the test compound Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha recorded lowest head damage with 1.62% at Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha. Based on the study, it can be concluded that Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha recorded highest yield of 21.98 tons per ha and was found to be effective in suppressing the diamondback moth, *Plutella xylostella* and Leaf eating caterpillar population of cabbage. The predatory populations were statistically on par with all the dosages of Spinetoram 12% SC w/v (11.7% w/w) SC as well as with the standard check treatments. There were no phytotoxicity symptoms on cabbage plants treated with various dosages of Spinetoram 12% SC w/v (11.7% w/w) SC.

Keywords: Bio-efficacy, phytotoxicity, natural enemies, spinetoram 25% WG

Introduction
In India, vegetables are a major source of roughages, minerals, proteins, and carbs.
India is the second-largest producer of vegetables in the world, after China. The low consumption of vegetables could be attributed to their high cost, which most people cannot afford and also with their limited availability. Globally, vegetarianism is gaining popularity, which is driving up demand for vegetables. Thus, there is ample opportunity to boost vegetable production in order to meet domestic demand at fair prices and earn foreign exchange on the global market.
Cole crops are grown all over India and are considered superior to other winter vegetables (Mohanan, *et al*., 2022) [8]. Cole crops include Chinese cabbage, Brussels sprouts, cauliflower, Knol-khol, and sprouting broccoli. They belong to the genus Brassica and the family Cruciferae. One of the commonly grown species in the Brassicaceae family, cabbage (*Brassica oleracea* var. capitata L.) is typically eaten as a leafy green vegetable. Cabbage is low in calories but high in vitamins, minerals, and dietary fibre (Divekar *et al*, 2023) [4]. High concentrations of calcium, iron, iodine, potassium, sulphur, and phosphorus are other characteristics that make it stand out.
Due to its anti-cancer properties, cabbage is an amazing nutritional remedy for fighting the dreaded disease of cancer (USDA 2009) [11]. Despite cabbage's nutritional and economic value, the primary obstacle to its production is the significant losses in terms of both quality and quantity brought on by insect pests (Alula and Tesfaye 2021) [2]. According to reports of respectively Krishnamoorthy (2004) [6] and Ali and Rizvi (2007) [1] the two main biotic stresses in the production of cabbage in India are the diamondback moth (DBM), *Plutella xylostella* DBM, and the cabbage butterfly, *Pieris brassicae* (Linn.) CB, which cause 52%

and 40% of the yield losses. The highly polyphagous aphid *M. persicae* has been shown to feed on over 500 different types of host plants from at least forty different families, including some important agricultural crops.

There are several management practices for the control of thrips such as cultural, mechanical, physical, biological, and chemical components. Among them, chemical control is the most commonly used method, because it controls the pests quickly and is easily available. Most of the insects already developed resistance lost their effectiveness, few caused a resurgence and are highly toxic to non-target organisms. In this context, the identification of a novel insecticide, which is having unique mode of action, green-labeled, and effectively controls the pests is the need of the hour. With this background, the present study was aimed to evaluate Spinetoram 12% SC w/v (11.7% w/w) SC against lepidopteran insect pests in cabbage ecosystem and standardized the dosage, further, we assessed the effectiveness of the chemical against natural enemies, and its phytotoxicity experiments were conducted.

Materials and Methods

Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against lepidopteran pests

Field trial was conducted to evaluate the bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against diamond back moth, *Plutella xylostella* and Leaf eating caterpillar, *Spodoptera litura* on cabbage crop. Cabbage crop variety BC-79 seeds was sown in the nursery on 18th February 2021 to raise the seedlings. Later, one month old seedlings were transplanted to a main field in a plot size of 5.40 × 3.90 m (21.06 sq.mt) with a spacing of 60cm × 30 cm at the Main Agricultural Research Station, Raichur. The experiment was laidout in a Randomized Complete Block Design with eight treatments having four replications. The crop was raised with recommended package of practices prescribed by the UAS, Raichur excluding plant protection measures. The test chemical, Spinetoram 12% SC w/v (11.7% w/w) SC was tested at five doses *viz*., 36, 45, 54, 67.5 and 108 g a.i/ha wherein, the highest dose of 108 g a.i/ha of test compound was tested for phytotoxicity studies. All these dosages were compared with standard check treatments *viz*., Emamectin benzoate 05.00% SG @ 10 g a.i/ha and Spinosad 2.50% SC @ 17.50 g a.i/ha along with untreated check (Table 1). First imposition of treatments was made, when the pest population reached the Economic Threshold Level (ETL), with a knapsack sprayer using 500 liters of spray fluid per hectare.

