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Infested Shoot Clipping for Managing Brinjal Shoot and Fruit Borer: An Eco-Friendly Approach

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ABSTRACT

The brinjal shoot and fruit borer (BSFB) is a noteworthy hindrance that harshly affects brinjal production. However, effective control of the insect enables growers to get the maximum return. The present investigation was carried out to evaluate the effectiveness of infested shoot clipping as an eco-friendly approach to minimize BSFB infestation and enhance marketable yield at the Entomology Research Field, Department of Entomology, Bangladesh Agricultural University, Mymensingh during the *Rabi* season. Shoot Clipping provided moderate protection to Brinjal fruit against the infestation of BSFB. However, shoot clipping with sanitation provided sufficient protection to brinjal fruit against BSFB. The result also demonstrated that each of the treatment plots produced significantly better yields compared to the control. The lowest yield was produced in the untreated control, which was less than 6 t/ha. The highest brinjal was produced at Shoot Clipping +Sanitation, with the mean yield more than 14t/ha. Shoot clipping treated plot production was 10 t/ha. The overall results suggested that shoot clipping with sanitation provided the maximum marketable yield of brinjal. The benefit-cost ratio (BCR) was higher in the plot treated with shoot clipping with sanitation, which was 1.68. Thus, shoot clipping with sanitation could be a valuable IPM module for better management of BSFB.

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Introduction

Brinjal (*Solanum melongena* L.), commonly known as eggplant, is one of the most important vegetables grown in many tropical and subtropical regions of the world, especially in Central and South East Asia, some parts of Africa, and Central America (Lawande and Chavan, 1998; Harish *et al*., 2011). It ranks as the third most significant Solanaceae crop worldwide, following potatoes and tomatoes, with a global production of approximately 59.3 million tons in 2022 (FAO, 2024). Asia is responsible for 94.1% of this production, with China (37.8), India (12.8), and Egypt (1.4 million tons being the top cultivating countries (FAO, 2024). Bangladesh grows brinjal widely due to its high demand and nutritional value. More than 20 varieties of brinjal are grown in different regions in the country, and approximately 8.0 million farmers are involved in brinjal cultivation in Bangladesh (BBS, 2022). In 2022–23, Rabi brinjal was cultivated over 348.03 sq. km of land with a total production of 446 M tons. However, Kharif brinjal (summer) was cultivated over 198.3 sq. km of land with a total output of 235 M tons (BBS, 2024). Despite its significance, insect infestations pose a major challenge in sustainable brinjal production in Bangladesh. Amin et al. (2018) ascertained a total of 9 species of insects derived from 7 families of 4 orders as pests in the brinjal field. Among them, brinjal shoot and fruit borer (*Leucinodes orbonalis*) is the most common damaging pest that attacks both vegetative and reproductive phases of the crop (Abhishek and Dwivedi, 2021; Islam et al., 2019). It is induced to inflict about 16% damage to shoots and as high as 70% to fruits. In Bangladesh, BSFB (*Leucinodes orbonalis Guenée*) is the most destructive pest, responsible for 31–86% fruit damage (Alam et al., 2003). Chakraborti and Sarkar (2011) enumerated that the larval stage of BSFB is mainly disastrous and liable for 70–92% of yield loss.

Different pest management tactics, such as utilization of resistant varieties, spraying of chemical insecticides, botanical insecticides, biopesticides, clean culture, mechanical handpicking and removal of infested parts, application of sex pheromone traps, and the use of integrated pest management (IPM) technologies, have been practiced for the control of BSFB (Srinivasan, 2008; Chowdhury et al., 2017). However, chemical control is inadequate due to the underground habit of BSFB larvae infesting shoots and fruits by boring. So, growers use 25–30 applications of insecticides during a season, which also do not provide satisfactory control (Natekar et al., 1987; Sajjan and Rafee, 2015; Sarkar et al., 2022). The intensive and indiscriminate application of pesticides in managing BSFB has resulted in many problems, such as pest resistance, secondary pest resurgence, pesticide residues on consumable fruits, and adverse effects on human and environmental health (Kabir et al., 2011; Islam et al., 2019).

