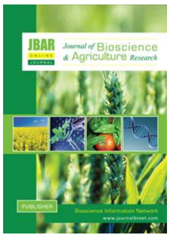
Journal BiNET
Scientific Publication

Published with Open Access at Journal BiNET
Vol. 28, Issue 01: 2335-2340
Journal of Bioscience and Agriculture Research
Journal Home: www.journalbinet.com/jbar-journal.html



Eco-friendly management of okra shoot and fruit borer using bio-control agents

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Article received: 10.06.2021; Revised: 12.08.2021; First published online: 30 August, 2021.

ABSTRACT

The purpose of this study was to evaluate efficiency of certain biological control agents for the ecologically sound and sustainable management of okra shoot and fruit borer (OSFB) at the Sher-e-Bangla Agricultural University, Dhaka. Randomized Complete Block Design (RCBD) with three replications was used for this experiment. It consists of seven different types of treatments, including as application of Trichogramma evanescence @5 Tricho cards/plots (T_1), Trichogramma evanescence @0.08 g/plot (T_2), Bracon hebetor @10 adults (Male:Female = 4:6) per plot (T_3) while applying Bracon hebetor @15 adults (Male:Female = 6:4)/plot (T_4). Applying Bacillus thuringiensis Serovar kurstaki @2ml suspension/liter water/4plot in T_5 and Bacillus thuringiensis Serovar kurstaki @1ml suspension/liter water/plot in T_6. T_7 stands for untreated control in this study. All the treatments were applied at 7 days intervals. The best performance was obtained from treatment (T_5) in reducing the shoot and fruit infestation (56.88 and 71.86%, respectively) by number and weight over control. The maximum total fruit yield (6544 kg/ha), i.e., 71.30% increase over control of okra, was produced in T_5. So, from the present study, it may be revealed that bio-control agents can be used for the ecologically sound and sustainable management of okra shoot and fruit borer. Bacillus thuringiensis Serovar kurstaki may be used in this regard and the optimum dose may be 2ml suspension/liter water/plot and 7 days application interval should be followed.

Key Words*: Bio-control agents, Eco-friendly management, Okra shoot and fruit borer, Food safety and Organic vegetable*

Cite Article: Amin, R., Hossain, M. E., Sultana, R., Alam, M. A. and Hossain, M. A. (2021). Eco-friendly management of okra shoot and fruit borer using bio-control agents. Journal of Bioscience and Agriculture Research, 28(01), 2335-2340.
Crossref: https://doi.org/10.18801/jbar.280121.283

I. Introduction

Okra (*Abelmoschus esculentus*) is one of the most common annual vegetables grown in Bangladesh, and it is popular not only in Bangladesh but also around the world. It belongs to the Malvaceae family and is said to have originated in tropical Africa (Purseglove, 1987). However, this vegetable can be successfully grown throughout the year, even though it is primarily produced during the kharif season

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(Rashid et al., 2006). During 2017-2018, Bangladesh produced approximately 38508 metric tons of okra (BBS, 2020). In Bangladesh, okra is primarily harvested from February to July (Rashid et al., 2006) and insects from the vegetative to reproductive phases greatly impede their production (Nair et al., 2017).

Okra is infested by a variety of insects, but the okra shoot and fruit borer (OSFB) is one of the most damaging, causing significant damage (Butani and Jotwani, 1984). Bangladesh's most problematic okra pest is causing both quantitative and qualitative losses due to its infestation. About 40-50% damage of okra fruit was recorded by Srinivasan et al. (2014) due to the infestation of OSFB in some regions of Southeast Asian countries. Krishnaiah (1980) documented the infestation of fruit borer to 35% in harvestable fruit of okra. In Madras, 40-50% of the fruit was also damaged by this pest (Srinivasan et al., 2014). The fruit borer *Earias vittella* attacks the okra 4-5 weeks after germination, whether in kharif or summer. The buds at the top dry up, while the flowers, buds, and developing fruits fall prematurely. The immature stage (larvae) of OSFB (*Earias vittella*) into the tips of shoot in seedlings and fruits makes the fruits unpalatable.