Observations were recorded on the effect of treatments on the cabbage diamond back moth, *Plutella xylostella* and Leaf eating caterpillar, *Spodoptera litura* before application and at 1, 3, 7, 10 and 14 days after spray. Ten plants were selected randomly in each plot per replication to record the head borer complex along with per cent head damage by counting affected and good heads to calculate head damage. Similarly, the post-treatment observation at 1, 3, 7, 10 and 14 days after spray was made for above mentioned pests. Predatory population *viz.*, coccinellids per plant on 10 selected plants was recorded on one day before and ten days after each spraying later it was averaged and subjected to statistical analysis. The observations were recorded on per cent head damage by considering the whole harvesting head count from picking sorted them into bad head and good head along with their weights finally the head damage was worked out separately.

Cabbage yield

The total yield per plot was worked out by adding the yields of harvesting. Later, per plot yield was converted to per hectare basis and expressed in tons per ha.

Phytotoxicity

Observations on phytotoxicity of test compound on cabbage was scored at 0, 1, 3, 5, 7 and 14 days after spray on injury to leaf tips, leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty graded by adopting following 0 to 10 scale (Table 2).

Rating	Phytotoxicity%
0	No phytotoxicity
1	1 – 10
2	11 – 20
3	21 – 30
4	31 – 40
5	41 – 50
6	51 – 60
7	61 – 70
8	71 – 80
9	81 – 90
10	91 – 100

Weather parameters

Weather factors *viz*., maximum temperature and minimum temperature, relative humidity and rainfall data during the cropping period were obtained from the automatic weather station, installed at MARS, Raichur.

Statistical analysis

The data generated on the lepidopteran pests *viz*., diamond back moth, *Plutella xylostella* and leaf eating caterpillar, *Spodoptera litura* along with natural enemies at pre and post-count (1, 3, 7, 10 and 14 days after each application) from five randomly selected plants were averaged to per plant basis. Further, data was subjected to statistical analysis after transforming them to $\sqrt{x+1}$.

Results and Discussion

Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against diamond back moth, *Plutella xylostella*

Population of diamond back moth, *Plutella xylostella* were ranged from 5.33 to 5.75 larvae per plant and showed non-significant difference indicating uniform distribution of pests in the experimental area prior to the imposition of treatments. Population of diamond back moth, *Plutella xylostella* larvae reached the economic threshold level prior to first imposition of treatments. Lowest larval population was registered in Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha with 1.82, 0.70, 0.57, 0.74 and 1.58 larvae per plant at 1, 3, 7, 10 and 14 days after treatment imposition, respectively. The above treatments differed significantly, with the lower dosage of @ 45 g a.i/ha. Standard check treatments *viz.*, Spinosad 2.50% SC @ 17.50 g a.i/ha (2.23,1.10, 1.72, 2.14 and 3.74 larvae/plant) and Emamectin benzoate 05.00% SG @ 10 g a.i/ha have followed next order of merit 2.85, 1.72, 2.99, 3.76 and 4.31 larvae/plant at 1, 3, 7, 10 and 14 days after application, respectively (Table 1).

Once again to confirm the results of first treatment imposition, the second imposition of treatments was made

which reduced the larval population significantly (Table 3). Later the post count was taken on one day after spray, wherein, the test compound Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha recorded lowest larval population of 1.99 larvae per plant. Followed by next lower dosages *viz*., 45 g a.i/ha and 36 g a.i/ha (3.09 and 4.04 larvae/plant, respectively). The standard check treatment *viz*., Spinosad 2.50% SC @ 17.50 g a.i/ha (2.35 larvae/plant) and Emamectin benzoate 05.00% SG @ 10 g a.i/ha recorded (3.21 larvae/plant). Further, when the observation recorded on 3rd, 7th, 10th and 14th days after spraying showed similar trend as that of one day observation. However, there was gradual increasing in the population of diamond back moth was noticed as the days progressed (Table 1).

Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against leaf eating caterpillar, *Spodoptera litura*

One day after spray, the observation recorded wherein, the test compound Spinetoram 12% SC w/v (11.7% w/w) SC @ 54g a.i/ha recorded lowest *Spodoptera* population of 1.64 per plant. Meanwhile, these treatments differed significantly with other lower dosages *viz.*, Spinetoram 12% SC w/v (11.7% w/w) SC @ 45 and 36 g a.i/ha (1.95 and 2.06 larva/ plant, respectively). The standard check treatment like Spinosad 2.50% SC @ 17.50 g a.i/ha recorded lowest larval population of 1.79 per plant followed by Emamectin benzoate 05.00% SG @ 10 g a.i/ha recorded highest population of 2.26 *Spodoptera* larvae per plant and found to be inferior in reducing larval population. The observation recorded on 3, 7, 10 and 14 days after spray, followed the same trend as that of one day observation. However, there was a decreasing in the population of *Spodoptera* larvae up to 14 days after spray, but sudden increase in the pest population as days progressed (Table 2).

After the first imposition of treatments, second time the population of insect pests which was just above the threshold level was brought down drastically among all the treatments. Lowest larval population was registered in highest dosage of new molecule *i.e.*, Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha it showed 1.51, 0.73, 0.23, 0.31 and 0.69 larvae per plant at 1, 3, 7, 10 and 14 days after spray, respectively. The above treatments were differed significantly over the lower dosages *viz.*, Spinetoram 12% SC w/v (11.7% w/w) SC @ 45 g a.i/ha with 1.84, 1.06, 0.60, 1.12 and 1.20 larvae per plant at 1, 3, 7, 10 and 14 days after application, respectively as well as standard check treatments *viz.*, Spinosad 2.50% SC @ 17.50 g a.i/ha (1.69, 0.91, 0.86, 0.97 and 1.09 larvae per plant) at 1, 3, 7, 10 and 14 days after application, respectively. However, Emamectin benzoate 05.00% SG @ 10 g a.i/ha recorded highest larval population of 2.18, 1.40, 1.41, 1.74 and 1.85 larvae per plant depicting inferior in reducing the larval population (Table 2).

Effect of Spinetoram 12% SC w/v (11.7% w/w) SC on per cent head damage

The data recorded on per cent head damage revealed that the test compound Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha (1.62%). Wherein, these treatments were superior to rest of the lower dosage of the chemical @ 45 g a.i/ha (2.43%). The standard check treatments *viz.*, Spinosad 2.50% SC @ 17.50 g a.i/ha followed by Emamectin benzoate 05.00% SG @ 10 g a.i/ha as they recorded 2.22 and 2.40 per cent head damage respectively. Wherein, untreated plot registered 5.94 per cent head damage (Table 3).

Effect of Spinetoram 12% SC w/v (11.7% w/w) SC on Yield

Test compound Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha (21.98 t/ha) followed by lower dosage of 45 g a.i/ha (20.03 t/ha). The standard check treatments *viz*., Spinosad 2.50% SC @ 17.50 g a.i/ha (20.18 t/ha) and Emamectin benzoate 05.00% SG @ 10 g a.i/ha (18.13 t/ha) have followed the next order. Lowest cabbage yield of 7.99 ton per ha was harvested from the untreated control plot (Table 3).

Effect of Spinetoram 12% SC w/v (11.7% w/w) SC on natural enemies population

Population of natural enemies one day prior to the imposition of treatments and 10 days after the imposition of treatment was also recorded. The populations of natural enemies like *Coccinellids* noticed prior to treatment imposition were ranged from 1.12 to 1.24 per plant. However, the population of natural enemies has been affected to some extent after the imposition of treatment. The test compound @ highest dosage of Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha recorded 1.00 and 1.12 population of *Coccinellids* per plant at 10 days after first spray and 10 days after second spray, respectively which was comparable with the lower dosage treatments. Meanwhile, the test compound Spinetoram 12% SC w/v (11.7% w/w) SC was found to be on par with all dosage of test chemical as well as with standard check treatments (Table 4).

Effect of Spinetoram 12% SC w/v (11.7% w/w) SC on phytotoxicity

No phytotoxic symptoms were observed in any of the Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 & 67.5 g a.i/ha treated plots and the product even at higher dosage of Spinetoram 12% SC w/v (11.7% w/w) SC @ 108 g a.i/ha has no harmful effects on cabbage crop.

