

Comparative efficacy of biopesticides & insecticides against flea beetle (*Phyllotreta cruciferae* Goeze & *Monolepta signata* Olivier), infesting *Brassica rapa* L. in Odisha

ABSTRACT

The field trial carried out against the flea beetle (*Phyllotreta cruciferae* Goeze and *Monolepta signata* Olivier) infesting rapeseed-toria (*Brassica rapa* L.) revealed that spinetoram 11.7% SC @ 500ml/ha applied at 15 days interval (Three times) was comparatively effective among the tested treatments in suppressing flea beetle. This was followed by *Lecanicillium lecanii* CFU 1×10^9 per ml @2500ml/ha, Diafenthiuron 50% WP @600g/ha, Chlorantraniliprole 18.50% SC @150ml/ha, *Azadirachta indica* 300 ppm @2500ml/ha and *Bacillus thuringiensis* 3.5% ES @2500ml/ha. The treatment, diafenthiuron 50% WP @600g/ha was found to be relatively safe towards natural enemies viz., coccinellids, syrphids and spiders.

Keywords: Biopesticides; flea beetle; coccinellids; syrphids; natural enemies; rapeseed-toria

1. INTRODUCTION

Rapeseed-mustard is a group of oil-rich crops that includes Indian mustard, toria, yellow sarson, brown sarson, gobhi sarson, karan rai, black mustard and taramira [1]. Of these, Toria (*Brassica rapa* Linnaeus, $2n = 20$) is a major oilseed crop in the Indian subcontinent, [2,3,4], plays a crucial role in India's edible oil sector; accounting for nearly 80% of the total *Rabi* oilseed production [1]. The yield of this plant is significantly plagued and hindered by various insect pests [5]. Among them, the mustard flea beetle (*Phyllotreta cruciferae* Goeze) is a major pest impacting rapeseed and toria in India, especially during the seedling stage [6]. This beetle is known to inflict considerable damage, particularly on early-sown crops. Research indicates that flea beetle activity peaks between October and December, which results in stunted plant growth and diminished crop yields in some regions [7]. Apart from this, the white spotted flea beetle, *Monolepta signata* Olivier significantly affects the yield of rapeseed-toria causing severe defoliation at the seedling stage [8,9]. Nonetheless, pest density in the crop ecosystem has often been attenuated by several natural enemies and predators like coccinellid beetles, syrphid flies, and spiders [10].

Common mitigation strategies against insect pests may include extensive and unregulated application of conventional chemical pesticides, nevertheless, it has been shown to not only accelerate the development of insecticide resistance but also result in pest resurgence, environmental pollution, harm to non-target organisms and accumulation of harmful residues in the food chain [11]. To address these challenges, integrated pest management (IPM) practices, such as adjusting sowing times and employing novel insecticides with improved efficacy are increasingly recommended to protect mustard crops in India. Consequently, there is an urgent need for both safer and more effective insecticides, featuring diverse modes of action to delay resistance. Researchers have increasingly emphasized the adoption of next-generation insecticides with biopesticides as sustainable solutions for pest control [12] in rapeseed-toria cultivation and so is the present field experiment.

2. MATERIALS AND METHODS

The field experiment was conducted for two consecutive *Rabi* seasons of 2021/22 and 2022/23 at the Experimental Farm, College of Horticulture, Odisha University of Agriculture and Technology, Chiplima, (21°21'47"N 83°53'32"E) Odisha. In this field trial 21 plots were marked in a randomized block design and each plot had the size of 20 m² (4 x 5 m) [13], and with 30 X 10 cm plant to row spacing. "Sushree" variety was sown @ 5kg/ha [14] during mid-October of 2021 as well as in 2022. There were seven treatments, each replicated thrice. The details of all the treatments are provided below.

In each plot, ten plants were selected randomly, and from each plant, an average number of insects per plant *i.e.*, Flea beetle (No. of grubs+adults plant⁻¹), Coccinellid beetles (No. of grubs+adults plant⁻¹), Syrphid fly (No. of maggots plant⁻¹) and Spider (No. of adults plant⁻¹) was calculated. A pre- and post-count of insect pest population (No. of grubs plant⁻¹) was recorded.

All recommended agronomical practices were followed to raise the crop [15].

