Fundamental and Applied Agriculture
Vol. 4(2), pp. 792–797: 2019
doi: 10.5455/faa.20352

Plant Protection
ORIGINAL ARTICLE

Biorational management of tomato fruit borer, *Helicoverpa armigera* (Hübner) in winter under field condition of Bangladesh

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ARTICLE INFORMATION

Article History
Submitted: 05 Dec 2018
Revised: 02 Feb 2019
Accepted: 27 Feb 2019
First online: 02 Mar 2019

Academic Editor
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ABSTRACT

An experiment was conducted during the period of December 2014 to March, 2015 in the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University on the management of tomato fruit borer, *Helicoverpa armigera* (Hübner) using different biorational insecticides on winter tomato variety BARI-2 in Bangladesh. Efficacy of seven different biorational insecticides *viz.* Neem oil, Mahogany oil, Karanja oil, Ambush 1.8 EC, Libsen 45 SC, Emamectin benzoate 5 SG and *Beauveria bassiana* were evaluated on the basis of percentage of fruit damage and percentage increase/decrease of yield. All the biorational insecticides were significantly effective in comparison to control treatment. Besides, among seven insecticides; Emamectin benzoate 5 SG provided the best result with the lowest cumulative mean percentage fruit infestation (20.95% and 17.24% based on number and weight, respectively). Percentage reduction of infested fruit was the highest (57.50 and 62.38%, by number and weight, respectively) in Emamectin treated plots. Similarly the highest percentage protection (58.99 and 63.06% by number and weight, respectively) of infested fruit was also found from the Emamectin benzoate treatment. But Libsen 45 SC revealed the highest efficacy on marketable fruit yield (20.23 t ha^{-1}) compared to other treatments. So, Emamectin benzoate and Libsen both might be used to manage tomato fruit borer effectively.

Keywords: Management, tomato fruit borer, Spinosad, Emamectin benzoate, Abamectin, *Beauveria bassiana*

Cite this article: Biswas D, Uddin MM, Ahmad M. 2019. Biorational management of tomato fruit borer, *Helicoverpa armigera* (Hübner) in winter under field condition of Bangladesh. Fundamental and Applied Agriculture 4(2): 792–797. doi: 10.5455/faa.20352

1 Introduction

In Bangladesh, tomato is cultivated all over the country from November to March and from April to October. Bangladesh grew tomato in 27,114 hectares of land in the year 2014 with a total production of 260,000 t approximately showing an average yield of 95,891 hectogram ha^{-1} and Bangladesh is 54th in the world in tomato production (FAOSTAT, 2014). Though tomato production is increasing but still Bangladesh is lying behind the requirement. Of the various factors, responsible for low yield of tomato, in Bangladesh, the insect pests are the most important. Among the various insect pests, tomato fruit borer, *Helicoverpa armigera* (Hübner) is highly destructive causing serious damage (Muthukumaran and Selvanarayanan, 2013). Fruiting stage of the crop and the time of plantation govern the incidence of fruit borer (Chakraborty et al., 2011). Larvae invade fruits, preventing fruit development and causing the fruit dropping (CABI, 2007). Tomato Fruit Borer damage can also be responsible for decreasing the seed viability compared to undamaged fruit (Karabhantanal et al., 2010). Larvae can be found only by opening the infested fruit (Shah et al., 2013). Severe infestation causes necrosis to the leaf chlorophillus tissue, suppresses tomato flowers to bloom and makes the mature fruit unfit to consume (Jallow and Matsumura, 2001). It has been reported to cause serious losses throughout its range, in particular to tomato it has been found to cause a yield loss of 35% to 37.79% fruit (Dhandapani et al., 2003).

The farmers of Bangladesh usually control this pest by the application of chemical insecticides because they are available, very easy to apply on plant and most importantly, these chemicals give very quick result. The presence of residues of DDT, HCH, Endosulfan, Malathion and Primisphos-Methyl in market samples of tomato has been reported (Ravi et al., 2008). To avoid such problems caused due to indiscriminate use of insecticides, utilization of biorational insecticides is an ecologically viable, alternate insect pest management strategy. The term 'biorational' was coined by Djerassi et al. (1974). Biorational or 'reduced risk' insecticides are synthetic or natural compounds that effectively control insect pests, but have low toxicity to non-target organisms (such as humans, animals and natural enemies) and the environment (Hara, 2000). Although they are mostly synthetic, they are more selective than conventional insecticides, hence safer, and fit well into integrated pest management (IPM) programs (Casida and Quistad, 1998). Biorational insecticides includes biochemical insecticides (botanicals, insect growth regulators, insect pheromones, photoinsecticides, and inorganics); biological insecticides, using of natural enemies such as parasitoids, predators, nematodes, and pathogens (virus, bacteria, fungi, or protozoa); and transgenic insecticides (genetically modified plants or organisms) (Khater, 2011). In Bangladesh, the use of biorational insecticides to manage the tomato fruit borer is not very common. With the above views the present research has been conducted to test the effectiveness of seven biorational insecticides in managing *H. armigera* in winter tomato under field condition.