The present results are in line with the reports of Kumar *et al* (2017) [7] investigated Spinetoram 12 SC against *S. litura* in onion at field conditions. Spinetoram 12 SC was applied as foliar spray at 30, 36 and 45 g a.i. ha-1 and compared with emamectin benzoate 5 SG @ 11 g a.i. ha-1, spinosad 45 SC @ 78 g a.i. ha-1, fipronil 80 WG @ 40 g a.i. ha-1 and thiamethozam 25 WG @ 62.5 g a.i. ha-1. Results indicated that spinetoram 12 SC was significantly effective at 36 and 45 g a.i. ha-1 when sprayed thrice at 15 days interval in minimizing leaf damages on onion plants and in increasing the bulb yield. All the spinetoram doses did not show any phytotoxic symptoms on onion plants. Similarly, Mohanan *et al* (2022) [8] studied the bio-efficacy of newer insecticide against *Plutella xylostella* L. infesting cabbage. Highest Percent reduction of *Plutella xylostella* population over untreated control was observed in Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i./ha. (75.89%) followed by Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g.a.i/ha, (74.86%). There was minimum percent reduction of *P. xylostella* population (62.18%) over untreated control in 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

Spinetoram 12% SC w/v (11.7% w/w) SC @ 67.5 g.a.i./ha (73.63%) followed by Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g.a.i./ha, (65.04%). The results are also in line with the reports of Kkadan *et al* (2020) [5] who, evaluated the Spinetoram for control of lepidopteran and thrips in the field and nursery. The effectiveness of Spinetoram-based solution (0.12%) was 100% against *S. exigua* and 95% to *Scirtothrips* sp. 15 days after treatment. The severity of *Scirtothrips* sp. was 5.3% in the Spinetoram (0.12%) treatment, while it was 80% in standard check chlorpyrifos (0.4%) and 96% in untreated control at 15 days after treatment. Spinetoram at 12 g a.i./ha was found significantly effective against *S. semicanella* in Eucalyptus spp. Spinetoram has broad insecticidal spectrum activity and reliable indices for integrated pest management strategies against major pests of *Acacia crassicarpa* and Eucalyptus spp. Similarly, Dharne and Bagde (2011) [3] Spinetoram 12% SC @ 60 g ai/ha, 56 g ai/ha, 48 g ai/ha, 42 g ai/ha along with other insecticides was evaluated against thrips and fruit borer in on chilli. Application of Spinetoram 12% SC @ 60 g ai/ha and 56 g ai/ha caused the highest reduction in population of thrips and fruit borer infestation which was found significantly superior over fipronil, Novaluron, except Spinosad 45 SC @ 73 g ai/ha. The highest chilli fruits yield was recorded (21.65 q/ha) in Spinetoram 12% SC @ 60 g a.i./ha, which was found significantly superior over all insecticidal treatments.

The results are also confirmed the reports of Sunilkumar *et al* (2012) [10] evaluated the bio-efficacy of Spinetoram 12 SC at four doses viz., 36, 45, 54 and 60 g a.i ha-1 against the soybean defoliator, *Spodoptera litura* at Bidar. Spinetoram 12 SC @ 60 g a.i ha-1 was highly effective in checking the larval population of *Spodoptera litura*. Spinetoram 12 SC @ 30 g a.i ha-1 proved to the best treatment recording lowest larval population of *S. litura* and also in giving highest yield during both the years. Similarly, Srinivasan *et al* (2023) [9] reveled that Spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i/ha and flubendiamide 34.35 SC @ 48 g a.i/ha from 45 DAS at 15 days interval proved to be most effective and superior in reducing the lepidopteran pod borers like *M. vitrata* and *L. boeticus* and no lethal effect was recorded towards the coccinellid predators, *Menochilus sexmaculatus*, *C. transversalis* and spiders. This combination did not cause any phytotoxic symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty at any day after treatment on stems, leaves, flowers and pods of greengram. Similarly, Visnupriya and Muthukrishnan (2017) [12] investigagted spinetoram 12 SC w/v (11.7 w/v) against okra shoot and fruit borer, *Earias vittella* (Fabricius). LC50 values of spinetoram 12 SC against 3rd instar larvae of E. vittella on okra were 4.81, 1.88 and 1.30 ppm. In okra spinetoram 12 SC 54 and 45 g a.i./ha were persisted up to 14 days after treatment (DAT) and 36 g a.i./ha persisted for 11 DAT. Regarding field experiment in okra, during first season, field application of 54 and 45 g a.i./ha, three times at 15-20 days interval based on economic threshold level were significantly superior in minimizing larval population of *E. vittella* (81.8 and 78.2% reduction respectively). Spinetoram 12 SC provided effective control of *Earias vittella* and is compatible with the predatory coccinellids. It is an effective and excellent tool to be incorporated into integrated pest management for okra crop.