2.1 Treatment schedule:

- T1: *Azadirachta indica* 300 ppm @2500ml/ha,
- T2: *Bacillus thuringiensis* 3.5% ES @2500ml/ha,
- T3: *Lecanicillium lecanii* CFU 1X10⁹ per ml @2500ml/ha,
- T4: Spinetoram 11.7%SC @500 ml/ha,
- T5: Diafenthiuron 50% WP @600g/ha,
- T6: Chlorantraniliprole 18.50% SC @150ml/ha applied in each treatment

Date of chemical application:

I spray: 30 days after sowing (DAS)

II spray:15 days after first scheduled application *i.e.*, 45 DAS

III spray:15 days after the 2nd scheduled application *i.e.*, 60 DAS

2.2 Per cent reduction in insect-pest and natural enemies' population in the treated plot over untreated control

The per cent reduction in pest and natural enemies' population count was calculated using the Abbott's formula [16], given below:

$$\text{Per cent reduction in pest or natural enemies over untreated control (\%)} = \frac{\text{Pest or natural enemy population (untreated plot - treated plot)}}{\text{Pest or natural enemy population in the untreated plot}} \times 100$$

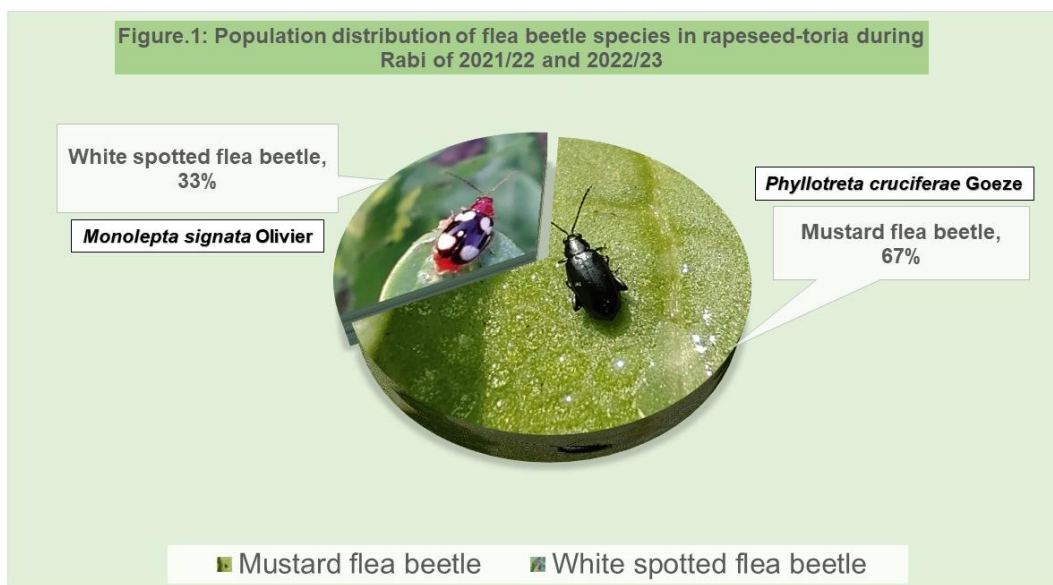
2.3 Statistical analysis

The data obtained for various insect counts were subjected to square root transformation. The data was analyzed using the procedures given by Gomez and Gomez [17]. The statement variations were tested for significance by the "F" test. The standard error of means SE(m)± and critical difference (CD) at a 5% significance level was calculated following the standard procedure. Treatment means were compared with a critical difference (CD). Based on the statistically analyzed data, the results of the observations were interpreted.

3. RESULTS AND DISCUSSION

3.1 Flea beetle

Incidence of two different species of flea beetles, *i.e.*, *Phyllotreta cruciferae* and *Monolepta signata*, were observed in the crop ecosystem 4 weeks after sowing. This corroborates with the findings of Das [18] and Keot *et al.* [19], who confirmed the pest incidence of flea beetles of both species as well. Figure 1 represents the distribution of the mustard flea beetle and white spotted flea beetle in the rapeseed-toria crop ecosystem, throughout the cropping seasons.