2 Materials and Methods

An experiment was conducted during December 2014 to March 2015 in the Field Laboratory, Department of Entomology, Bangladesh Agricultural University, Mymensingh, Bangladesh. The experimental site was characterized by scantly rainfall with moderately low temperature during Rabi Season (November-March). The soil of the experimental site was silty loam belonging to the Old Brahmaputra Floodplain Alluvial Tract under the Agro Ecological Zone 9 having pH 6.8 (UNDP/FAO, 1988). The winter variety of tomato BARI tomato-2 (Ratan, development year 1986, developed by Olericulture Division, HRC, Gazipur, BARI) was used as host plant. Seed was collected from BARI. Before sowing seeds, the germination test was done and 90% germination was ensured. Seeds were then directly sown in the well ploughed and cowdung mixed seedbed and light irrigation was provided after sowing.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of a unit plot was 4 feet length and 3 feet breadth. Distance of 1 foot between blocks and between the plots was maintained to facilitate different intercultural operations. Different types of fertilizers were provided to each plot as per recommended dose of BARI fertilizer recommendation guide for winter tomato. In the main field 30 days old six healthy seedlings were transplanted in every plot. All the agronomic practices were done for the better growth of the plants. Seven biorational insecticides named Neem (*Azadirachta indica*) oil @ 1.5 mL L^{-1} of water, Mahogany oil (*Swietenia mahagoni* L.) @ 1.5 mL L^{-1}, Karanja oil (*Millettia pinnata*) @ 1.5 mL L^{-1}, Abamectin (Ambush 1.8 EC) @ 2.5 mL L^{-1}, Spinosad (Libsen 45 SC) @ 0.5 mL L^{-1}, Emamectin benzoate (Suspend 5 SG) @ 1 g L^{-1} and *Beauveria bassiana* @ 7.5 g L^{-1} were sprayed on the tomato plants using a knapsack sprayer. The biorational insecticides were started to spray after fruiting and a sufficient infestation of tomato fruit borer and were repeated after 15 d interval. A control treatment was maintained and the control plots were sprayed only with water. Data were recorded from three randomly selected plants from each plot on number of healthy fruits $plot^{-1}$, number of infested fruits $plot^{-1}$, weight of healthy fruits $plot^{-1}$ and weight of infested fruits $plot^{-1}$. Increased healthy fruit over control (%), fruit infestation and protection over control (%) by number, increased healthy fruit weight over control (%), fruit infestation and protection over control (%) by weight, yield (ton ha^{-1}) and yield increased over control (%) were calculated from collected data. Analysis of data was done by using MSTAT-C package program (Russell, 1986) whereas means were separated by DMRT (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Effect of biorational insecticides on healthy fruits and fruit yield

The results showed significant differences among the treatments against *H. armigera* as well as on the yield factors of healthy fruits. During winter, Spinosad showed significantly higher performance on the highest cumulative mean number of healthy fruits $plot^{-1}$

Table 1. Effect of different biorational insecticides on the production of healthy fruit and fruit yield

	Neem oil	Mahogany oil	Karanja oil	Abamectin	Spinosad	Emamectin	Beauveria bassiana	Control	Sig. lev.	CV (%)
Number of healthy fruits plot^{-1}										
1st harvest	35.00a	33.33a	34.00a	35.33a	40.33a	40.00a	34.33a	23.33b	*	14.28
2nd harvest	30.66ab	24.33bc	24.33bc	30.66ab	33.66a	30.00ab	25.33abc	17.66c	*	16.48
Cumulative mean	65.66a	57.66a	58.33a	65.99a	73.99a	70.00a	59.66a	40.99b	**	11.07
Weight of healthy fruit plot^{-1} (kg)										
1st harvest	1.05a	1.00a	1.02a	1.06a	1.21a	1.20a	1.03a	0.70b	*	14.28
2nd harvest	0.95ab	0.75bc	0.76bc	0.95ab	1.04a	0.93ab	0.78abc	0.54c	*	16.48
Cumulative mean	2.00a	1.75a	1.78a	2.01a	2.25a	2.13a	1.81a	1.24b	**	11.08
Marketable yield (t ha^{-1})										
	17.96a	15.75a	15.93a	18.05a	20.23a	19.12a	16.30a	11.20b	**	11.08