Several control strategies have been adopted against OSFB. The use of synthetic chemical insecticides is a common method to control OSFB. These synthetic chemical insecticides are tremendously harmful to the environment. Those result in the accumulation of residues in the harvested produce and various health hazards (Chinnaiah et al., 2019). Bio-control agents are a safe and non-hazardous free tactic for managing insect pests (Hasan et al., 2012). Among them, the parasitic wasp. *Trichogramma* is an egg parasite, *Bracon* sp. the larval parasitic wasp and *Bacillus thuringiensis* pathogen are recently introduced to prevent and control crop pests in Bangladesh. Many parts of the world use *Trichogramma* sp. successfully for crop production (Hasan et al., 2012). However, farmers in Bangladesh are far behind in using biological control agents to manage okra shoot and fruit borers and are not even familiar with them.

At one time, research developed insecticide spray schedules that involved calendar spraying, whether the pest was present or not. But this method has led to several problems such as increased application of insecticides that ultimately increase the production costs, rapid environmental pollution, drastically reduction of natural enemies leading to the insecticide resistance in OSFB, high residual toxicity in fruits and the ultimate result was pest resurgence. If the indiscriminate use of synthetic insecticide is continued, it will adversely affect vegetables, including okra (Hasan et al., 2012). Therefore, it is high time to use environmentally friendly and easily biodegradable insecticides with a few toxic effects on the natural enemies and non-target organisms. Bio-control agents have broad term applications for controlling pests with their safe apply species specific in operation and easy to process and use (Chinnaiah et al., 2019). From Bangladesh's perspective, the uses of bio-control agents possess several advantages, such as easy production by small traders and cost of production is less expensive. However, very few scientific and continuous research work have been done in Bangladesh to explore available bio-control agents effective for controlling harmful pests of okra plant. The current study was aimed to document the occurrence of OSFB and evaluate the effectiveness of some biological control agents.

II. Materials and Methods

The present demonstration was carried out at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, from January to June 2018. The demonstration plot was characterized as having shallow red-brown terrace soil with a pH range of 5.8-6.5. Using a randomized complete block design with three replications, the demonstration was conducted. The treatments were as bellows applying in the seven days interval in all cases.

T_1	*Trichogramma evanescence*@5 Tricho card/plot
T_2	*Trichogramma evanescence*@0.08 g/plot
T_3	Bracon hebetor @10 adults (Male: Female = 4: 6)/plot
T_4	Bracon hebetor @15 adults (Male: Female = 6: 4)/plot
T_5	*Bacillus thuringiensis* Serovar kurstaki@2ml suspension/liter water/plot
T_6	*Bacillus thuringiensis* Serovar kurstaki @1ml suspension/liter water/plot
T_7	Untreated control

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To make things easier, the primary experimental plot was separated into three major parts. There were also seven sub-plots in each major block, resulting in a total of 21 plots and each unit sub plot was 3m long and 2m wide, with a 0.75m plot-to-plot spacing in between.

The seed materials used in this assessment were collected from Advanced Chemical Industry (ACI) Limited and were sown on the field on 15th January. According to the fertilizer recommendation guide (BARC, 2012), manures and fertilizers were applied to produce okra per hectare. All the Intercultural operations were performed when for ensuring the normal physiological build-out of the crop. Data on different parameters were collected from five randomly selected and tagged okra plants. The incidence of OSFB infestation on okra plants was inspected at both (vegetative and reproductive) life stages. Infestation on okra shoots by number was documented at seven days recess period after intensive documentation on the existence of OSFB and their faecal material at both plant life stages. The infestation status on okra fruit was recorded at the reproductive stage. The number of infested okra fruits by OSFB was counted at harvesting at three days intervals. Data analysis was done with MSTAT-C software and treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez, 1984).

