



Management of *Helicoverpa armigera* (Hubner) infesting tomato using biopesticides under field condition and its effect on tomato yield

Md. Khademul Islam¹, Mohammad Tofazzal Hossain Howlader^{2✉}, Kazi Shahanara Ahmed²

¹Ispahani Agro Limited (Biotech Wing), Gazipur, Bangladesh

²Insect Biotechnology and Biopesticide Laboratory, Department of Entomology, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

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Correspondence:

Mohammad Tofazzal Hossain
Howlader

✉: tofazzalh@bau.edu.bd



ABSTRACT

The tomato fruit borer, *Helicoverpa armigera* (Hubner) is a very destructive insect pest of tomato affecting its yield. We, hereby, assessed four biopesticides applied individually viz. Spinosad, Emamectin benzoate, Abamectin, and *Lecanicillium lecanii* and a chemical insecticide (Cartap) for the management of it under field conditions and effects on tomato yield. The efficacy was evaluated based on percent fruit infestation, healthy fruits, number of healthy and infested fruits per sq. meter and yield of marketable and infested fruits (ton/ha). We have found that all the tested biopesticides significantly reduced the fruit infestation caused by *H. armigera* and thereafter increased the marketable yield of tomato. However, the Spinosad was found as the most effective biopesticide considering the reduction of percent fruit infestation, increasing the fruit yield and decreasing the infested fruit yield which was followed by Emamectin benzoate, Abamectin, Cartap, and *L. lecanii*, respectively. The highest percentage of healthy fruits (81.82%) and the lowest fruit infestation (18.18%) were recorded when the tomato plants were treated with the Spinosad. Moreover, 48.09% of fruits were protected from infestation when Spinosad was used. The highest marketable yield (24.01 ton/ha) and lowest infested yield (2.26 ton/ha) were obtained from Spinosad treated plots. The application of Emamectin benzoate, Abamectin, Cartap, and *L. lecanii* provided 20.77, 19.76, 15.23 and 13.67 (ton/ha) marketable yield, respectively. It is therefore concluded that the application of Spinosad performed as the most effective ones against tomato fruit borer and it could be suggested for effective management of tomato fruit borer.

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Introduction

The Tomato (*Lycopersicon esculentum* Mill) is one of the most popular, extensively consumed and high demand vegetable crops in the world (Grandillo *et al.*, 1999). It is a good source of vitamins A, B, C, and many minerals. It is a nutritious and delicious vegetable used for various purposes. Bangladesh ranked 43rd position in the world in tomato production (FAOSTAT, 2017). It is cultivated both in winter and summer seasons in Bangladesh. The infestation of the tomato fruit borer (*Helicoverpa armigera*) is considered as one of the most limiting factors of tomato yield and market value (Faqiri and Kumar, 2016). It can attack tomato fruit at any stage of growth decreasing its market value. It is a polyphagous pest, i.e., it also attacks cotton, tobacco, maize, sorghum, various legumes, okra, and other horticultural crops (Kranz *et al.*, 1978). It is reported to be responsible for 40-50 percent damage to the tomato crop (Pareek and Bhargava, 2003) and a yield loss in the range of 20 to 60% (Herald and Tayde, 2018). The

chemical method is very popular for Bangladeshi farmers to manage *H. armigera*. Unfortunately, a high level of pesticide residues in the fruit, insecticide resistance, destruction of natural enemies and environmental pollution due to the use of chemical insecticides is of great concern to the consumers to avail quality and safe tomatoes (Chauhan *et al.*, 2013). Therefore, it is necessary to develop and adopt eco-friendly and sustainable management system of tomato fruit borer.