Table 1: Bio-efficacy of Spinetoram 12% SC w/v (11.7% w/w) SC against Diamond back moth (*Plutella xylostella*) on cabbage

Tr. No.	Treatment Details	Dose (g a.i/ha)	Pre - count	No. of larvae/plant										% Reduction over control
				I Spray					II Spray					
				1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	
T_1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	5.65 (2.58)	3.62 (2.02)	2.50 (1.87)	2.94 (1.98)	3.71 (2.17)	4.19 (2.28)	4.04 (2.13)	2.92 (1.98)	3.38 (2.09)	3.89 (2.21)	5.30 (2.51)	51.50
T_2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	5.50 (2.54)	2.61 (1.76)	1.49 (1.57)	2.35 (1.82)	2.70 (1.92)	3.29 (2.07)	3.09 (1.89)	1.97 (1.72)	2.61 (1.90)	3.30 (2.07)	4.29 (2.30)	60.75
T_3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	5.45 (2.54)	1.82 (1.52)	0.70 (1.28)	0.57 (1.24)	0.74 (1.32)	1.58 (1.61)	1.99 (1.57)	0.87 (1.37)	0.92 (1.38)	0.95 (1.39)	1.89 (1.70)	82.70
T_4	Emamectin Benzoate 05.00% SG	10	5.75 (2.59)	2.85 (1.83)	1.72 (1.63)	2.99 (2.00)	3.76 (2.18)	4.31 (2.3)	3.21 (1.92)	2.09 (1.75)	3.62 (2.15)	3.99 (2.23)	5.22 (2.49)	52.24
T_5	Spinosad 2.50% SC	17.50	5.62 (2.56)	2.23 (1.65)	1.10 (1.42)	1.72 (1.65)	2.14 (1.77)	3.74 (2.18)	2.35 (1.68)	1.23 (1.49)	2.32 (1.82)	2.82 (1.95)	4.88 (2.43)	55.35
T_6	Untreated control	--	5.60 (2.57)	6.30 (2.60)	8.70 (3.11)	8.91 (3.15)	9.05 (3.17)	9.31 (3.21)	9.45 (3.15)	10.67 (3.41)	10.09 (3.33)	9.94 (3.30)	10.93 (3.45)	
	S.Em (±)		0.10	0.03	0.16	0.08	0.06	0.07	0.04	0.07	0.06	0.07	0.08	
	CD @ 5%		NS	0.09	0.49	0.25	0.18	0.23	0.12	0.23	0.18	0.22	0.25	
	CV (%)		10.23	9.68	10.33	9.89	9.96	10.07	10.45	10.74	10.55	10.61	9.87	

DAS – Days after spray; NS: Non-Significant

*Figures in parenthesis are square root $\sqrt{x+1}$ transformed values

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

Tr. No.	Treatment Details	Dose (g a.i/ha)	Pre - count	No. of larvae/plant										% Reduction over control
				I Spray					II Spray					
				1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	
T_1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	3.35 (1.96)	2.06 (1.60)	1.28 (1.53)	1.16 (1.47)	1.55 (1.60)	1.75 (1.66)	2.15 (1.62)	1.37 (1.53)	1.11 (1.45)	1.44 (1.56)	1.70 (1.64)	62.38
T_2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	3.39 (1.97)	1.95 (1.56)	1.17 (1.47)	0.68 (1.30)	1.02 (1.42)	1.17 (1.47)	1.84 (1.52)	1.06 (1.44)	0.60 (1.27)	1.12 (1.46)	1.20 (1.48)	73.45
T_3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	3.43 (1.98)	1.64 (1.46)	0.89 (1.37)	0.25 (1.11)	0.35 (1.16)	0.62 (1.27)	1.51 (1.41)	0.73 (1.31)	0.23 (1.11)	0.31 (1.14)	0.69 (1.30)	84.73
T_4	Emamectin Benzoate 05.00% SG	10	3.48 (1.99)	2.26 (1.66)	1.48 (1.57)	1.40 (1.55)	1.83 (1.68)	1.82 (1.68)	2.18 (1.63)	1.40 (1.55)	1.41 (1.55)	1.74 (1.66)	1.85 (1.69)	59.07
T_5	Spinosad 2.50% SC	17.50	3.38 (1.96)	1.79 (1.51)	1.01 (1.42)	0.96 (1.40)	0.94 (1.39)	1.18 (1.47)	1.69 (1.47)	0.91 (1.37)	0.86 (1.36)	0.97 (1.40)	1.09 (1.44)	75.88
T_6	Untreated control	--	3.44 (1.98)	3.49 (1.99)	3.66 (2.03)	3.75 (2.06)	3.93 (2.10)	4.02 (2.12)	4.13 (2.15)	4.24 (2.17)	4.33 (2.19)	4.38 (2.20)	4.52 (2.24)	
	S.Em (±)		0.07	0.03	0.05	0.05	0.05	0.06	0.03	0.06	0.05	0.06	0.04	
	CD @ 5%		NS	0.09	0.15	0.16	0.16	0.18	0.08	0.19	0.14	0.19	0.13	
	CV (%)		10.45	10.22	9.99	10.27	10.55	9.98	10.41	10.22	10.65	10.34	10.77	

DAS – Days after spray; NS: Non-Significant

*Figures in parenthesis are square root $\sqrt{x+1}$ transformed values.

Table 3: Impact of Spinetoram 12% SC w/v (11.7% w/w) SC on fruit damage caused by (*Plutella xylostella*) and yield of cabbage

Tr. No.	Treatment Details	Dose (g a.i/ha)	Per cent head damage	Yield (t/ha)
T_1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	2.51 (9.11)	19.21
T_2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	2.43 (8.96)	20.03
T_3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	1.62 (7.31)	21.98
T_4	Emamectin Benzoate 05.00% SG	10	2.40 (8.91)	18.13
T_5	Spinosad 2.50% SC	17.50	2.22 (8.56)	20.18
T_6	Untreated control	--	5.94 (14.10)	7.99
	S.Em (±)		0.19	0.57
	CD @ 5%		0.61	1.71
	CV (%)		10.68	10.35

DAS – Days after spray; NS: Non-Significant

*Figures in parenthesis are square root $\sqrt{x+1}$ transformed values

Table: 4. Population of natural enemies in cabbage ecosystem

Tr. No.	Treatment Details	Dose (g a.i/ha)	*Coccinellid* adults/ plant		
			Pre- count	10 days after 1st Spray	10 days after 2nd Spray
T_1	Spinetoram 12% SC w/v (11.7% w/w) SC	36	1.19 (1.30)	1.03 (1.23)	1.13 (1.27)
T_2	Spinetoram 12% SC w/v (11.7% w/w) SC	45	1.16 (1.28)	1.05 (1.24)	1.10 (1.26)
T_3	Spinetoram 12% SC w/v (11.7% w/w) SC	54	1.23 (1.31)	1.00 (1.22)	1.12 (1.27)
T_4	Emamectin Benzoate 05.00% SG	10	1.12 (1.27)	1.03 (1.23)	1.12 (1.27)
T_5	Spinosad 2.50% SC	17.50	1.13 (1.27)	1.06 (1.24)	1.14 (1.28)
T_6	Untreated control	--	1.21 (1.30)	1.33 (1.35)	1.41 (1.38)
	S.Em (±)		0.07	0.02	0.02
	CD @ 5%		0.20	0.06	0.05
	CV (%)		7.22	8.32	9.36

DAS – Days after spray; NS: Non-Significant

*Figures in parenthesis are square root $\sqrt{x+1}$ transformed values

Conclusions

Based on the study, it can be concluded that Spinetoram 12% SC w/v (11.7% w/w) SC @ 54 g a.i/ha recorded highest yield of 21.98 ton per ha and found to be effective in suppressing the diamond back moth, *Plutella xylostella* and Leaf eating caterpillar population of cabbage. The predatory populations were statistically on par with all the dosages of Spinetoram 12% SC w/v (11.7% w/w) SC as well as with the standard check treatments. There was no phytotoxicity symptoms on cabbage plants treated with various dosages of Spinetoram 12% SC w/v (11.7% w/w) SC.

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