III. Results and Discussion

Effect of bio-control agents on the shoot infestation

During different growth and development stages of okra, OSFB detected significant variance in % shoot infestation (Table 01). At the initial growth stage of okra, T_5 (the treated plot) had the lowest shoot infestation (4.77 percent), whereas T_7 (the untreated control) had the highest (13.75 percent). The highest shoot infestation compared to untreated control was recorded in T_7 (35.73%) followed by T_3 (23.12%). A similar trend was observed at the final growth stages of okra. The lowest shoot infestation was found in T_5, intermediate and final growth stages (14.25% and 24.59%, respectively). The untreated control treatment was the highest shoot infestation (35.73% and 50.24%, respectively). However, in the case of treated plots, the highest shoot infestation at intermediate and final growth stage (23.12% and 37.95%, respectively) was in T_3 (application of 5 Tricho card with *Trichogramma evanescence* followed by T_4 (21.93% and 36.08%, respectively), T_2 (19.89% and 34.86%, respectively). Considering the mean infestation, the lowest shoot infestation was recorded in T_5 (14.33%), followed by T_6 (17.02%), T_1 (18.65%) and T_2 (19.98%). On the contrary, the maximum shoot infestation (33.24%) was recorded in T_7 (untreated control) followed by T_3 (24.02%) and T_4 (22.21%). In case of shoot infestation reduction compared to control, the maximum reduction (56.88%) was observed in T_5 followed by T_6 (48.79%), T_1 (43.89%) and T_2 (39.89%), whereas the lowest reduction shoot infestation compared to control was recorded in T_3 (27.73%) accompanied by T_4 (34.17%). The above findings revealed that the T_5 comprised with the application of 2 ml suspension of *Bacillus thuringiensis* serovar kurstaki/litre water had believed to perform better in the matter of the highest reduction of shoots infestation compared to control. The result obtained from the present study was similar to Rabindra and Ramanujam (2007) and Satpute et al. (2002).

Table 01. Effect of bio-control agents on the shoot infestation applied against okra shoot and fruit borer at various fruiting stages

Treatment	% Shoot infestation				
	Initial fruiting stage	Intermediate fruiting stage	Final fruiting stage	Mean (%)	% reduction over control
T_1	6.78 b	17.10 e	32.18 e	18.65 d	43.89
T_2	6.98 b	19.89 d	34.86 d	19.98 d	39.89
T_3	6.87 b	23.12 b	37.95 b	24.02 b	27.73
T_4	7.02 b	21.93 c	36.08 c	21.88 c	34.17
T_5	4.77 d	14.25 g	24.59 g	14.33 f	56.88
T_6	6.08 c	15.65 f	29.98 f	17.02 e	48.79
T_7	13.75 a	35.73 a	50.24 a	33.24 a	--
$LSD_{0.05}$	5.86	11.29	12.12	8.57	--
CV (%)	5.33	6.19	8.56	7.23	--

[In column the treatment means with same letters indicate the statistically similar at 5% level of significance]

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Effect of bio-control agents on the fruit infestation by number

Different management techniques significantly impacted percent fruit infection by number at various fruiting stages of okra as influenced by OSFB (Table 02). The minimum amount of fruit infestation by number (11.86%) was recorded in T_5, whereas the highest (43.12%) was in untreated control at the initial fruiting stage of okra. In case of the initial fruiting stage under managed plots, the maximum fruit infestation was observed in T_3 (32.54%) followed by T_4 (28.33%), T_2 (22.01%), T_1 (17.47%) and T_6 (15.88%). A similar trend was observed at intermediate final fruiting stages of okra. The least infestation of fruit by number at intermediate and final fruiting stage (13.23% and 16.85%, respectively) was in T_5, while the highest (47.96% and 66.20% intermediate final respectively) was in the untreated control.