In same row different letters indicate significant difference; ** and * indicate 1% and 5% level of significance, respectively; Abamectin = Ambush 1.8 EC, Spinosad = Libsen 45 SC, and Emamectin = Emamectin benzoate 5 SG

(73.99) than other treatments. Spinosad showed higher performance on the highest mean number of healthy fruits plot^{-1} during both harvest followed by Emamectin benzoate (40.0), Abamectin (35.33), Neem oil (35.0), *B. bassiana* (34.33), Karanja oil (34.0) and Mahogany oil (33.33) after first harvest and Abamectin (30.66), Neem oil (30.66), Emamectin benzoate (30.0), *B. bassiana* (25.33), Mahogany oil (24.33), Karanja oil (24.33) after second harvest (Table 1). Similar findings were also obtained by Vojoudi et al. (2011) who evaluated the effect of biorarionals for the control of *H. armigera* where they found that Spinosad showed good performance against this pest and in increasing of healthy fruit number.

The highest cumulative mean weight of healthy fruit plot^{-1} (2.25 kg) was observed in Spinosad treated plot followed by Emamectin benzoate, Abamectin and Neem oil treated plot with a mean weight of 2.13, 2.01 and 2.00 kg plot^{-1}, respectively. Spinosad was statistically superior to all the biorational insecticides and control in both first harvest (1.21) and second harvest (1.04) in case of producing the highest mean weight of healthy fruits plot^{-1}. These findings are in agreement with Carneiro et al. (2014). The result of the experiment also revealed that all the treatments could increase marketable fruit yield (t ha^{-1}) of tomato significantly ($p<0.01$) as compared to the control (Table 1). Spinosad contributed the highest (20.23 t ha^{-1}) fruit yield of tomato was found statistically identical to all other treatments. Next to the Spinosad, the better fruit yield was found from Emamectin benzoate (19.12 t ha^{-1}) treated plots followed by Abamectin (18.05 t ha^{-1}), Neem oil (17.96 t ha^{-1}), *B. bassiana* (16.30 t ha^{-1}), Karanja oil (15.93 t ha^{-1}) and Mahogany oil (15.75 t ha^{-1}). The lowest fruit yield was obtained from control (11.20 t ha^{-1}). Dandule et al. (2000) from their study proved that Spinosad was more effective in controlling the *H. armigera* than synthetic pyrethroids and increasing of fruit yield. Ghosh et al. (2010) also found from the similar result. Carneiro et al. (2014) performed an experiment with different chemical groups including the Spinosad demonstrated that Spinosad was highly effective to produce the highest yield of tomato. Spinosad also produced the highest percentage increase of healthy fruit over control by number (80.51%) (Fig. 1a), percentage increase of healthy fruits over control by weight (81.45%) (Fig. 1b) and increased yield over control (80.63%) (Fig. 1c).

3.2 Effect of biorational insecticides on reduction of fruit infestation

The performance of all biorational insecticides in decreasing the rate of fruit infestation varied significantly among the all biorational insecticides tested. Emamectin benzoate provided significantly the best result on the lowest cumulative mean number (17.99) and mean weight (0.41 kg) of infested fruit plot^{-1}. During first harvest minimum mean number of infested fruit was obtained from the plots treated with Spinosad (8.33) and also Emamectin benzoate (8.33) and the highest was from control (19.0). During the second harvest, the lowest mean numbers of infested fruits were obtained from the plots treated with Emamectin benzoate (9.66) having statistical similarity with the results of Spinosad (11.66), Abamectin (13.33), Neem oil (13.66) and *B. bassiana* (13.66) where the maximum mean number of infested fruit plot^{-1} was collected from control (23.33) which showed statistical similarity with Mahogany oil (20.33) and Karanja oil (21.33) (Table 2).