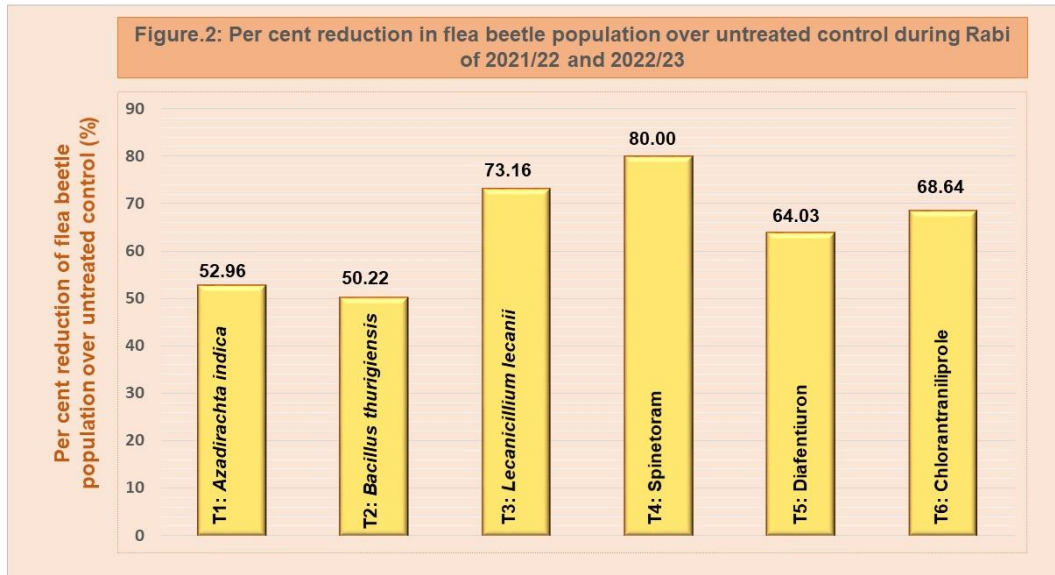
3.1.1. Comparative efficacy of different biopesticides and insecticides against flea beetle population

Table 1 presents the pooled analysis data of two years, *i.e.*, two consecutive *Rabi* seasons of 2021/22 and 2022/23, on the comparative efficacy of various biopesticides and insecticides against the flea beetle population on rapeseed-toria. Before initiating the first application, the population recorded in the treatment plots varied from 7.07 to 10.00 grubs+adults plant⁻¹.

After first application of different test insecticides, the lowest mean population of flea beetle was observed in rapeseed-toria plot treated with T4: spinetoram 11.7% SC with a mean population of 1.25 grubs+adults plant⁻¹, closely followed by T3: *Lecanicilium lecanii* CFU 1X10⁹ per ml with 1.99 grubs+adults plant⁻¹ pest count. However, these two treatments were statistically at par with each other. Among the test insecticides, T2: *Bacillus thuringiensis* 3.5% ES recorded the highest population of 4.92 grubs+adults plant⁻¹. In rest of the treatments the mean population of flea beetle varied between 1.25 to 4.92 grubs+adults plant⁻¹; while the untreated control plot harboured the maximum pest population of 11.77 grubs+adults plant⁻¹.

Subsequent to the second and third applications, a consistent trend of population reduction was observed, suggesting that the outcomes were largely comparable to those identified during the first application in terms of efficiency. This trend was evident across all test treatments, with the exception of T4: spinetoram 11.7% SC, where the most significant reduction in pest population occurred between the second and third applications. Specifically, a decrease from 0.80 to 0.14 grubs and adults per plant was recorded. This finding was closely followed by T3: *Lecanicilium lecanii* CFU 1X10⁹ per ml, which exhibited a reduction from 1.24 to 0.57 grubs and adults per plant interposed between the last two applications (Table 1).

The order of efficacy (in descending order) of different treatments tested against the flea beetle in pooled mean population of two years follows the sequence mentioned below (Figure 2):