However, in terms of treated plots, the maximum amount of fruit infestation by number at intermediate and final fruiting stage (35.11% and 42.01%, respectively) was in T_3, followed by T_4 (31.86% and 34.91%, respectively), T_2 (24.02% and 29.97%, respectively). Considering the mean infestation, the minimum fruit infestation (14.75%) was documented in T_5 followed by T_6 (19.01%), T_1 (22.16%) and T_2 (25.22%). On the contrary, the highest fruit infestation (52.42%) was documented in untreated control (T_7) treatment which was followed by T_3 (37.04%) and T_4 (32.03%). In the matter of fruit infestation reduction compared to control, the maximum reduction compared to control (71.86%) was observed in T_5 followed by T_6 (63.73%), T_1 (57.72%) and T_2 (51.88%), whereas the lowest fruit infestation reduction compared to control was recorded in T_3 (29.33%) accompanied by T_4 (38.89%). The above findings revealed that the T_5 comprised with the utilization of *Bacillus thuringiensis* Serovar *kurstaki* @2 ml suspension/litre water had believed to perform better than other treatments in terms of the maximum reduction of fruit infestation compared to control. The result obtained from this investigation was closely refined to the detection of Swaroop et al. (2005).

Table 02. Effect of bio-control agents on the fruit infestation by number applied against okra shoot and fruit borer at various fruiting stages

Treatment	% Fruit infestation by number				
	Initial fruiting stage	Intermediate fruiting stage	Final fruiting stage	Mean (%)	%reduction over control
T_1	17.47 e	20.93 e	28.08 e	22.16 e	57.72
T_2	22.01 d	24.02 d	29.97 d	25.22 d	51.88
T_3	32.54 b	35.11 b	42.01 b	37.04 b	29.33
T_4	28.33 c	31.86 c	34.91c	32.03 c	38.89
T_5	11.86 g	13.23 g	16.85 g	14.75 g	71.86
T_6	15.88 f	18.01 f	23.11 f	19.01 f	63.73
T_7	43.12 a	47.96 a	66.20 a	52.42 a	--
$LSD_{0.05}$	9.55	11.22	23.01	14.62	--
CV (%)	6.25	7.24	9.19	8.32	--

[in column the treatment means with same letters indicate the statistically similar at 5% level of significance]

Effect of bio-control agents on the fruit infestation by weight

Various treatments significantly influenced percent fruit infestation by weight at different fruiting stages of okra as affected by OSFB (Table 03). As shown in Table 03, the least infestation of fruit by weight (12.02 %) was recorded in T_5, whereas the highest (40.75 %) fruit infestation was recorded with untreated control treatment at the initial fruiting stage of okra. At the initial fruiting stage of okra, the highest fruit infestation by weight was observed in T_3 (31.71%), followed by T_4 (28.11%), T_2 (20.88%), T_1 (17.56%) and T_6 (15.65%). A similar trend was observed at intermediate and the final fruiting stages of okra. In the middle and final stages of the fruit, the lowest fruit infection rate by weight (13.97% and 17.01%, respectively) was recorded at T_5, while the highest fruit infection rate (46.01% and 62.75%, respectively, the final and intermediate stage) was recorded at unprocessed control. But for the treated plots, the highest infestation rate of fruit weight in T_3 was recorded in the middle and final fruiting stages (34.91% and 40.03%, respectively).

Considering the mean infestation, the minimum fruit infestation by weight (14.39%) was documented in T_5 accompanied by T_6 (18.25%), T_1 (21.54%) and T_2 (24.72%). On the other hand, the unmanaged plot (T_7) recorded the highest fruit infestation (49.84 percent), followed by T_3 (35.71 percent) and T_4 (31.01 percent). Regarding fruit infestation over control, T_5 had the most reduction (71.12%),

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followed by T_6 (63.38%), followed by T_1 (56.78%) and T_2 (50.40%), while T_3 had the lowest reduction (28.35%) followed by T_4 (37.78 percent). From the results mentioned above, it may be said that the T_5 comprised with the utilization of *Bacillus thuringiensis* Serovar *kurstaki* @2 ml suspension/litre water believe in performing better than treatments in terms of the maximum reduction of fruit infestation compared to control. Swaroop et al. (2005) also found a similar type of results.