The cumulative mean percentage infestation of fruits after two sprays showed that Emamectin benzoate was excellent with the lowest mean infestation 20.95% and 17.24% by number and weight, respectively (Table 2). The percentage of fruit infestation by number both in first and second spray showed sig-

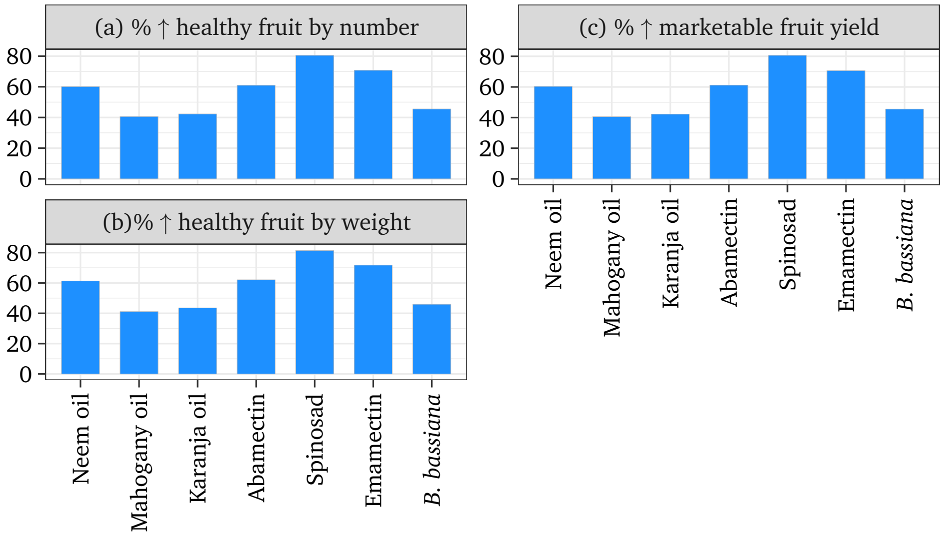

Figure 1. Effect of biorational insecticides on (a) % increase of healthy fruit by number, (b) % increase of healthy fruit by weight, and (c) % increase of marketable fruit yield over control

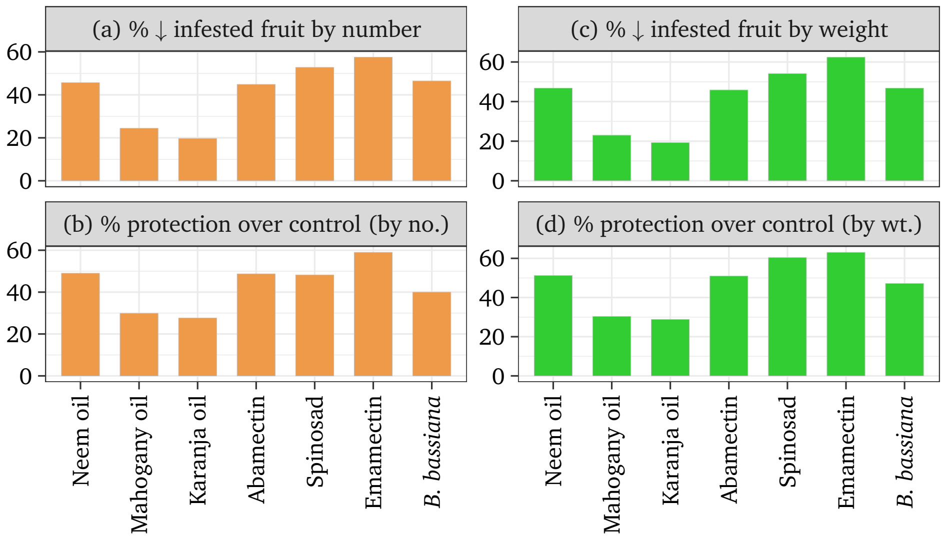

Figure 2. Effect of biorational insecticides on (a) % reduction of infested fruit by number over control, (b) % protection over control (by number), (c) % reduction of infested fruit by weight over control, and (d) % protection over control (by weight)

nificant variation among the biorational insecticides used to manage the tomato fruit borer. In first spray, the lowest mean rate of fruit infestation (17.17%) was observed in Spinosad which was statistically identical with the Emamectin benzoate (17.51%) treated plot while the untreated control plot had maximum fruit infestation (45%). Percentage of fruit infestation after second spray revealed the lowest fruit infestation in plots treated with Emamectin benzoate (24.39%) which was statistically similar with results produced by Spinosad (26.02%). As usual, the highest fruit infestation was observed in untreated control plot (57.17%). The percentage of fruit infestation by weight of infested fruits in both first and second spray showed significant variation among the biorational insecticides. In first spray, the minimum rate of fruit infestation (14.73%) was observed in Spinosad treated plot while the untreated control plot had maximum fruit infestation (40.56%) and Emamectin benzoate (15.05%) showed statistically identical result with the effect of Spinosad. After second spray, the lowest fruit infestation was found from Emamectin benzoate (19.42%) which was statistically similar with results produced by Spinosad (22.23%). The highest fruit