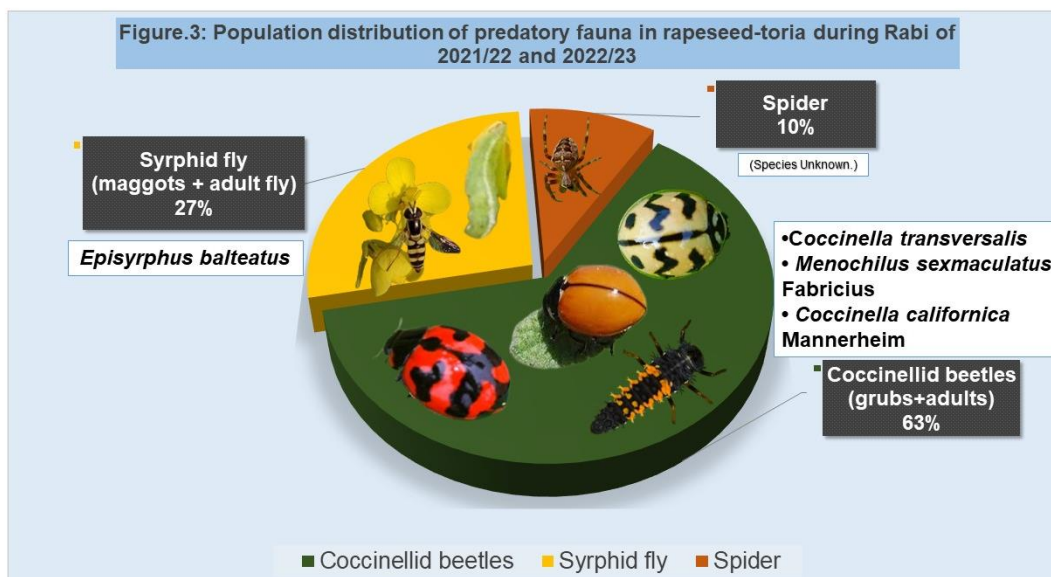
(T₄): Spinetoram 11.7 % SC @500 ml/ha (80.00% ROC) > (T₃): *Lecanicillium lecanii* CFU 1X10⁹ per ml @2500ml/ha (73.16% ROC) > (T₆): Chlorantraniliprole 18.50 % SC @150 ml/ha (68.64% ROC) > (T₅): Diafenthiuron 50% WP @600 g/ha (64.03% ROC) > (T₁): *Azadirachta indica* 300ppm @2500ml/ha (52.96% ROC) > (T₂): *Bacillus thuringiensis* 3.5% ES @2500 ml/ha (50.22% ROC).

Following the three applications, the percent reduction observed across the six treatments ranged from 50.22% to 80.00% compared to the untreated control (ROC %). Each treatment exhibited significant field efficacy, as all achieved a reduction in pest populations of 50% ROC or greater.

The results revealed that the “spinetoram (T₄)” was found to be effective among all treatments with 2.31 grubs+adults plant⁻¹ and 80.00% reduction in population over untreated control (ROC) underscoring its’ efficacy in managing pest population effectually. Similar results were reported by Srinivasan *et al.* [20] which concluded that three applications of foliar spray of spinetoram 10% w/w + sulfoxaflor 30% w/w WG @350 ml/ha and spinetoram 10% + sulfoxaflor 30% WG @300 ml/ha were superior and effective in reducing the flea beetle damage. This was followed by the findings associated with “*Lecanicillium lecanii* (T₃)” which recorded an average of 3.03 grubs and adults per plant, accompanied by a rate of control (ROC) of 73.16%. Pradhan *et al.* [21] drew the inference that *L. lecanii* (NBAIR) with 0.09 flea beetle/plant was the best treatment followed by *L. lecanii* (AAU-J culture) with 0.12 flea beetle/plant.

3.2 Natural enemies (predators)

Apart from flea beetles, three natural enemies (predators) *viz.* Coccinellid beetles, Syrphid flies, and Spiders associated with the major rapeseed-toria/mustard crop pests were observed in the crop field (Figure 3).



3.2.1 Comparative efficacy of different biopesticides and insecticides on predatory fauna population

The pre-application population of predators and natural enemies was in the range of (4.34 - 4.99 grubs+ adults plant⁻¹) for coccinellid beetles during both Rabi seasons, (1.49 – 1.73 maggots plant⁻¹) for syrphid fly, (0.83 - 0.92 adults/plant) for spider and without any significant difference (Table 2,3 and 4). Subsequently in each applications of the tested treatments, T₅: diafenthiuron 50% WP recorded statistically identical population, for coccinellid beetle, syrphid fly and spiders with that of untreated control.

The pooled data of two consecutive *Rabi* seasons of 2021/22 and 2022/23, on coccinellid beetles (Table 2), revealed that “diafenthiuron 50% WP @600g/ha (T₅)” was relatively safer with least reduction of the population over untreated control (4.50 grubs+adults plant⁻¹ with 10.53% ROC), followed by “spinetoram 11.7 % SC @500 ml/ha (T₄)” which had 4.33 grubs+adults plant⁻¹ with 13.91% ROC. Likewise for syrphid fly, “diafenthiuron 50% WP @600g/ha (T₅)” was comparatively safer with 1.68 maggots plant⁻¹ (Table 3) and 15.57% ROC followed by “chlorantraniliprole 18.50 % SC @150ml/ha (T₆)” and “*Bacillus thuringiensis* 3.5% ES @ 2500ml/ha (T₂)” which had 1.47 maggots plant⁻¹ with 26.13% ROC. In addition, for the spider population, “diafenthiuron 50% WP @600g/ha (T₅)” was relatively safer with least reduction of the population over untreated control (0.85 adults/plant and 18.26% ROC) followed by “chlorantraniliprole 18.50 % SC @150ml/ha (T₆)” which had 0.79 adults plant⁻¹ with 24.03% ROC (Table 4). The findings resembled the outcomes by Bajya *et al.* [22], it was concluded that diafenthiuron 47.8 SC @ 286.8 g a.i./ha was highly effective in suppressing the sucking pests, and it had no adverse effects on the natural enemies. Studies made by researchers like Ranjith [23] and Stanley [24] also support the above findings on safety of diafenthiuron to natural enemies.

4. CONCLUSION

From the present study, it can be concluded that the novel insecticide, “spinetoram 11.7% SC @500ml/ha (T₄) at 15 days intervals (Three times)” was comparatively effective against both the species of flea beetle infesting rapeseed-toria under field conditions, in both the trials carried out during 2021/22 and 2022/23 in the west-central tableland region of Odisha, India. Diafenthiuron 50% WP was found to be the fourth most effective treatment and comes highly recommended due to its safety for predators and beneficial natural enemies of the crop. The

current studies confirm that newer molecules and next generation insecticides are highly effective against flea beetles and could serve as a better alternative to the insecticides to which they have developed resistance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

UNDER PEER REVIEW

**Table 1: Comparative efficacy of biopesticides and insecticides against flea beetle in rapeseed-toria
(Pooled data of Rabi, 2021/22 and 2022/23)**

Treatments	Mean population of flea beetle (No. of grubs+adults/plant)					Overall pest count	Reduction over untreated control (%)
	1 DBA	1 st Application	2 nd Application	3 rd Application			
		14 DAA	14 DAA	14 DAA			
T1: <i>Azadirachta indica</i> 300 ppm	10.00 (3.17)	4.05 (2.02)	3.84 (1.97)	3.37 (1.85)	5.31	52.96	
T2: <i>Bacillus thuringiensis</i> 3.5% ES	8.69 (2.96)	4.92 (2.23)	4.45 (2.12)	4.43 (2.12)	5.62	50.22	
T3: <i>Lecanicillium lecanii</i> CFU 1x10 ⁹ per ml	8.33 (2.90)	1.99 (1.43)	1.24 (1.14)	0.57 (0.79)	3.03	73.16	
T4: Spinetoram 11.7% SC	7.07 (2.67)	1.25 (1.14)	0.80 (0.92)	0.14 (0.44)	2.31	80.00	
T5: Diafenthiuron 50% WP	8.33 (2.89)	2.95 (1.73)	2.50 (1.60)	2.46 (1.59)	4.06	64.03	
T6: Chlorantraniliprole 18.50% SC	8.10 (2.85)	2.51 (1.60)	2.07 (1.46)	1.51 (1.25)	3.54	68.64	
T7: Untreated control	9.08 (3.02)	11.77 (3.44)	11.89 (3.45)	12.45 (3.54)	11.29	-	
SE(m) ±	0.122	0.207	0.055	0.146	-	-	
CD (P=0.05)	NS	0.63	0.17	0.44	-	-	

*Figures in parentheses are square root transformed values.

Each value is mean of two years observation.

DBA: Days before application;

DAA: Days after application

**Table 2: Comparative efficacy of biopesticides and insecticides on Coccinellid beetle in rapeseed-toria
(Pooled data of Rabi, 2021/22 and 2022/23)**

Treatments	Mean population of coccinellid beetle (No. of grubs+adults/plant)					Overall count	Reduction over untreated control (%)
	1 DBA	1 st Application	2 nd Application	3 rd Application	Overall count		
		14 DAA	14 DAA	14 DAA			
T1: <i>Azadirachta indica</i> 300 ppm	4.94 (2.23)	3.57 (1.90)	3.67 (1.93)	3.68 (1.93)	3.96	21.27	
T2: <i>Bacillus thuringiensis</i> 3.5% ES	4.81 (2.21)	3.12 (1.78)	2.85 (1.70)	2.22 (1.51)	3.25	35.38	
T3: <i>Lecanicillium lecanii</i> CFU 1X10 ⁹ per ml	4.97 (2.24)	3.08 (1.77)	2.86 (1.70)	2.34 (1.55)	3.31	34.19	
T4: Spinetoram 11.7% SC	4.34 (2.10)	4.48 (2.13)	4.37 (2.10)	4.15 (2.05)	4.33	13.91	
T5: Diafenthiuron 50% WP	4.66 (2.17)	4.35 (2.10)	4.49 (2.13)	4.52 (2.14)	4.50	10.53	
T6: Chlorantraniliprole 18.50% SC	4.77 (2.20)	3.99 (2.01)	3.64 (1.92)	3.64 (1.92)	4.01	20.27	
T7: Untreated control	4.77 (2.20)	4.60 (2.16)	5.12 (2.27)	5.66 (2.39)	5.03	-	
SE(m) ±	0.043	0.087	0.104	0.051	-	-	
CD (P=0.05)	NS	0.26	0.31	0.15	-	-	

*Figures in parentheses are square root transformed values.