Table 03. Effect of bio-control agents on okra shoot and fruit borer infestations at different stages of fruiting

Treatment	% Fruit infestation by weight				
	Initial fruiting stage	Intermediate fruiting stage	Final fruiting stage	Mean (%)	% Reduction over control
T_1	17.56 e	20.14 e	26.94 e	21.54 e	56.78
T_2	20.88 d	23.94 d	28.98 d	24.72 d	50.40
T_3	31.71 b	34.91 b	40.03 b	35.71 b	28.35
T_4	28.11 c	32.98 c	33.81 c	31.01 c	37.78
T_5	12.02 g	13.97 g	17.01 g	14.39 g	71.12
T_6	15.65 f	17.11 f	22.05 f	18.25 f	63.38
T_7	40.75 a	46.01 a	62.75 a	49.84 a	--
$LSD_{0.05}$	8.17	9.54	20.11	13.02	--
CV (%)	4.19	6.25	7.19	9.34	--

[in column the treatment means with same letters indicate the statistically similar at 5% level of significance]

Total fruit yield

In case of total fruit yield of okra, significant variations were observed in various treatments at various fruiting stages of okra as affected by OSFB (Table 04). Results showed that the highest total fruit yield (1071 kg/ha, 3462 kg/ha and 2011 kg/ha at initial, intermediate and final fruiting stage respectively) was obtained by T_5 where the lowest total fruit yield (471 kg/ha, 2338 kg/ha and 1011 kg/ha at initial, intermediate and final fruiting stage respectively) of okra was with untreated control treatment. Among the plots treated with control measures, the minimum total fruit yield (559 kg/ha, 2677 kg/ha and 1141 kg/ha at initial, intermediate and final fruiting stages, respectively) was observed by T_3. A similar finding was observed by Sasikala et al. (1999) and Rabindra and Ramanujam (2007), which has conformity with the present study.

Table 04. Effect of bio-control agents on total fruit weight against okra shoot and fruit borer at various fruiting stages

Treatment	Fruit yield (kg/ha)				
	Initial fruiting stage	Intermediate fruiting stage	Final fruiting stage	Total fruit yield/ha (kg)	% increase over control
T_1	782c	3079 c	1471 c	5332 c	39.58
T_2	681 d	2863 d	1378 d	4922 d	28.84
T_3	559 f	2677 f	1141 f	4377 f	14.58
T_4	631 e	2754 e	1298 e	4683 e	22.59
T_5	1071 a	3462 a	2011 a	6544 a	71.30
T_6	836 b	3191 b	1559 b	5586 b	46.23
T_7	471 g	2338 g	1011 g	3820 g	--
$LSD_{0.05}$	24.254	19.235	33.45	22.231	--
CV (%)	8.61	9.59	7.61	9.92	--

[In column the treatment means with same letters indicate the statistically similar at 5% level of significance]

IV. Conclusion

In shoot and fruit infestation, due to the management of okra shoot and fruit borer by bio-control agents, the lowest infestation was recorded in T_5 (14.33% and 14.75%, respectively) fruit infestation over control by 56.88% and 71.86%, respectively. On the contrary, maximum infestation on shoot and fruit (33.24 and 52.42% respectively) was recorded in T_7 (untreated control). This means that the treatment consisting of applying *Bacillus thuringiensis* Serovar kurstaki @2ml suspension liter water plot for seven days (T_5) worked better in decreasing shoot and fruit infestation by number as well as

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weight. Overall fruit output (6544 kg/ha) was likewise the highest, up to 71.30 percent above the control of okra. To summarize, bio-control agents can be utilized to manage okra shoot and fruit borer pests in a safe, environmentally sound and sustainable way (OSFB). One of the most effective biological control methods was applying *Bacillus thuringiensis* Serovar kurstaki @2ml suspension/liter water/plot at seven day break.

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