Of several options, use of biopesticides is the best alternatives to manage the pest. Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals that are less toxic, more quickly biodegradable, and specific to targeted pests (EPA, 2019). The use of biopesticides thus suppresses the pest population making the pest less abundant and less damaging to the crop (Gopalakrishnan *et al.*, 2016). Thus, it plays an important role in providing pest management tools in areas where pesticide resistance, environmental concerns limit the

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use of chemical pesticide products. As a result, farmers can get a satisfactory yield, as well as consumers; can get fresh and safe products. In this work, we have managed several biopesticides that are available in the local market from different groups for the management of *H. armigera* using tomato crop under field conditions and their effect on tomato yield was also evaluated in this study. We believe our results will be helpful for the tomato growers to produce safe and quality tomato.

Materials and Methods

Experimental layout and location

The research was carried out in the field laboratory of the Department of Entomology, Bangladesh Agricultural University from November 2017 to March 2018. The experiment was laid out in Randomized Block Design (RBD) with three replications maintaining 6 treatments including untreated control.

Variety, land preparation, and plant development

The Roma VF tomato variety was used as the host plant. The seedlings were collected from Horticulture Farm of Bangladesh Agricultural University; Mymensingh. The land was prepared with a power tiller followed by laddering and leveling the surface of the soil. Cow dung and other inorganic fertilizers were applied as per recommended doses (Rashid, 1993). The size of a unit plot was 1.5 m × 1.0 m. A distance of 1.0 m between blocks and 0.5 m between the plots was maintained to facilitate different intercultural operations. Twenty-five days old seedlings were transplanted at the main field. Irrigation and other inter-cultural operations were performed as per recommendations.

Selection of the biopesticides, doses, and spraying

Four biopesticides, a chemical insecticide as a positive check were selected. They were as follows: **T1**-Control (Untreated), **T2**- Suntap 50SP (Cartap) @2g/L, **T3**-Noclaim 5SG (Emamectin Benzoate) @1g/L, **T4**-Mycotal (*Lecanicillium lecanii*) @2g/L, **T5**-Tracer 45SC (Spinosad) @1ml/L, **T6**-Ambush 1.8EC (Abamectin) @1.5ml/L. The Ambush 1.8 EC, Tracer 45SC and the Noclaim 5SG were brought from the local market, Mymensingh and the *L.lecanii* was from MYCOTAL of Koppert Biological Systems collected from collection of “The Insect Biotechnology and Biopesticide Laboratory”, Department of Entomology, BAU, Mymensingh. The field was monitored regularly to confirm the infestation level and when considerable fruits were found to be infested, then spraying was initiated. A total of two sprays applied at 12 days interval after pests (*H. armigera*) had infested. Spraying was started at 9.00 am to avoid bright sunshine and drift caused by strong wind.

Data collection parameters and procedures

Data were collected on 3, 7 and 10 days after spraying (DAS). The following parameters: Number of total, healthy and infested fruits per plot, percent fruit infestation, percent fruit protection over control, number of healthy or marketable fruits/m², yield (t/ha) of infested fruits, yield (t/ha) of marketable fruits, increase of marketable fruit yield (times) over control were considered for the efficacy evaluation of the selected bio-pesticides. Data was calculated of the above-mentioned parameters as per the formula and procedures described earlier by Khatun *et al.* (2015) and Khatun *et al.* (2016).

Data analysis

All the recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of a computer statistical package Statistix 10. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) when necessary.

Results and Discussion

Fruit infestation of tomato

It was found that the tested four biopesticides i.e. Spinosad, Emamectin benzoate, Abamectin, and *L. lecanii* showed efficacy on significant ($p < 0.05$) reduction of percent fruit infestation by *H. armigera* compared to control (Table 1). The highest percent of fruit infestation was found in control with a continuously increasing trend of fruit infestation which was ranged from 29.92 to 41.98% and the cumulative mean of infestation was 35.02%. The lowest percent of fruit infestation was observed in the treatment of Spinosad (T5) having cumulative mean of fruit infestation 18.18% ranged from 15.25 to 21.50% which was statistically significant ($p < 0.05$) than that of other treatments except Emamectin benzoate (T3). Spinosad (T5) treated plants showed almost static level of percent fruit infestation at different days after 1st and 2nd spray. The cumulative mean of percent fruit infestation for Abamectin (T6), Cartap (T2) and *L. lecanii* (T4) were 23.72, 26.72 and 30.21% respectively. Thus, the application of Spinosad (T5) performed best on percent fruit infestation of tomato. The least efficacy was recorded in Cartap (T1) treatment with 26.72 percent fruit infestation. In addition, percent protection of tomato fruits over control was also calculated is shown in Fig. 1. It was found that the highest percent (48.09%) of fruits were protected from infestation from the use of Spinosad (T5) against the tomato fruit borer infestation (Fig. 1).

The use of Emamectin benzoate (T3) resulted in the second-highest (39.26%) fruit protection over control. The use of Abamectin (T6), Cartap (T2) and *L. lecanii* (T4) resulted 32.07, 23.70 and 13.74% respectively,

percent protection of tomato fruits over control (Fig. 1). These clearly suggested the effective performance of Spinosad and Emamectin benzoate against *H. armigera* infestation of tomato fruit.

Table 1. Efficacy of biopesticides on percent fruit infestation caused by tomato fruit borer (*H. armigera*) at different sprayings

Treatments	Mean percent fruit infestation at different sprayings						Cumulative mean
	Day after 1 st spray			Day after 2 nd spray			
	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	
T1 (Control)	23.92 ^b	36.11 ^a	37.78 ^a	34.49 ^a	35.83 ^a	41.98 ^a	35.02 ^a
T2 (Cartap, Suntap 50SP@2.0 g/L)	32.36 ^a	27.50 ^{bc}	27.89 ^{bc}	19.65 ^{cd}	24.84 ^{bc}	28.05 ^b	26.72 ^c
T3 (Emamectin benzoate, Noclaim 5SG@1.0g/L)	25.27 ^{bc}	27.37 ^{bc}	24.61 ^c	19.26 ^{cd}	16.43 ^d	14.68 ^{cd}	21.27 ^{de}
T4 (<i>L. lecanii</i> , Mycotol@2.0 g/L)	31.88 ^a	32.74 ^{ab}	34.30 ^{ab}	30.22 ^{ab}	27.20 ^b	24.90 ^b	30.21 ^b
T5 (Spinosad, Tracer 45SC@1.0 ml/L)	18.40 ^c	21.5 ^c	18.92 ^d	15.25 ^d	18.81 ^d	16.18 ^d	18.18 ^e
T6 (Abamectin, Ambus 1.8 EC @ 1.5ml/L)	19.00 ^c	27.78 ^b	29.74 ^{bc}	25.8 ^{bc}	20.50 ^{cd}	19.90 ^c	23.79 ^{cd}
LSD _{0.05}	3.98	6.03	6.56	7.22	4.61	3.52	3.21
Level of significance	**	**	**	**	**	**	**

In a column, means of the similar letter (s) do not differ significantly; **= Significant at 1% level.

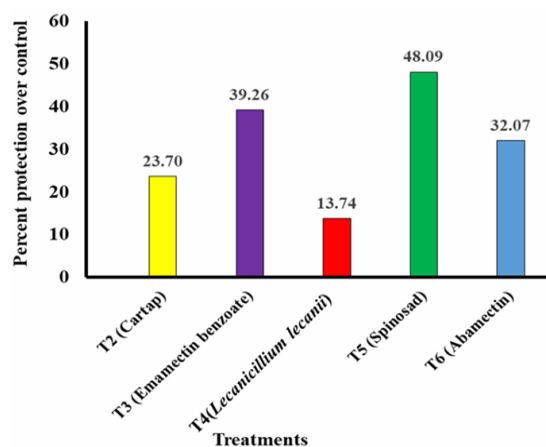


Fig. 1. Percent protection of tomato fruits over control when the plants were treated with selected biopesticides

Efficacy of the selected biopesticides on the number of marketable and infested fruits of tomato per sq. meter

Marketable fruits are those which do not have any visibility of deformation, hole, puncture or pseudo-puncture on the fruit. On the other hand, when tomatoes were found to be deformed or pseudo-punctured or any abnormalities in color were regarded as infested fruits (Khatun et al., 2015). A total of two pickings of tomato fruits at 12 days of the interval were made, the healthy fruits were separated from the infested ones and counted carefully. The competence of the selected tested biopesticides on the number of marketable and infested fruits caused by tomato fruit borer, (*H. armigera*) per sq. meter analyzed and is presented in Table 2. It was observed that the selected tested biopesticides significantly ($p < 0.05$) increased the number of marketable tomatoes and reduced the number of infested fruits in comparison with that of the control. The highest total number of marketable tomatoes from two harvests was obtained when plants were treated with Spinosad

(T5) about 36 nos./m² (16.50 and 20.43 nos./m² for 1st and 2nd pickings, respectively) followed by the plants were treated with Emamectin benzoate (T3) (31.96 nos./m²), Abamectin (T6) (30.40 nos./m²) which produced the statistically ($p < 0.05$) the same number of marketable tomatoes from two harvests. The lowest total number of marketable tomato from two harvests was obtained from control (15.17 nos./m²). On the other hand, Cartap and *L. lecanii* treated plants resulted statistically ($p < 0.05$) same number of marketable tomatoes 23.42 and 21.03 nos./m², respectively (Table 2). So, all the treatments showed significant number of healthy fruits over control. Interestingly, the chemical insecticide, Cartap treatment did not yield maximum number of healthy tomatoes possibly due to resistance development. On the other hand, when considering the number of infested tomato fruits, it was followed an almost similar trend as in case of the number of marketable tomatoes per sq. meter. Spinosad (T5) yields the lowest number of infested fruits followed by

the effect of Emamectin benzoate (T3) which is statistically same. As expected, the highest number of infested fruits was obtained from control (11.13 nos./m²) (Table 2).

Marketable and infested fruits

The resultant effects on yield of marketable and infested fruits (ton/ ha) due to the application of four different biopesticides along with a chemical insecticide are presented in Table 3. It was found that the tested treatments significantly increase the yield of marketable tomato fruits and reduced yield of the infested fruits compared to untreated control (Table 3). As observed in the case of the other parameters, the application of Spinosad (T5) produced statistically significant (p < 0.05) maximum yield of the marketable and minimum

yield of infested tomato fruits was recorded (24.01, 2.26 ton/ha, respectively). On the other hand, the reverse trend, i.e., the lowest yield of marketable tomato fruits (9.86 ton/ha) and highest yield of infested tomato fruits (7.69 ton/ha) was recorded from control (T1) (Table 3). The second highest yield of marketable fruits was from the treatment of Emamectin benzoate (20.77 ton/ha) followed by Abamectin (19.76 ton/ha) which are statistically same indicating that use of both them have equal effects on marketable yield. The application of Cartap (T2) and *L. lecanii* (T4) showed statistically same significant effect both on marketable and infested fruit yield of tomatoes over control (Table 3).

Table 2. Efficacy of the selected biopesticides on number of marketable and infested fruits

Treatments	Number of marketable fruits/m ²			Number of infested fruits/m ²		
	1 st picking	2 nd picking	Total	1st picking	2nd picking	Total
T1 (Control)	7.90 ^d	7.27 ^d	15.17 ^d	5.72 ^a	6.11 ^a	11.83 ^a
T2 (Cartap, Suntap 50SP@2.0 ml/L)	10.73 ^c	12.69 ^c	23.42 ^c	3.59 ^{bc}	3.63 ^{bc}	7.23 ^{bc}
T3 (Emamectin benzoate@1.0ml/L)	14.97 ^{ab}	16.99 ^b	31.96 ^b	2.26 ^{cd}	2.33 ^{cd}	4.59 ^d
T4 (<i>L. lecanii</i> , Mycotol@2.0g/L)	9.97 ^{cd}	11.07 ^c	21.03 ^c	4.43 ^{ab}	4.47 ^b	8.90 ^b
T5 (Spinosad, Tracer 45 SC@1.0ml/L)	16.50 ^a	20.43 ^a	36.93 ^a	1.90 ^d	1.57 ^d	3.47 ^d
T6 (Abamectin, Ambus1.8EC@1.5ml/L)	13.77 ^b	16.63 ^b	30.40 ^b	2.25 ^d	3.00 ^{bcd}	5.25 ^{cd}
LSD _{0.05}	2.13	2.24	3.60	1.35	1.58	2.49
Level of significance	**	**	**	**	**	**

In a column, means of the similar letter (s) do not differ significantly; **= Significant at 1% level

Table 3. Efficacy of biopesticides on the yield of marketable and infested fruits on different treated plant

Treatments	Yield(ton/ha)					
	Marketable fruits			Infested fruits		
	1 st picking	2 nd picking	Total	1 st picking	2 nd picking	Total
T1 (Control)	5.14 ^d	4.72 ^d	9.86 ^d	3.72 ^a	3.97 ^a	7.69 ^a
T2 (Cartap, Suntap 50SP@2.0 ml/L)	6.98 ^c	8.25 ^{cd}	15.23 ^c	2.34 ^{bc}	2.36 ^{bc}	4.70 ^{bc}
T3 (Emamectin benzoate@1.0ml/L)	9.73 ^{ab}	11.05 ^b	20.77 ^b	1.47 ^{cd}	1.52 ^{cd}	2.99 ^d
T4 (<i>L. lecanii</i> , Mycotol@2.0g/L)	6.48 ^{cd}	7.19 ^c	13.67 ^c	2.88 ^{ab}	2.91 ^b	5.78 ^b
T5 (Spinosad, Tracer 45 SC@1.0ml/L)	10.73 ^a	13.28 ^a	24.01 ^a	1.24 ^d	1.02 ^d	2.26 ^d
T6 (Abamectin, Ambus1.8EC@1.5ml/L)	8.95 ^b	10.81 ^b	19.76 ^b	1.46 ^d	1.95 ^{bcd}	3.41 ^{cd}
LSD _{0.05}	1.38	1.45	2.34	0.88	1.03	1.62
Level of significance	**	**	**	**	**	**

In a column, means of the similar letter (s) do not differ significantly; **= Significant at 1% level

Our results that Spinosad performed effective treatment are in agreement with previous findings of Agale *et al.*, (2017) who indicated that Spinosad showed maximum mortality against tomato fruit borer (*H. armigera*). Our results have shown that Spinosad also caused the highest reduction of fruit borer infestation about 48%. Meena and Raju (2014), Ghosh and Chatterjee (2009) also reported that Spinosad consistently performed superior to other tested insecticides against *H. Armigera*. When considering yield of marketable healthy fruit yield of tomato, Biswas *et al.*, (2019), Babar *et al.*, (2016), Sarker *et al.*, (2015), Devi *et al.*, (2014) and Singh *et al.*, (2012) found that use of Spinosad returned higher fruit yield and maximum mortality against tomato fruit

borer (*H. armigera*) on various crops which supported our observations. We also found that Emamectin benzoate provided second best which supports the previous observations of Biswas *et al.*, (2019), Govindan *et al.*, (2013), Murugaraj *et al.*, (2006), Kanna *et al.*, (2005), Upadhyay *et al.*, (2005) on serval crops.

Conclusion

Based on this study, it is thus concluded that the application of Spinosad is more effective against tomato fruit borer returning the maximum marketable yield and minimum infested yield of tomatoes. This treatment, therefore, could be recommended to the tomato growers for the effective management of tomato fruit borer (*H.*

armigera). In addition, we have also found that the use of Emamectin benzoate performed second best treatment. Hence, in addition to Spinosad, Emamectin benzoate could also be suggested for the effective management of tomato fruit borer (*H. armigera*), where Spinosad is not available.

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