In this regard, eco-friendly management practices like infested fruit clipping - a strategy based on the removal and disposal of BSFB-infested fruits have become potential alternatives. These practices are very effective when they are undertaken in combination with cultural and mechanical practices such as sanitation and field monitoring (Islam et al., 2019). By removing infested portions before the pest's life cycle completion, the operation interferes with the pest population and lowers infestations at effectively environmentally friendly levels (Sarkar et al., 2022).

While some previous research has investigated various management practices, few field studies have measured the efficacy of clipping infested fruit alone or combined with other practices like sanitation. This study aims to evaluate the efficiency of the eco-friendly method of pest control through infested fruit clipping and its effects on BSFB incidence, fruit damage, and yield performance in general. The study will also investigate the influence of abiotic factors on BSFB population dynamics, hence giving insight into their role in seasonal patterns of infestation and sustainable pest management. The outcome of this research is expected to contribute to reducing chemical pesticide dependency while promoting environmentally sound brinjal production practices.

Materials and Methods

Experimental Site

The experimental site was located at 24.750 N latitude, 90.50 E longitude, with an elevation of about 9.2 m above sea level (Figure 1). The field experiments were conducted under a sub-tropical climate with moderately low temperature, scanty rainfall during October-March. The soil of the field experiment area was under the Old Brahmaputra Alluvial Tract under the Agro Ecological Zone 9, with sandy loam soil and texture, having good irrigation and drainage facilities. The soil was silty loam in texture, having a pH of 6.94, organic matter of 1.62%, and cation exchange capacity of 15.00 m. eq 100^{-1} g soil (Rahman *et al.*, 2015).

Figure 1. Location of the experiment plot

Land Preparation

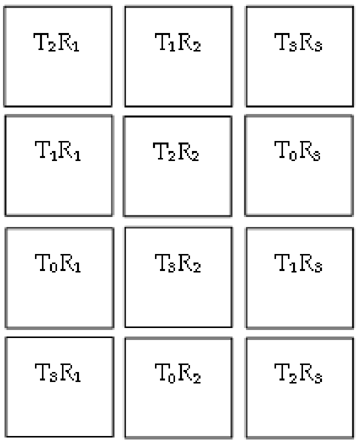
The land was ploughed and cross-ploughed several times with a power tiller to obtain final tilth, which was followed by laddering and spading. The stubble of the crops and uprooted weeds were removed from the field, and the land was then labeled before transplanting. The field layout was designed, and plots were raised by 10 cm from the soil surface, keeping the drain around the plots. Individual plots were prepared using a spade, providing a basal dose of chemical fertilizers. The plots were spaded one day before seed sowing, and the whole amount of fertilizer was incorporated thoroughly before seed sowing according to the fertilizer recommendation for the brinjal variety.

Experimental Setup

To conduct this experiment, brinjal seeds variety Singnath were sown in the seed bed. One-month-old seedlings were planted in the main field. The individual plot size was (2X2) m^2. Two adjacent unit plots and blocks were separated by 60 cm and 80 cm apart respectively. Plots were allocated randomly, and they were separated in such a way that the impact of every treatment could be quantified. All the agronomic practices were provided to ensure healthy plants. These plants were used for studying the effect of shoot & fruit clipping on the infestation of BSFB in the field. The shoot & fruit clipping were started after the start of pest infestation and continued until the last harvesting, maintaining a 7-day interval. Data was collected at 7-day intervals. The percentage of shoot and fruit infestation was calculated using the formulae mentioned in the first experiment. The percentage protection of shoot and fruit over control was determined following the formulae mentioned in the second experiment. Finally, marketable yield and percentage yield loss of fruit were determined. The percentage yield increase over the control was also calculated using the formula stated in the second experiment. BCR was calculated.

Treatments

T_0= Untreated control
T_1= Shoot clipping
T_2 = Sanitation
T3 = Shoot clipping + Sanitation
Design: Randomized Complete Block Design



Here Unit plot Size = 2m X 2 m
Row to Row Distance = 80 cm
Plant to Plant distance = 60 cm

Figure 2. Layout of the experimental plots

Observations

Data were collected on number of infested shoots/plants, number of infested fruit/plant, extent of damage to the shoot/plant (cm), number of holes/fruit, number of larvae/fruit and yield of marketable fruits/ha using the formula developed by Rahman et al. 2019 and mamun et al. 2014.

Data analysis

Before analysis, Shapiro-Wilk tests (assumption $P > 0.05$ should be met) were conducted to ascertain the normality of data. Data were processed following one-way analysis of variance (ANOVA), henceforth analyzed using the statistical computer program R Studio. Hereafter, the recognition of means with significant treatment effects by the F-test and intercepted by the Least Significant Difference (LSD) test at $p < 0.05$. Therefore, the data were visualized with the help of Origin 2020 (OriginLab Corporation, Version 9.6.5, Massachusetts, USA).

Results

Efficacy of infested shoot clipping on % shoot infestation and % protection over control

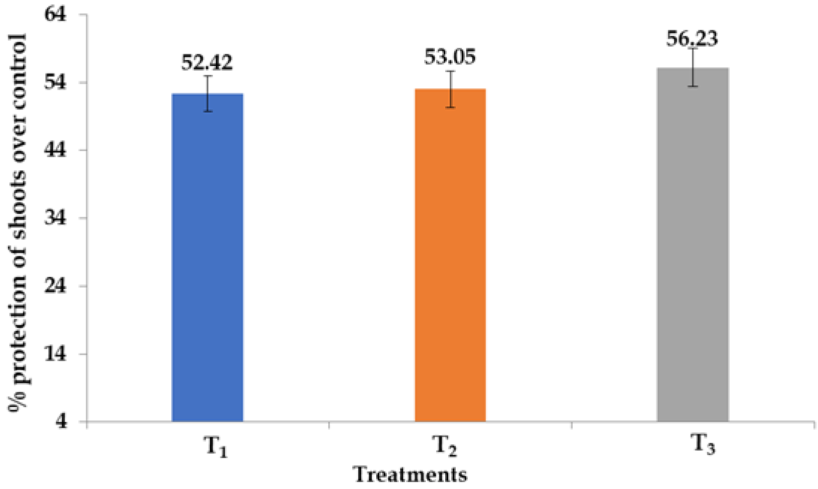
Shoot clipping and sanitation showed a significant (p<0.05%) effect on the brinjal shoot infestation by BSFB in comparison to the untreated control. Data presented in Table 1 shows the effectiveness of different methods on shoot infestation and % protection of shoots over the control. From Table 1, it was observed that all the treatments showed a significant effect on the percentage shoot infestation in comparison to the untreated control treatment. Among the selected treatments, T_3 had the highest efficacy, showing the lowest grand mean shoot infestation (1.17%), followed by T_1 with the second highest efficacy (3.33%), while the untreated control treatment had the highest grand mean (16.14%) shoot infestation (Table 1). In addition, the shoot clipping followed a rising trend of percentage shoot infestation from 7 to 70 days after shoot clipping. On the other hand, the control treatment had the highest level of infested shoots (19.6%), whereas T_3 had the lowest, 1.00% infested shoots, at 70 days of clipping. Thus, it may be said that, when compared to the untreated control, T_3 showed a noticeable variation in the percentage of shoot infection in brinjal.

Table 1. Efficacy of infested shoot clipping on the % shoot infestation

Treatments	Pre-treatment	% Shoot infestation on different days of shoot clipping										Grand Mean
		7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	
T_0	3.00	4.29	10.32a	13.89a	24.07a	9.72a	14.17a	17.86a	17.13a	18.5a	19.6a	16.14a
T_1	2.44	3.00	6.67b	0.00b	5.56b	0.00b	0.00b	0.00b	0.00b	1.60	2.10	3.33b
T_2	3.25	4.00	0.00c	0.00b	6.67b	0.00b	0.00b	0.00b	0.00b	1.20	2.00	4.24b
T_3	0.62	3.50	0.00c	0.00b	0.00c	0.00b	0.00b	0.00b	0.00b	0.60	1.00	1.17c
SE (±)	**0.77**	0.90	1.10	0.90	2.34	0.63	0.91	1.15	1.11	1.20	1.56	1.61
CV (%)	8.42	10.92	6.86	49.98	14.89	20.38	30.75	103.92	56.93	59.60	54.45	11.69
LSD 0.05	6.21	0.66	0.34	2.00	1.56	0.83	0.86	5.35	2.81	3.50	2.67	2.64
Level of significance	NS	NS	**	**	**	**	**	**	**	**	**	**

T_0= Untreated control, T_1= Shoot clipping, T_2= Sanitation, T_3= Shoot Clipping + Sanitation
*1% Level of Significance, ** 5% Level of Significance

The highest percentage protection of shoot was found from the combined shoot clipping and sanitation treatment (56.23%), followed by sanitation (53.05%) and Shoot Clipping (52.42%) to brinjal against BSFB (Figure 3).



T_1= shoot clipping, T_2= sanitation, T_3 = shoot Clipping + Sanitation
The % protection of shoot infestation over control

Figure 3. Effect of different treatments on % protection of shoots over the control

Efficacy of infested shoot clipping on % fruit infestation and % protection of fruit over control

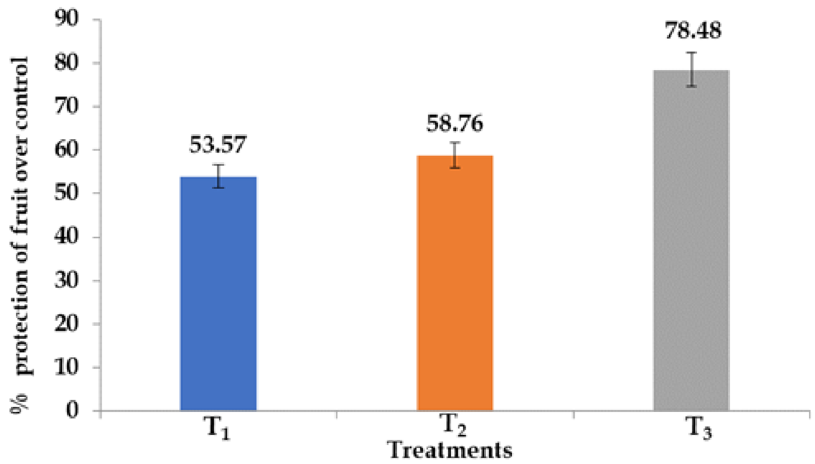
Table 2 presents a comparison of the effectiveness of several treatments of infested shoot clipping on fruit infestation, expressed as a percentage. From the data of Table 2, it was observed that all the treatments had a significant effect on the fruit infestation compared to the untreated control treatment. T3 had the highest efficacy from the selected treatments, demonstrating the lowest average fruit infestation rate (23.31%), followed by treatment T1 (29.55%). In contrast, the untreated control treatment had the highest average fruit infestation (42.1%) (Table 2).

Table 2. Effect of infested shoot clipping on percentage fruit infestation

Treatments	**Pre-treatment**	**% fruit infestation at different days after shoot clipping**										**Grand Mean**
		7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	
T_0	36.03	35.41	11.57b	43.58a	34.44a	50.9a	68.25a	53.97a	66.67a	50.75a	47.50a	42.10a
T_1	26.78	30.00	16.67a	24.07b	22.01ab	36.79b	61.11a	42.38b	33.33b	35.50a	40.50b	29.55b
T_2	28.94	26.75	25.00a	26.11b	36.11a	53.08a	33.33b	46.67b	50.0ab	46.50b	37.45b	33.79b
T_3	27.35	22.35	16.67a	29.09b	20.00b	25.00c	33.33b	46.67b	35.71b	30.35b	24.45c	23.31c
SE (±)	7.04	0.48	4.51	7.93	5.97	10.70	12.65	12.24	11.99	11.20	13.50	8.31
CV (%)	78.92	19.02	62.17	30.713	55.58	26.66	11.38	9.37	24.58	25.60	25.30	29.17
LSD 0.05	11.88	0.41	12.53	8.02	14.83	12.75	6.43	5.13	13.16	14.12	16.20	9.81
Level of significance	NS	NS	*	*	*	NS	**	NS	*	*	*	*

T_0 = Untreated control**,** T_1= shoot clipping, T_2= Sanitation, T_3= shoot Clipping + Sanitation
*1% Level of Significance, ** 5% Level of Significance

The Figure 4 shows the effect of different treatments on % protection of fruit over the control.



T_1 = shoot clipping, T_2 = Sanitation, T_3 = shoot Clipping + Sanitation

Figure 4. Effect of different treatments on % protection of fruit over the control

The data presented in Figure 4 indicates that the highest level of fruit protection over control was observed in plants that underwent shoot clipping and sanitation treatment, with a percentage of 78.48%. This was followed by sanitation treatment alone, which resulted in a protection of 58.76% fruit, and shoot clipping alone, which resulted in a protection of 53.57.

Efficacy of infested shoot clipping on the number of holes/fruit

The results shown in Table 3 demonstrated that all of the treatments had a non-significant effect on the mean number of holes per fruit in comparison to the untreated control treatment. From all the selected treatments, T_3 exhibited the best efficacy, as it demonstrated the lowest average number (1.08) of holes/fruit, followed by T_2 (1.33). In contrast, the untreated control treatment had the highest average number (2.35) of holes/fruit.

Efficacy of infested shoot clipping on the number of larvae/fruit

The findings shown in Table 4 showed that all of the treatments had notable impacts on the average number of larvae per fruit in comparison to the untreated control treatment. From all the selected treatments, T_2 and T_3 showed the highest efficacy, as they demonstrated the lowest average number (1.61) of larvae/fruit. But the untreated control treatment had the highest average number (1.90) of larvae/fruit (Table 4).

Efficacy of infested shoot clipping on the number of holes/fruit

The following (Table 3) presents a comparison of the percentage-based efficacy of different holes/fruits that utilize infested shoot clipping.

Table 3. Effect of infested shoot clipping on the number of holes/fruit

Treatments	**Pre-treatment**	**Number of holes/ fruit on different days after shoot clipping**										**Grand Mean**
		7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	
T_0	1.61	0.00	1.33	2.00	2.50	3.00	3.33a	3.63	3.97	4.50a	5.00a	2.35
T_1	2.28	0.00	1.00	2.33	2.53a	3.67	1.33b	1.00	1.33	2.50b	3.03b	1.56
T_2	1.22	0.00	2.33	1.33	1.33b	2.00	0.33b	2.67	0.67	2.75b	2.50c	1.33
T_3	0.94	0.00	0.67	3.00	0.00c	1.33	0.67b	2.00	1.00	1.50c	2.00c	1.08
SE (±)	0.39	0.00	0.34	0.62	0.37	0.71	0.30	0.45	0.37	0.57	0.63	0.40
CV (%)	183.3	0	100.78	41.95	71.56	71.71	55.33	45.67	97.01	55.68	89.50	86.6
LSD 0.05	0.92	0.00	1.55	1.17	1.17	2.27	0.74	0.92	1.59	2.50	2.10	087
Level of significance	NS	NS	NS	NS	*	NS	*	NS	NS	*	*	NS

T_0**=** Untreated control**,** T_1**=** shoot clipping, T_2**=** Sanitation, T_3**=** shoot Clipping + Sanitation
*1% Level of significance, ** 5% Level of Significance

Table 4. Effect of infested shoot clipping on the number of larvae/fruits

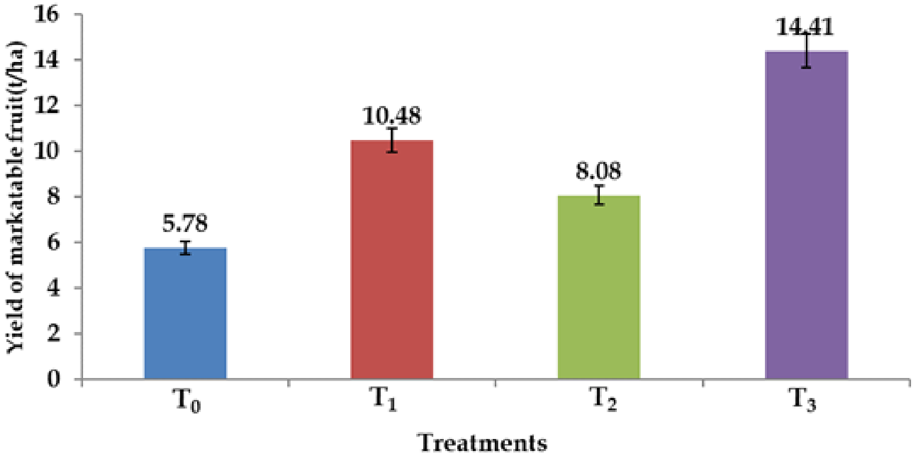
Treatments	Pre-treatment	Number of larvae/fruit on different days after treatment application										Grand Mean
		7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	
T_0	0.00	0.06	1.33	1.00	1.67	2.67	1.67	2.33	1.67	2.50	2.50	1.90
T_1	0.00	0.00	1.00	2.33	2.00	2.33	1.83	2.00	1.73	1.50	2.0	1.78
T_2	0.67	0.00	1.33	1.67	2.00	2.33	1.73	2.33	1.67	0.50	2.0	1.51
T_3	0.00	0.00	0.67	1.00	1.70	2.00	2.00	2.00	2.00	1.50	1.0	1.61
SE (±)	0.04	0.04	0.34	0.77	0.37	1.05	0.41	0.75	0.49	0.40	0.35	0.53
CV (%)	346.41	346.41	91	40.45	53.91	78.3	69.82	62.86	87.39	90.33	82.50	124.89
LSD 0.05	0.67	0.67	1.40	1.40	0.88	3.69	1.28	2.11	1.93	1.67	1.75	2.50
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T_0= Untreated control, T_1= shoot clipping, T_2= Sanitation, T_3= shoot Clipping + Sanitation

*1% Level of significance, ** 5% Level of Significance

Effect of infested shoot clipping on marketable yield and % protection over control

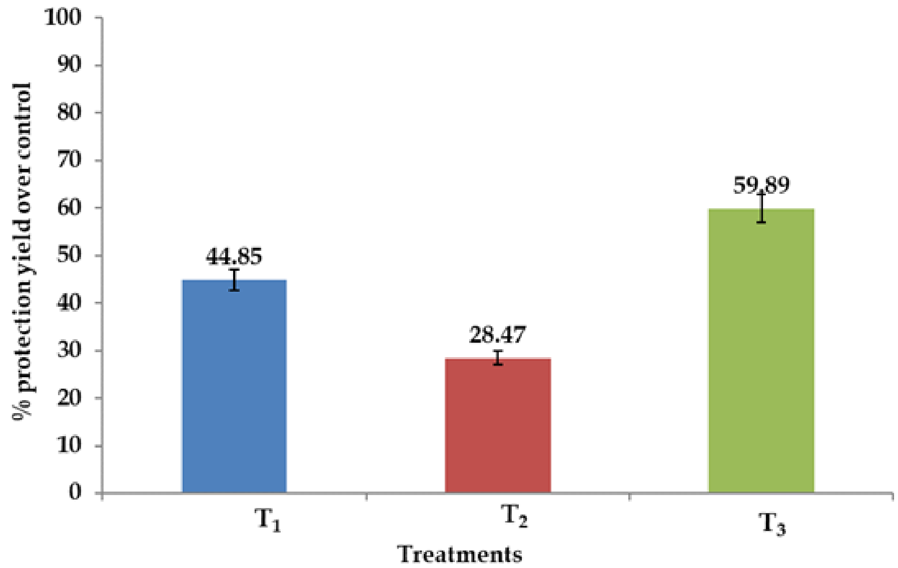
Figure 5 illustrates the marketable fruit yield (t/ha), whereas Figure 6 shows the percentage of protection of fruit over control.



T_0= Untreated control, T_1= Shoot clipping, T_2= Sanitation, T_3= Shoot Clipping + Sanitation

Figure 5. Effect of different treatments on the marketable yield

The Figure 5 demonstrated that each of the treatments produced significantly better yields compared to the control. The lowest yield was produced in the untreated control, which was less than 6.00 t/ha. The highest brinjal was produced at Shoot Clipping + Sanitation with the mean yield more than 14.00 t/ha. In case of only Shoot Clipping treated plot, production was 10.00 t/ha. According to Figure 5, Shoot Clipping + Sanitation (59.89%) provided better percent protection over control than only Shoot Clipping (44.85%) and Sanitation (24.87%).



T_1= Shoot clipping, T_2= Sanitation, T_3= Shoot Clipping + Sanitation

Figure 6. Effect of different treatments on % protection yield over control

BCR calculation

The effects of different treatments on the yield of marketable fruit displayed in the (Table 5).

Table 5. Comparative BCR under different treatments in managing BSFB

Treatments	Yield(t/ha)	Total cost Tk /ha	Net Return Tk/ha	B:C
T_1= Shoot Clipping	10.48	205000	315000	1.54
T_2 = Sanitation	8.08	215000	242400	1.12
T_3= Shoot Clipping + Sanitation	14.41	225000	432300	1.92

The market price for healthy brinjals is Tk 30 per Kilogram. The cost of shoot clipping plot is 205000 Tk per hectare with a net return of 315000 Tk per hectare. The cost of sanitation plot is 215000 Tk per hectare with a net return of 242400 Tk per hectare. The cost of shoot clipping and sanitation combined is 225000 Tk per hectare with a net return of 432300 Tk per hectare. The combined approach of Shoot Clipping + Sanitation resulted in the maximum marketable yield of brinjal at 14.41 t/ha. Additionally, the benefit-cost ratio of 1.92 suggests that the economic returns from this treatment outweigh the costs, indicating a financially favorable outcome. Shoot Clipping alone provided a moderate marketable yield of 10.48 t/ha. Sanitation alone resulted in a lower marketable yield of 8.08 t/ha. The benefit-cost ratio was stated to be more or less similar to the Shoot Clipping alone treatment.

Discussion

This study evaluated the efficacy of shoot clipping as a cultural control measure against brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis*, under field conditions. Shoot clipping is the elimination of shoots and fruits that are infested with the pest, thereby interrupting the life cycle of the pest and reducing subsequent infestation. When practiced regularly and diligently, this process minimizes plant damage and contributes to the growth of healthy crops. Our result showed that shoot clipping, especially when combined with sanitation, had a remarkable reduction in BSFB infestation and brinjal yield. Shoot clipping alone lowered infestation levels; however, the combination of shoot clipping and sanitation (removal of plant debris and fallen fruits) even further increased pest control, to give the highest marketable yield of more than 14 t/ha. By comparison, shoot clipping alone provided 10 t/ha, while the control plots provided less than 6 t/ha. The benefit-cost ratio (BCR) was also highest under the shoot clipping + sanitation treatment (1.68), indicating its economic efficacy as well as efficiency. All these findings underscore the imperative for the use of several non-chemical methods of pest control combined for sustainable management.

The findings are in line with Javed et al., (2017), whose research indicated remarkable *Leucinodes orbonalis* infestation suppression and yield enhancement through the integration of non-chemical management methods such as hoeing, clipping of infested plant tissues, weeding, and introduction of the biological control agent *Trichogramma chilonis*. Their study reached the conclusion that integrating non-chemical approaches is crucial not only for effective pest control but also for climate-smart and sustainable crop production systems. Aligning with such findings, this research places emphasis on culture and sanitation-based control as key in BSFB management. Although clipping is good on its own, when combined with other methods, it improves efficiency and decreases dependency on chemical pesticides. Systematic field monitoring and early shoot and fruit infestation removal are also paramount in avertible pest accumulation and crop yield conservation. The research shows that shoot clipping along with sanitation is a viable, eco-friendly, and cost-effective approach to BSFB management in brinjal farming. For increased efficiency, future IPM activities must include biological control agents and other non-pesticidal approaches. Abiotic factor monitoring could also supplement predictive models to facilitate early and specific interventions against pest infestations, further promoting sustainable pest management.

Among all the practices tried, shoot clipping + sanitation was found to be most effective in reducing BSFB infestation and yield maximization. This is to further emphasize the role of sanitation practices such as removal of infested parts, fallen fruits, and field trash in breaking the pest's life cycle and limiting its population growth. The integration of shoot clipping and regular sanitation not only decreased the number of larvae feeding and breeding sites of BSFB but also led to a healthier growth of the crop and higher marketable yield. The finding agrees with earlier reports emphasizing the importance of non-chemical means of pest management. For example, Javed et al. (2017) noted that integration of cultural, mechanical, and biological practices substantially lowered eggplant shoot and fruit borer infestation and yield. Likewise, scientists who promoted the application of botanical pesticides like mahogany oil and also stressed the importance of integration of environmentally friendly practices in attaining sustainable pest management. Thus, in the same way that the use of mahogany-based products was encouraged for BSFB control, brinjal farmers can also be encouraged to adopt the integrated strategy of shoot clipping and sanitation as an effective, inexpensive, and environment-friendly BSFB management technique for increased yield and sustainability in production systems.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Author Contributions

The study was a collaborative effort among all authors. Mohammad Mahir Uddin and K. M. Badrul Haque conceptualized the experiment; K. M. Badrul Haque performed fieldwork while Mohammad Mahir Uddin supervised the project; Md. Azizul Haque and Gopal Das co-supervised; Md. Mostofa Kamal, Aninda Arnab Pandit and Shimul Das write the initial draft of manuscript. After reviewing and cross-checking, all the team members agreed on the final submission.

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