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Vol. 30, Issue 01: 2513-2519
Journal of Bioscience and Agriculture Research
Journal Home: www.journalbinet.com/jbar-journal.html

Efficacy of eco-friendly agents on damage extent of lepidopteran insect on summer tomato

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Article received: 14.09.2022; Revised: 09.01.2023; First published online: 23 March, 2023

ABSTRACT

Eco-friendly agents are excellent tools for managing insect pests which can reduce the dependency on chemical pesticides. This study aimed to evaluate a biological control agent with the integration of some biopesticides on the extent of lepidopteran insect pest damage and the production of summer tomatoes. The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 from January 2021 to December 2021. The variety, BARI HYBRID Toamato-8, was a summer tomato. The experiment comprises five treatments viz. T_1= Bacillus thuringiensis K. @3 g/L of water with Trichogramma evanescense @0.5g/plot @7 days interval, T_2= Neem oil @ 3ml/L of water with Trichogramma evanescense @0.5g/plot @7 days interval, T_3= Spinosad 45% SC @0.5ml/L of water with Trichogramma evanescense @0.5g/plot @7 days interval, T_4= Halicoverpa armigera Nuclearpolyhedrosis Virus (HaNPV) @0.4ml/L of water with Trichogramma evanescense @ 0.5g plot @7 days interval and T_5= untreated control. Randomized Complete Block Design (RCBD) was followed to lay out the experiment with four (4) replications. All data were collected at 52, 73, 80, 100 and 112 days after transplanting (DAT). Spinosad with Trichogramma evanescense (T_3) expresses the best performance among the bio-agents in terms of less damage by insects and enhancing crop production. The highest total number of fruits per plant 40.50, the number of healthy fruit (35.25) and the lowest number of infested fruits per plant (5.50) were obtained for this treatment. The contribution of Spinosad with Trichogramma evanescense treatment in fruit number further resulted in the highest yield of tomato. Conversely, fruit loss was highest in the untreated control plot.

***Key Words**: Helicoverpa armigera, Bacillus thuringiensis, Trichogramma evanescense, Spinosad and Nuclear Polyhedrosis Virus.*

Cite Article: Akter, M. M., Yasmin, S., Akter, M. S. and Sarkar, S. (2023). Efficacy of eco-friendly agents on damage extent of lepidopteran insect on summer tomato. Journal of Bioscience and Agriculture Research, 30(01), 2513-2519.
Crossref: https://doi.org/10.18801/jbar.300123.303

I. Introduction

Tomato (*Solanum lycopersicon* L.) is one of the major vegetable crops in Bangladesh. Tomato is now cultivated all year round. About 6.10% of the area is now cultivated during both the summer and

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winter seasons (Karim et al., 2009). Although production is higher in the winter, due to unfavorable weather and insect pest attacks, it is lower than anticipated in the summer. All plant parts of the tomato are vulnerable to damage by several insect pests such as tomato fruit worms, potato aphids, stink bugs, leaf-footed bugs, hornworms and Whitefly. One of the main pests of tomato is the tomato fruit borer *Helicoverpa armigera* (Hübner), which can damage up to 93.7% (Afreen et al., 2017).

With the growing concern about the harmful effect of chemical pesticides on the ecosystem, alternative pest control approaches are increasing to manage the pest insects. These alternative approaches include cultural, mechanical, biological control, and different biopesticides. Trichogramma is a biological control agent that exclusively attacks the eggs of lepidopteran insect pests. Due to the naturally occurring effects of this bio-control agent (Wang et al., 1999), mass rearing and inundative release for the control of insect pests increased dramatically. For relatively slow action, Trichogramma had used with low doses of chemical pesticides. However, pesticides are proven to be detrimental to beneficial insects, even in low doses. Thus, using environmentally friendly biopesticides such as Spinosad, HaNPV, Neem and *Bacillus thuringiensis K.* can be integrated with the bio-control agent to replace the use of chemicals. Spinosad is a naturally occurring novel pesticide that has recently gained popularity as a biopesticide. This microbial pesticide comprises two naturally occurring components (sponosyne A and D), which are produced by the soil actinomycete bacterium *Saccaropolyspora spinosa.* With both contact and stomach-poison properties, this microbial is highly toxic to the target pests, primarily lepidoptera, diptera, and thysanoptera insects (Campos et al., 2014). The *H. armigera* Nucleopolyhedro Virus (HaNPV) is a type of baculovirus that primarily infects and kills larvae of *H. armigera* and a few closely related species (Abid et al., 2022). Neem, *Azadirachta indica*, is a native of the arid areas of the Indian subcontinent, where it can reach heights of 12–24 m at altitudes of 50–100 m and requires 130 mm of annual rainfall to maintain normal growth (Chandel et al., 2006). *Bacillus thuringiensis* (*Bt)* has been used as a tool for insect pest control all over the world because its well-known insecticidal properties. A gram-positive soil microorganism that produces spores is known as *Bt*. The advantages of *Bt* go beyond its effectiveness as an insecticide; it also has chitinolytic activity, which is used to control phytopathogenic fungi (Saxena et al., 1999).

Previous studies attempted to investigate the integrated effect of bio-control agents (Usman et al., 2012) or only biopesticides (Author et al., 2015). However, research on the efficacy of the integration of bio-control agents and biopesticides is limited. Hence, this study attempted to investigate the effectiveness of *Trichogramma* in combination with different biopesticides on the damage extent of lepidopteran insect pests and the production of summer tomatoes.

II. Materials and Methods

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 from May 2021 to September 2021 because the planting material (BARI HYBRID tomato-8) is a summer variety. This is the favorable period of cultivation of this variety. Well-pulverized field with 4-5 times ploughing was done with laddering. Farmyard manure/compost and recommended dose of chemical fertilizer is incorporated into the soil during final ploughing. Plots of 3 m x 2 m size were laid out in Randomized Completely Block Design (RCBD) with four (4) replications.

T_1	*Bacillus thuringiensis* K. @ 3 g/L of water + *Trichogramma evanescense* @ 0.5g plot^{-1} at 7 days interval
T_2	Neem oil @ 3 ml/L of water + *Trichogramma evanescense* @ 0.5g plot^{-1} at 7 days interval
T_3	Spinosad 45% SC @ 0.5ml/L of water + *Trichogramma evanescense* @ 0.5g plot^{-1} at 7 days interval
T_4	HaNPV @ 0.4ml/L of water + *Trichogramma evanescense* @ 0.5g plot^{-1} at 7 days interval
T_5	Untreated control

Seeds are collected from the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Dhaka. Seed rate of the variety is 200-220 g for one hectare of land. Thiram 75% dust @ 0.3g mixed with 100 gm seed and shaken well before sowing. Tomato seedlings are raised in the nursery bed. The seedbed was 3 m in length and 1 m in breadth. Seed beds are prepared with a mixture of sand, compost and soil. Tomato seeds are sown in the line on a well-prepared seed bed and lightly covered with soil. After

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7-10 days of sowing, the young seedlings are transplanted on the second bed at a distance of 4 cm in both ways. The bed was irrigated immediately after transplanting. The seedling was protected from strong sun and heavy rain. Thirty days old seedlings were transplanted in the main field at a spacing of 60 cm × 40 cm (row × plant).

Bacillus thuringiensis and HaNPV are collected from Ispahani agro limited. There are no facilities for rearing *Trichogramma evanescense* in the entomology laboratory at sher-e-Bangla Agricultural University. Trichocard was collected from the Sugarcane research institute, Ishwardi, Pabna. Spinosad was collected from Russell IPM limited. All the treatments were applied according to their recommended dose. Four trichocards were used per plot. After 7 days older one was replaced with new trichocards.

The following parameters were considered for data collection- Number of fruits per plant, Number of total fruits per plot, Number of healthy fruits per plot, Weight of total fruit per plot, Number of fruits infested by lepidopteran insects per plot, Fruit infestation (%), Weight of fruits infested by lepidopteran insects per plot, Weight of infested fruit (%), Weight of healthy fruit per plot. Data collection was done on randomly selected 10 plants from per plot every 5 days after treatment application. Sometimes 7-10 days later due to the covid situation. The data obtained for different parameters were statistically analyzed following computer-based software SPSS -10 and mean separation will be done by LSD at 5% level of significance.

III. Results

Effect of treatments on the number and weight of healthy fruits per plot

Significant variations were observed among different treatments on different days after transplanting (DAT) on total number of healthy fruits per plot and weight of healthy fruits per plot. Spinosad in combination with *Trichogramma evanescense* (T_3) resulted in the highest number of healthy fruits per plot (6.25) and the highest weight of fruit per plot (125 g) which was statistically similar to the treatment of HaNPV with *Trichogramma evanescense* (T_4) and *Bacillus thuringiensis* with *Trichogramma evanescense* T_1 (Table 01 and Figure 01). The T_2 treatment (i.e., neem oil with *Trichogramma evanescense*) gave a lower number of healthy fruits per plot (3.50) and lower fruit weight (75 g/plot) which was significantly different from all other treatments. The untreated control T_5 gave the least fruits per plot (2.50) and lowest fruit weight (35 g/plot). A similar trend of results was obtained at 73, 80, 88, 100 and 112 DAT (Table 01 and Figure 01)

The highest total number of healthy fruits per plot (35.25) was recorded in treatment Spinosad in combination with *Trichogramma evanescense* which was significantly different from all other treatments. On the other hand, the lower (20.25) total number of healthy fruits per plot was recorded in treatment neem oil with *Trichogramma evanescense*. The untreated control showed the least healthy fruits per plot and the value was 11.00 which was significantly different from all other treatments (Table 01).

Table 01. Effect of different treatments on the number of healthy fruits plot^{-1}

Treatments	Number of healthy fruits plot^{-1}						
	52 DAT	73 DAT	80 DAT	88 DAT	100 DAT	112 DAT	Total
T_1	5.50 a	5.00 b	5.50 a	3.50 b	5.50 b	3.75 b	28.75 b
T_2	3.50 b	3.75 c	4.00 b	2.00 c	4.50 c	2.50 c	20.25 c
T_3	6.25 a	6.00 a	6.50 a	5.00 a	6.25 a	5.25 a	35.25 a
T_4	5.50 a	5.25 ab	5.50 a	3.50 b	5.75 ab	4.25 b	29.75 b
T_5	2.50 c	1.75 d	2.50 c	0.50 d	3.00 d	0.75 d	11.00 d
CV (%)	12.10	11.30	16.14	29.53	7.07	12.97	8.02
S. E.	0.28	0.25	0.39	0.43	0.18	0.21	1.02
LSD (0.05)	0.87	0.76	1.19	1.32	0.54	0.66	3.09

[T_1 = *Bacillus thuringiensis* K.@ 3 g L^{-1} of water +*Trichogramma evanescense* @ 0.5 g plot^{-1}; T_2 = Neem oil @ 3 ml L^{-1} of water + *Trichogramma evanescense* @ 0.5 g plot^{-1}; T_3 = Spinosad 45% SC @0.5 ml L^{-1} of water +*Trichogramma evanescense*@ 0.5 g plot^{-1}; T_4 = HaNPV @0.4 ml L^{-1}ofwater +*Trichogramma evanescense*@ 0.5 g plot^{-1}; T_5 = Untreated control; In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05% level of probability.]

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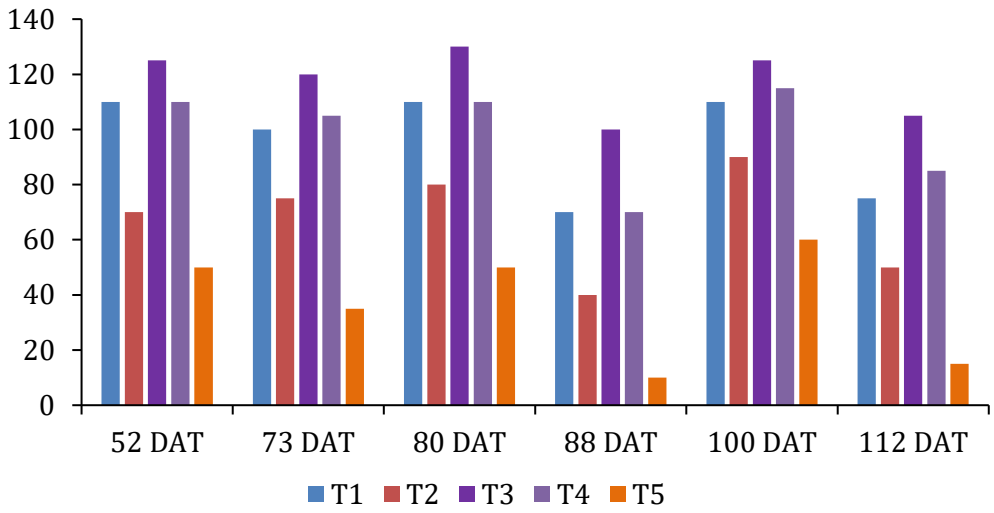

Figure 01. Weight of healthy fruits per plot of biopesticides on weight of healthy fruits plot^{-1}of tomato

T_1 = *Bacillus thuringiensis* K. @ 3g L^{-1} of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_2 = Neem oil @ 3 ml $L^{-1}$of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_3 = Spinosad 45% SC @ 0.5 ml L^{-1} of water +*Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_4 = HaNPV @0.4 ml L^{-1} of water +*Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_5 = Untreated control.

Effect of treatments on the number and weight of fruits per plot infested by lepidopteran insects

Among the treatment Spinosad with *Trichogramma evanescense* resulted lowest number of infested fruits per plot (1.00) and weight of infested fruit per plot (25 g/plot) which was statistically similar to the effect of Spinosad with *Trichogramma evanescense*. Treatment neem oil with *Trichogramma evanescense* gave the higher number of infested fruits per plot (2.50) and weight of infested fruit (62.50 g/plot). The untreated control gave the highest infested fruits per plot (4.25) and weight of infested fruit (104.25 g/plot) which was statistically different from all other treatments, at the 52 DAT. More or less similar trend of results was obtained at 73, 80, 88, 100 and 112 DAT (Table 02 and Figure 02).

The lowest total number of infested fruits per plot (5.50) was recorded in treatment Spinosad with *Trichogramma evanescense* which is statistically different from all other treatments. On the other hand, the highest total number of infested fruits plot (15.75) was recorded in treatment *Bacillus thuringiensis* with *Trichogramma evanescense*. The untreated control showed the highest infested fruits per plot (26.50) which was significantly different from all other treatments (Table 02).

Table 02. Number of infected fruits per plot

Treatments	Number of infested fruits plot^{-1}							Yield t ha^{-1}
	52 DAT	73 DAT	80 DAT	88 DAT	100 DAT	112 DAT	Total	
T_1	2.00 bc	1.75 b	2.00 c	2.00 c	2.00 bc	2.25 b	12.00 c	27.50 b
T_2	2.50 b	1.5 bc	3.25 b	3.26 b	2.50 b	2.75 b	15.75 b	23.00 c
T_3	1.00 d	1.00 c	0.75 d	0.77 d	1.00 d	1.00 c	5.50 e	34.25 a
T_4	1.50 cd	1.25 bc	1.50 c	1.50 c	1.50 cd	1.75 bc	9.00 d	26.25 b
T_5	4.25 a	3.25 a	4.50 a	4.52 a	4.50 a	5.50 a	26.50 a	13.00 d
CV (%)	17.21	22.74	14.73	14.74	17.75	25.55	13.18	8.40
S. E.	0.19	0.20	0.18	0.19	0.20	0.34	0.91	1.05
LSD (0.05)	0.60	0.61	0.54	0.55	0.63	1.04	2.79	3.22

[T_1 = *Bacillus thuringiensis*K.@3g L^{-1} of water +*Trichogramma evanescense*@ 0.5 g $plot^{-1}$; T_2 = Neem oil @ 3 ml L^{-1}ofwater + *Trichogrammaevanescense*@0.5 g $plot^{-1}$; T_3 = Spinosad45% SC @0.5 ml L^{-1} of water +*Trichogramma evanescense*@ 0.5 g $plot^{-1}$; T_4 = HaNPV @0.4 ml L^{-1}ofwater +*Trichogramma evanescense*@ 0.5 g $plot^{-1}$; T_5 = Untreated control; In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05% level of probability.]

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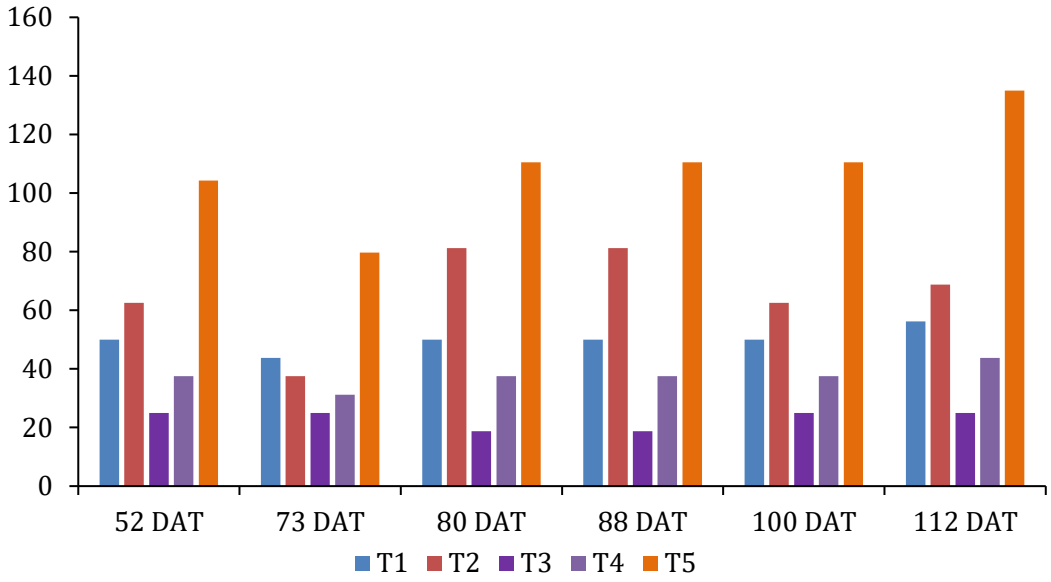

Figure 02. Effect of bio-pesticides on weight infested fruits per plot of tomato

T_1 = *Bacillus thuringiensis* K. @ 3g L^{-1} of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_2 = Neem oil @ 3 ml $L^{-1}$of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_3 = Spinosad 45% SC @ 0.5 ml L^{-1} of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_4 = HaNPV @ 0.4 ml L^{-1} of water + *Trichogramma evanescense* @ 0.5 g $plot^{-1}$; T_5 = Untreated control.

Effect of treatments on the yield of tomato

Significant variation was observed in case of yield. The highest yield was observed for the treatment Spinosad with *Trichogramma evanescense* (35.25 ton/ha), which is statistically different from the others treatments. For HaNPV with *Trichogramma evanescense* treatment the yield of tomato was (26.25 ton/ha), which was statistically similar to treatment *Bacillus thuringiensis* with *Trichogramma evanescense* (27.50 ton/ha). The yield of tomato for neem oil with *Trichogramma evanescense* treatment was 23 ton/ha, which is statistically different from other treatments. However, the lowest fruits yield was found in untreated control (13.0 ton/ha).

IV. Discussion

Field experiment was conducted to evaluate the effectiveness of some eco-friendly agents on the damage extent of lepidopteran insect pests and the production of summer tomatoes in Bangladesh. Five treatments viz. T_1 = *Bacillus thuringiensis* K. @ 3 g/L of water with *Trichogramma evanescense* 0.5g plot @ 7 days interval, T_2 = Neem oil @ 3 ml L @ 1 of water with *Trichogramma evanescense* @ 0.5g/plot at 7 days interval, T_3 = Spinosad 45% SC @ 0.5ml/L of water with *Trichogramma evanescense* @ 0.5g plot @ 7 days interval, T_4 = *Halicoverpa armigera* Nuclearpolyhedrosis Virus (HaNPV) @ 0.4ml/L of water with *Trichogramma evanescense*@ 0.5g plot @ 7 days interval and T_5 = untreated control, were evaluated in this study. Among the treatments, Spinosad with *Trichogramma evanescense* demonstrated as the most effective treatment in minimizing pest damage and increasing crop yield. Consistence with these findings Ghosh et al. (2010) found that Spinosad alone can curtail the damage of *H. armigera*. However, in the study of Ghosh et al. (2010) Spinosad was not combined with Trichogramma. Combined the Spinosad with HaNPV and found similar results on percentage of fruit damage and percentages of fruit yield (Ravi et al. 2008). In addition, Spinosad treated plot showed the similar result of yield of fruits of tomato (El Shafie & Abdelraheem, 2012). Insects exposed to Spinosad quickly undergo contact and ingestion activity, which stimulates the nervous system and causes paralysis and a stop of feeding. Therefore, Spinosad with Trichogramma can be a potential option in the management of lepidopteran insect pests of tomato in summer.

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V. Conclusion

The study was conducted to evaluate the effectiveness of the combination of some environment friendly management of lepidopteran insect pests in summer tomato in Bangladesh. Treatment includes, *Bacillus thuringiensis* K. @ 3 g/L of water with *Trichogramma evanescense* @ 0.5g/plot @ 7 days interval as T_1, Neem oil @ 3 ml/L of water with *Trichogramma evanescense* @ 0.5g/plot @ 7 days interval as T_2, Spinosad 45% SC @ 0.5ml/L of water with *Trichogramma evanescense* @ 0.5g/plot @ 7 days interval as T_3, *Halicoverpa armigera* Nuclearpolyhedrosis Virus (HaNPV) @ 0.4ml/L of water with *Trichogramma evanescense*@ 0.5g/plot @ 7 days interval as T_4 and untreated control as T_5. Spinosad along with Trichogramma (T_3) demonstrated the best performance among the treatments. Both least damage by the insects and highest yield of summer tomato were observed for this treatment. The findings suggest that combination of Spinosad and Trichogramma can be a potential option as an effective and environment-friendly management tool for lepidopteran insects in summer season. However, further research should be conducted at the farmers' field before the mass implication of this combination of eco-friendly agents.

ACKNOWLEDGEMENTS

Gratitude to Sher-e-Bangla Agricultural University Research System (SAURES) for the funding to conduct the research.

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HOW TO CITE THIS ARTICLE?

Crossref: https://doi.org/10.18801/jbar.300123.303

MLA
Akter, M. M. et al. "Efficacy of eco-friendly agents on damage extent of lepidopteran insect on summer tomato". Journal of Bioscience and Agriculture Research, 30(01), (2023): 2513-2519.

APA
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