Each value is mean of two years observation.

DBA: Days before application

DAA: Days after application

**Table 3: Comparative efficacy of biopesticides and insecticides on Syrphid fly in rapeseed-toria
(Pooled data of Rabi, 2021/22 and 2022/23)**

Mean population of Syrphid fly (No. of maggots/plant)						
Treatments	1 DBA	1 st Application	2 nd Application	3 rd Application	Overall count	Reduction over untreated control (%)
		14 DAA	14 DAA	14 DAA		
T1: <i>Azadirachta indica</i> 300 ppm	1.59 (1.28)	1.29 (1.16)	1.27 (1.15)	1.21 (1.12)	1.34	32.66
T2: <i>Bacillus thuringiensis</i> 3.5% ES	1.68 (1.32)	1.46 (1.23)	1.40 (1.20)	1.34 (1.18)	1.47	26.13
T3: <i>Lecanicillium lecanii</i> CFU 1X10 ⁹ per ml	1.56 (1.27)	1.40 (1.20)	1.35 (1.18)	1.29 (1.16)	1.4	29.64
T4: Spinetoram 11.7% SC	1.78 (1.35)	1.11 (1.08)	1.03 (1.04)	0.87 (0.96)	1.19	40.20
T5: Diafenthiuron 50% WP	1.73 (1.33)	1.67 (1.31)	1.68 (1.31)	1.67 (1.31)	1.68	15.57
T6: Chlorantraniliprole 18.50% SC	1.49 (1.24)	1.48 (1.24)	1.46 (1.23)	1.47 (1.23)	1.47	26.13
T7: Untreated control	1.56 (1.27)	1.87 (1.38)	1.93 (1.39)	2.63 (1.64)	1.99	-
SE(m) ±	0.133	0.054	0.056	0.045	-	-
CD (P=0.05)	NS	0.16	0.17	0.14	-	-

*Figures in parentheses are square root transformed values.

Each value is mean of two years observation

DBA: Days before application

DAA: Days after application

**Table 4: Comparative efficacy of biopesticides and insecticides on Spider in rapeseed-toria
(Pooled data of Rabi, 2021/22 and 2022/23)**

Treatments	Mean population of Spider (No. of adults/plant)					Overall count	Reduction over untreated control (%)
	1 DBA	1 st Application	2 nd Application	3 rd Application	Overall count		
		14 DAA	14 DAA	14 DAA			
T1: <i>Azadirachta indica</i> 300 ppm	0.83 (0.94)	0.73 (0.88)	0.68 (0.85)	0.64 (0.83)	0.72	30.76	
T2: <i>Bacillus thuringiensis</i> 3.5% ES	0.87 (0.96)	0.67 (0.85)	0.55 (0.77)	0.40 (0.67)	0.62	40.38	
T3: <i>Lecanicillium lecanii</i> CFU 1X10 ⁹ per ml	0.85 (0.95)	0.59 (0.80)	0.41 (0.68)	0.54 (0.77)	0.59	43.26	
T4: Spinetoram 11.7% SC	0.89 (0.97)	0.74 (0.89)	0.64 (0.83)	0.60 (0.81)	0.71	31.73	
T5: Diafenthiuron 50% WP	0.89 (0.97)	0.88 (0.96)	0.82 (0.93)	0.84 (0.94)	0.85	18.26	
T6: Chlorantraniliprole 18.50% SC	0.85 (0.95)	0.80 (0.92)	0.76 (0.90)	0.77 (0.91)	0.79	24.03	
T7: Untreated control	0.92 (0.99)	1.07 (1.06)	1.07 (1.06)	1.11 (1.08)	1.04	-	
SE(m) ±	0.015	0.033	0.057	0.131	-	-	
CD (P=0.05)	NS	0.10	0.17	0.40	-	-	

*Figures in parentheses are square root transformed values.

Each value is mean of two years observation

DBA: Days before application

DAA: Days after application

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