Table 2. Effect of different biorational insecticides on the infestation of tomato fruit borer, *H. armigera*

	Control	Neem oil	Mahogany oil	Karanja oil	Abamectin	Spinosad	Emamectin	Beauveria bassiana	Sig. lev.	CV (%)
Number of infested fruits plot^{-1}										
First harvest	19a	9.33bc	11.66bc	12.66b	10bc	8.33c	8.33c	9bc	**	13.46
Second harvest	23.33a	13.66b	20.33a	21.33a	13.33b	11.66b	9.66b	13.66b	**	12.92
Cumulative mean	42.33a	22.99c	31.99b	33.99b	23.33c	19.99c	17.99c	22.66c	**	9.38
% fruit infestation by fruit number										
First harvest	45a	21.20bc	26.07b	27.16b	22.12bc	17.17c	17.51c	20.86bc	**	10.87
Second harvest	57.17a	30.90cd	45.57b	46.80b	30.28cd	26.02d	24.39d	35.25c	**	9.08
Cumulative mean	51.09a	26.05cd	35.82b	36.98b	26.20cd	21.60de	20.95e	28.06c	**	6.3
Weight of infested fruit plot^{-1} (kg)										
First harvest	0.48a	0.23c	0.29bc	0.32b	0.25bc	0.21c	0.19c	0.23c	**	13.45
Second harvest	0.61a	0.35b	0.55a	0.56a	0.34b	0.29b	0.22b	0.34b	**	15.21
Cumulative mean	1.09a	0.58c	0.84b	0.88b	0.59c	0.5c	0.41c	0.57c	**	12.18
% fruit infestation by fruit weight										
First harvest	40.56a	18.32bc	22.72b	23.72b	19.14bc	14.73c	15.05c	18.02bc	**	11.37
Second harvest	52.78a	27.20cd	42.28b	42.70b	26.63cd	22.23d	19.42d	31.27c	**	10.32
Cumulative mean	46.67a	22.76cd	32.5b	33.21b	22.89cd	18.48de	17.24e	24.65c	**	8.06

In same row different letters indicate significant difference; ** indicates 1% level of significance; Abamectin = Ambush 1.8 EC, Spinosad = Libsen 45 SC, and Emamectin = Emamectin benzoate 5 SG

infestation was observed in untreated control plot (52.78%) which was statistically dissimilar to all biorational treatments. Ravi et al. (2008) also found the similar findings in their experiments. Moreover the highest percentage reduction of infested fruit over control (57.50%) (Fig. 2a) by number, the highest protection over control (58.99%) (Fig. 2b) by number, the highest reduction of infested fruit weight over control (62.38%) (Fig. 2c) and the highest protection over control (63.06%) (Fig. 2d) by weight was obtained from Emamectin benzoate treated plot. These results are exactly in agreement with the findings of Fanigliulo and Sacchetti (2008), Murugaraj et al. (2006) and Kanna et al. (2005) where they proved that Emamectin benzoate can produce a high control of infestation of *H. armigera*.

4 Conclusions

Finally it could be concluded that, all biorational insecticides *viz.*, Neem oil, Mahogany oil, Karanja oil, Abamectin (Ambush 1.8 EC), Spinosad (Libsen 45 SC), Emamectin benzoate (Suspend 5 SG) and *B. bassiana* tested in this study was effective in reducing of infestation and increasing the yield of tomato. Emamectin benzoate (Suspend 5 SG) emerged out as highly effective biorational insecticides comparing to others of two foliar spray applications at 15 days interval produced the best result among all the biorational insecticides. Next to the Emamectin benzoate the better result was explored by Spinosad (Libsen 45 SC) @ 0.5 mL L^{-1} of water in all parameters considered in the experiment. From botanicals, Neem oil excelled with the best result in reducing the infestation and increasing the fruit yield. Therefore, the results of the present research might be helpful to develop a sustainable management strategy for tomato fruit borer successfully.

Acknowledgements

The authors cordially acknowledge Bangladesh Agricultural University Research System for providing fund to successfully conduct this research work under a project.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the
Farm to Fork Foundation
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa