Refinement of different combinations of (Brinjal Shoot and Fruit Borer) in Brinjal

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Abstract — BSFB (Brinjal shoot and fruit borer) Lesinoides orbonalis is the most destructive insect for brinjal production. It reduces the value of market price. The experiment comprised eight (8) treatments including one untreated plot. The treatments comprised different rational combinations of mechanical control involving collection and destruction of infested plant parts, use of sex pheromone trap in the centre of the plot and at the canopy level and judicious application of Marshal 20 EC @ 2ml per litre of water based on adult monitoring or routine spray. The treatments differed among themselves in efficacy, and treatment that comprised pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per litre of water 2 days interval just from the flowering was adjudged showed significantly lower fruit infestation (different fruiting stage 6.43%, 13.70%, 8.90% respectively) compared to other treatments. Among all the treatment T₃ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per litre of water 2 days interval just from the flowering) was the best option. This treatment also provided the highest benefit cost ratio (2.09) among all the treatments.

Keywords - Brinjal fruit and shoot borer, Integrated Pest Management, Management practices,

I. INTRODUCTION

Brinjal, Solanum melongena Linnaeus also known as eggplant, is one of the most important vegetable crops in Bangladesh. Eggplant is a warm season crop requiring contentious long warm weather during growth and fruit maturation. The optimum growing temperature is 22°C-30°C and growth stops at a temperature below 17°C. According to[1] Eggplant containing 92.70% water, 1.1% protein, 0.02% fat, 0.54% ash and 5.5% percent carbohydrate with calories of 130/Ib having a good source of vitamins A and B but poor in vitamin C.

Eggplant is extensively cultivated in Bangladesh and is grown in kitchen and commercial gardens in both Rabi and Kharif season. It is an important vegetable occupying the second place in production following potato in Bangladesh [2].

The important vegetable is attacked by a dozens of insect pests among which the most serious and destructive one is the Brinjal shoot and fruit borer (BSFB), Leucinodes orbonalis Guence [3],[4],[5],[6]The incidence of the pest occurs either sporadically or in outbreak every through this country wherever eggplant is grown [7]as well as in the Indian sub-continent .[8]

The damage by BSFB starts at seedling stage and continues till the last harvest of eggplant. The newly emerged larvae prefer tender shoot to bore. At early stage of plant growth, the larvae bore into petioles and mid ribs of large leaves and young shoots, close the entry points with their excreta, feed within [9] and cause drooping and withering of shoot [10]. At a later stage of plant growth, the larvae bore into the flower buds and fruits through calyx without leaving any holes through which the full grown larvae come outside the infested fruits for pupation. At this stage the pest damages both the shoots and fruits. Secondary infestations by certain bacteria cause further deterioration of the fruits. [11]

Incidence of BSFB in Brinjal could cause damage as high as 12-16% on shoots and 20-63% on fruits in Bangladesh[12,13] estimated 9.7% and 20.7% loss of fruit by weight and number, respectively. The yield loss caused by this pest has been estimated up to 67% in Bangladesh [14] and up to 63% in Haryana, India [15]. The
recent studies report the damage by BSFB in brinjal can cause up to 65% [16, 17] reported (BSFB damaged 31% and 33% of brinjal crop in 1999 and 2000 crop years respectively and fruit infestation caused by BSFB 44.49% reported by [18].

Considering the seriousness of the pest a wide range of organophosphorous, carbamates and synthetic pyrithorides with various spray formulations have been advocated from time to time against this pest [19], [20], [21], [22], [23], [24], [25], [26].

The insecticide use in controlling BSFB is very intense because larvae, which hatch from eggs laid on eggplant leaves, must be killed before they bore inside shoots or fruits. Once inside these plant parts, larvae are in accessible to the killing action of chemicals sprayed on the plant. Since neonate larva can enter a fruit or shoot within an hour after hatching, insecticides have to be applied frequently in order to have its sufficient residues on the plant surface to kill the crawling larva. Due to various reasons, including the possibility that the pest is gradually developing resistance to the insecticides, the use of insecticides is on the rise. Survey conducted in Bangladesh indicated that farmers sprayed their eggplant crop 120 in one season [27]. In order to reduce the reliance on pesticide studies to develop integrated pest management (IPM) package comprising different components have been conducted. [28],[29],[30],[31],[32],[33],[34],[35],[36], [36] identified an IPM package compromising spraying of Marshal 20EC at 2days interval +mechanical control + pheromone trap placed at plant canopy at the center of the plot as the best one that rendered highest protection of shoots and fruits against BSFB. But the treatment combinations with pheromone with Marshal 20EC @ 2days interval starting from flowering + mechanical control + pheromone trap was not considered.

Moreover, some inconsistency in the effect among the different treatments was observed and the IPM package was studied for specific local variety. Considering the above context, the present experiment comprising different combinations of sex pheromone trap, mechanical control and monitoring based application of insecticide.

II. MATERIALS AND METHODS

The present study on the efficacy of eight (8) different treatment combinations of pheromone trap, mechanical control and spray of Marshal 20EC @ of 2ml per liter of water to control the Brinjal shoot and fruit borer (BSFB) was carried out at the Bangabandhu Skeikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh during 5th July to 30th October 2008. The materials and methods adopted in the study are discussed in the following sub-headings:

Location
The study areas are situated at 24.9° N latitude and 90.26 °E longitude with an elevation of 8.4 meter from the sea level in BSMRAU, Gazipur.

Climate
The experimental farm is characterized by heavy tropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Daily maximum and minimum temperature, relative humidity and total rainfall was recorded in the study period at BSMRAU, Gazipur.

Soil
The soil of the experimental plots belongs to the grey terrace soils (AEZ-28), Gazipur.

Design of the experiment
The experiment comprising eight treatments, including a control was laid out in a Randomized complete block design(RCB) with three replication, but to avoid the influence of pheromone trap on other treatments and to exclude pheromone trap treatments on chemical control, the treatment no. 8 (untreated control) and treatment no. T1 (routine spray of Marshal 20EC @ 2ml per liter of water at seven days interval) were set on plots about 500 meter away from the main plots, The experiment was conducted with three replications with equal size of plot having 1.5 meter spaces between the blocks and each block was then again then sub divided into 6 plots (3meterx3meter) with 0.5 meter space between the plots. Fifteen pits were made in each plot at a distance of 100cm between the rows and 60cm between the pits on a row.

Land preparation
Due to heavy rainfall the plot was not regularly opened by the tractor on any other agricultural equipment rather the drains and the plots were made first to get ride from the water logging condition. Fertilizer was applied as
recommended by [36] for brinjal cultivation @ 15tons of cowdung and 250, 150 and 125 kg of Urea, TSP and MP respectively. Total amount of cowdung and half amount of TSP were applied in the pit at the time of transplanting. The rest dose of urea and the rest of MP were applied as top dressing. The first top dressing of Urea (one third) was made at 15 days after transplanting. One third of Urea and one third of MP at the time of flower initiation and rest of Urea and TSP and MP at the time of fruit initiation were applied to keep the plants at normal growth and production.

**Raising of seedlings and transplanting**

Brinjal seeds (BARI-8) were collected from Horticulture Research Center (HRC), Joydevpur, Gazipur. Seeds were sown directly on special tray for seedling rising at Entomology department of BSMRAU, Joydevpur, Gazipur. The plots were lightly irrigated regularly for ensuring proper growth and development of the seedlings. Fifty two days old healthy seedlings (3/4 leaf stage) were transplanted in the experimental plots.

**Cultural operations**

Dead and damaged seedlings were replaced immediately by new ones from the stock. Weeding, propping, irrigation and other necessary cultural operations were done whenever necessary. Propping of each plant using Bamboo sticks (1 meter height) was done for providing extra support to avoid lodging of the plants. The MP and Urea were top dressed in 3 splits as described earlier.

**Pheromone trap**

Pheromone traps were collected from Entomology Division, BARI, Joydevpur, Gazipur. Four pheromone traps were used for the experiment, first pheromone trap was placed in the monitoring plot at the same day of transplanting of seedlings for monitoring and another three pheromone traps were placed in the plot covering the total plot area just from the day of flowering. Traps were placed in the center of the plot at the plant canopy and height of pheromone traps were adjusted time to time for maintaining the canopy height. The plot containing the pheromone traps and the plots without pheromone traps were set half kilometre away to avoid the possible effect of pheromone traps.

**Details of the treatments**

Effectiveness of Eight treatments to reduce shoot and fruit borer infestation in Brinjal was evaluated against control having no treatment. Brinjal variety (BARI-8) was used, the treatments and the control thus including in the study were as follows:

- **T₁** = pheromone trap placed at the plant canopy
- **T₂** = pheromone trap placed at the plant canopy + mechanical control
- **T₃** = pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2ml per liter of water 2 days interval just from the flowering
- **T₄** = pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2ml per liter of water when 5 adults found in the monitoring trap
- **T₅** = pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2ml per liter of water when 10 adults found in the monitoring trap
- **T₆** = pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2ml per liter of water when 15 adults found in the monitoring trap
- **T₇** = routine spray of Marshal 20EC @ 2ml per liter of water at seven days interval
- **T₈** = untreated control

The plots containing the pheromone traps and the plots without pheromone traps were set half a kilometre away to avoid the possible effect of pheromone traps.

**Application of the insecticides**

Marshal 20 EC was procured from Gazipur district market @ TK. 80 per 50ml bottle. Sex pheromone was collected from BARI, Gazipur free of cost. The insecticide was mixed with water at the rate of 2ml per liter for the recommended dose for spraying in 3 plots as determined by calibrating the sprayer. The mixture within the spray tank was shaken well and sprayed covering the upper and lower surface of the leaf. The insecticides were sprayed at 2 days interval in **T₃**, sprayed in the **T₄**, **T₅** and **T₆** on observing 5, 10 and 15 adults BSFB observed in the monitoring trap. Spraying was done in the afternoon to avoid bright sun light and to prevent drift caused by the strong wind and adverse effect on pollinating honeybees.
Data collection
The following parameters were considered for evaluating the effectiveness of each treatment in controlling the BSFB infestation:

**BSFB adult number**
Number of BSFB adult was counted from one pheromone trap placed at the plant canopy in each morning from (16.07.2008) onward and another three pheromone traps were placed in rest of the plot covering the whole plot just from the flowering stage (11.08.2008), after collecting the adults they were destroyed and some of the insects (adult BSFB) were preserved in the glass vial with 40% ethanol for further identification. The height of the pheromone traps were adjusted time to time with the increasing height of brinjal plant, when required.

**Shoot infestation**
The total number of shoots and the number of shoots infested by the BSFB was recorded at every alternative day from five plants of each plots for each treatment during the period of 5th July to 30th October and percent shoot infestation and its reduction over control were calculated for all the treatments in every alternative day. In case of mechanical control, the infested shoots were clipped, removed and destroyed after counting.

\[
\text{% Shoots infestation} = \frac{\text{Number of infested shoots}}{\text{Number of total shoots}} \times 100
\]

\[
\text{% Reduction in shoot infestation} = \frac{\% \text{ shoot infestation in control} - \% \text{ shoot infestation in treatment}}{\% \text{ shoot infestation in control}} \times 100
\]

**Number of fruits per plant**
Data were collected on the basis of harvested fruits per plant in each treatment. The marketable fruits were harvested at 7 days interval at early, mid and late fruiting stage.

**Number of healthy and infested fruits**
Data was recorded on the basis of the number of healthy fruits (HF) and infested fruits (IF) harvested early, mid and late fruiting stages of the plant. There was 3, 3 and 4 harvest at early, mid and late fruiting stage, respectively. In total, ten (10) harvests were done throughout the fruiting period. Infestation rate (by number and weight) of brinjal fruits caused by BSFB at early, mid and late fruiting stage in different treatments and its reduction over control were calculated.

**Weight of healthy and infested fruit**
The weight of healthy and infested fruits at early, mid and late fruiting stage of egg plants was taken separately per plot fro each treatment.

**Fruit infestation percent**
The overall percent fruit infestation and those at three different fruiting stages were calculated using the formula.

\[
\text{%Fruit infestation by number} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100
\]

\[
\text{% fruit infestation reduction by number} = \frac{\% \text{ infestation of untreated control} - \% \text{ infestation of treatment}}{\% \text{ infestation of untreated control}} \times 100
\]

\[
\text{%Fruit infestation by weight} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100
\]

\[
\text{% fruit infestation reduction by weight} = \frac{\% \text{ infestation of untreated control} - \% \text{ infestation of treatment}}{\% \text{ infestation of untreated control}} \times 100
\]

The stage wise percent fruit infestation was calculated on the basis of the infestation occurred at each fruiting stage of the brinjal. The overall or accumulated infestation rate (both by number and weight) was derived from early, mid and late fruiting stages for different treatments and its reduction over control were also calculated.
Yield/hectare
The healthy and total yield of brinjal for each treatment was calculated in tons from the cumulative fruit production in a plot. Effective of different treatments on the increase and decrease of brinjal yield over control was also calculated.

Data analysis
The data were analyzed statically for important parameter like percent shoot and fruit infestation, healthy and infested yield; extend of damage, fruit bearing capabilities, intensity of attack, etc. The analysis of variance (ANOVA) of different parameter was performed and the range test of the mean was done by using Duncan’s Multiple Range Test (DMRT).

Benefit/cost analysis
For benefit cost analysis record of costs incurred in each treatment and that of control were maintained. Similarly, the price of harvested fruits of each treatment and that of control were calculated at market rate. Benefit-cost analysis was expressed in terms of benefit cost ratio (BCR).

III. RESULTS AND DISCUSSIONS
Effect of Different Treatments on BSFB Infestation and Yield of Brinjal:
Effect on shoot infestation:
The comparative effectiveness of various control options along with schedule spray on shoot infestation by the BSFB has been presented in Table 1. All the treatments ensured significantly less shoot infestation than T3 (untreated plot) in reproductive stage (flowering stage) and in the vegetative stage (pre flowering stage). Among the treatments, highest protection was rendered by T1 (pheromone trap placed at the plant canopy) allowing only 1.04% infestation, T4 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 5 adults found in the monitoring trap) (1.28%), T7 (routine spray of Marshal 20 EC @ 2 ml per liter of water at seven days interval) (1.45%) and T9 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering) (1.75%), which were statistically similar. These were followed by T2 (pheromone trap placed at the plant canopy + mechanical control) (2.27%), T8 (untreated plot) (3.03%) followed by statistically similar T3 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 10 adults found in the monitoring trap) (4.32%) and T6 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 15 adults found in the monitoring trap) (4.36%), but this result does not reflects the effectiveness of combination of different control options for managing BSFB in brinjal as observed in the reproductive stage (Flowering stage), possible reason in the routine and schedule spray in the experimental plot was not initiated in the vegetative stage (pre flowering stage) to minimize the pest control cost and in order to maximizing the B:C ratio. In reproductive stage (flowering stage) the experimental results revealed that all the treatments ensured significantly less shoot infestation over control and the lowest percent of shoot infestation (13.45%) was observed in treatment T7 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering), T4 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 5 adults found in the monitoring trap) (16.09%), T8 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 10 adults found in the monitoring trap) (16.53%), which were statistically similar among them. These were followed by T6 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 15 adults found in the monitoring trap) (17.37%), T7 (pheromone trap placed at the plant canopy + mechanical control) (19.20%), T1 (routine spray of Marshal 20 EC @ 2 ml per liter of water at seven days interval) (20.41%), followed by statistically similar T4 (pheromone trap placed at the plant canopy) (37.87%) and T8 (untreated plot) (37.87%) but incase of treatment T1 sole pheromone trap was used in the brinjal plant height canopy to control the BSFB (Brinjal shoot and fruit borer) and on the other hand in case of treatment T9 no controlling measure was used to control the pest rather the statistically similar results revealed that there is a little or few effect of pheromone trap for controlling the BSFB, if used singly, the results observed from the same study it also reveals that if pheromone trap used with other control options then the pest can be successfully controlled. These indicate that pheromone trap alone is not effective in rendering protection of the shoot against BSFB infestation.
Table 1. Effect of different treatments on shoots infestation at different stages of Brinjal plant grown in BSMRAU from 5th July to 30th October

<table>
<thead>
<tr>
<th>Treatment no.</th>
<th>Shoot infestation (%)</th>
<th>Vegetative stage (pre flowering stage)</th>
<th>Reproductive stage (flowering stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1.04 d</td>
<td></td>
<td>37.83 a</td>
</tr>
<tr>
<td>T2</td>
<td>2.27 bc</td>
<td></td>
<td>19.20 bc</td>
</tr>
<tr>
<td>T3</td>
<td>1.75 c</td>
<td></td>
<td>13.45 d</td>
</tr>
<tr>
<td>T4</td>
<td>1.28 c</td>
<td></td>
<td>16.09 cd</td>
</tr>
<tr>
<td>T5</td>
<td>4.32 a</td>
<td></td>
<td>16.53 cd</td>
</tr>
<tr>
<td>T6</td>
<td>4.36 a</td>
<td></td>
<td>17.37 bc</td>
</tr>
<tr>
<td>T7</td>
<td>1.45 c</td>
<td></td>
<td>20.41 b</td>
</tr>
<tr>
<td>T8</td>
<td>3.03 b</td>
<td></td>
<td>37.87 a</td>
</tr>
<tr>
<td>CV%</td>
<td>21.21</td>
<td></td>
<td>8.56</td>
</tr>
</tbody>
</table>

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T1 = Pheromone trap placed at the plant canopy
T2 = Pheromone trap placed at the plant canopy + mechanical control
T3 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering
T4 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 5 adults found in the monitoring trap
T5 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 10 adults found in the monitoring trap
T6 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 15 adults found in the monitoring trap
T7 = Routine spray of Marshal 20 EC @ 2 ml per liter of water at seven days interval
T8 = Untreated control

Fruit infestation by number:
Similar to the effect of shoot infestation, all the treatments had significant effect on percent reduction of fruit infestation by number at different stages of the crop compared to the control as presented in Table 2.
In early fruiting stage, among the treatments, the lowest percent of fruit infestation by number was observed in treatment T3 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering) (6.43%) followed by T4 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 5 adults found in the monitoring trap) (11.83%) followed by T5 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 10 adults found in the monitoring trap) (17.48%) T6 (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 15 adults found in the monitoring trap) (19.99%) T2 (pheromone trap placed at the plant canopy + mechanical control) (20.02%), T7 (Routine spray of Marshal 20 EC @ 2 ml per liter of water at seven days interval) (21.07%) T1 (pheromone trap placed at the plant canopy) (24.67%), which were statistically similar among them. All the treatments had significantly less shoot infestation as compared to the highest percent of fruit infestation by number in T8 (untreated plot) (31.15%).
This reveals that the best control option among the treatments in the early fruiting stage is T$_3$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering). This finding was in conformity with the previous finding of [36].

In the mid fruiting stage, the lowest percent of fruit infestation by number was observed in T$_3$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering) (13.70%) followed by T$_2$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water when 5 adults found in the monitoring trap) (18.80%) followed by T$_6$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2 ml per liter of water when 10 adults found in the monitoring trap) (26.12%), T$_1$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2 ml per liter of water when 15 adults found in the monitoring trap) (26.76%), T$_7$ (Routine spray of Marshal 20EC @ 2 ml per liter of water at 7 days interval) (27.22%) and T$_2$ (pheromone trap placed at the plant canopy + mechanical control) (27.30%), which were statistically similar among them. These were followed by T$_1$ (pheromone trap placed at the plant canopy) (32.68%), which was similar to the highest percent of fruit infestation by number observed in T$_5$ (untreated plot) (37.03%). This reveals that the most effective treatment in protecting the fruit against BSFB in terms of percent infestation by number was T$_3$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC @ 2 ml per liter of water at 2 days interval just from the flowering), (8.90%), at which also there was significant of fruit infestation by number (13.70%).

In the late fruiting stage, the lowest percent of fruit infestation by number was observed in T$_3$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2 ml per liter of water at 2 days interval just from the flowering) (8.90%) followed by T$_2$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC@ 2 ml/liter of water when 5 adults found in monitoring trap) (12.67%), followed by T$_3$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC@ 2 ml/liter of water when 10 adults found in monitoring trap) (15.87%), T$_6$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC@ 2 ml per liter of water when 15 adults found in monitoring trap) (18.11%), T$_7$ (Routine spray of marshal 20EC@ 2 ml per liter of water at 7 days interval) (18.11%), and T$_1$ (pheromone trap placed at the plant canopy) (19.69%), which were statistically similar. However, all these were significantly less than the T$_5$ (untreated plot), which had the highest percent of fruit infestation (25.12%). These findings reveal that T$_1$ (pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20EC@ 2 ml per liter of water at 2 days interval just from the flowering stage) that had the minimum fruit infestation by number (8.90%) was the most effective control option for controlling Brinjal fruit infestation by number in late fruiting stage.

Table 2. Effect of different treatments on fruit infestation by number at different stages of brinjal plant grown from 5th July to 30th October

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% infestation by number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early fruiting stage</td>
</tr>
<tr>
<td></td>
<td>infestation</td>
</tr>
<tr>
<td>1</td>
<td>24.67 b</td>
</tr>
<tr>
<td>2</td>
<td>20.02 c</td>
</tr>
<tr>
<td>3</td>
<td>6.43 e</td>
</tr>
<tr>
<td>4</td>
<td>11.83 d</td>
</tr>
<tr>
<td>5</td>
<td>17.48 c</td>
</tr>
<tr>
<td>6</td>
<td>19.97 c</td>
</tr>
<tr>
<td>7</td>
<td>21.05 c</td>
</tr>
<tr>
<td>8</td>
<td>31.15 a</td>
</tr>
<tr>
<td>CV%</td>
<td>10.72</td>
</tr>
</tbody>
</table>
In a column means having similar letter(s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

T₁ = Pheromone trap placed at the plant canopy

T₂ = Pheromone trap placed at the plant canopy + mechanical control

T₃ = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering

T₄ = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 5 adults found in the monitoring trap

T₅ = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 10 adults found in the monitoring trap

T₆ = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 15 adults found in the monitoring trap

T₇ = Routine spray of Marshal 20 EC @ 2ml per liter of water at seven days interval

T₈ = Untreated control

Healthy and infested Fruits by number:
Number of total healthy fruit, infested fruit and there percentages were calculated to determine the effects of treatments on the healthy fruit-set and ultimate harvest of healthy fruits, which have been presented in Figure 7. The highest number of healthy fruit was found in the treatment T₃ (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering) with a number healthy fruit was 148 while it was the lowest in treatment T₈ (untreated plot) with a fruit number 40. Conversely, the total number of infested fruit was the lowest in the treatment T₃ (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering), with a fruit number of 16 while it was the highest in treatment T₂ (Pheromone trap placed at the plant canopy + mechanical control) with fruit number 26 this treatment had higher number of infested fruit than untreated plot, which might be attributed to the higher number of fruit set due to mechanical control at the vegetative stage but failure to protect them against BSRB infestation in reproductive stage. Consistent with the number, in respect of percent(%) fruit infestation, the performance was found in treatment T₃ (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering) with the lowest number of fruit infestation (9.52%) as compared to the highest percent of fruit infestation (30.46%) in treatment T₈ (untreated plot). Accordingly, T₃ (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering) was found to perform best ensuring higher fruits yield both in terms of number and percentages.
Healthy and Fruit infestation by weight:
Fruit weight is the ultimate target that determines the benefit cost ratio and potential for the cultivation of brinjal. Higher number of brinjal with lower weight is always inferior to that with the higher weight, which ultimately provide higher yield and usually higher benefit cost ratio. This is virtually dependent on the number and weight of healthy fruits and infested fruits. Thus the effects of different treatments on the total healthy fruit and total infested fruit weight in (gm/plot) along with their percentage have calculated as presented in Table 3. Consistent with the effectiveness of different treatments, the lowest percent of fruit infestation by weight was found in the treatment T3 (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering) (8.30%) with a total healthy and infested fruit weight of 11255.98 and 1021.45 gm/plot respectively followed by T4 (Pheromone trap placed at the plant...
canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 5 adults found in the monitoring trap) (12.17%) with a total healthy and infested fruit weight of 7941.50 and 1102.07 gm/plot respectively followed by T3 (Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 10 adults found in the monitoring trap) (16.30%) with a total healthy and infested fruit weight of 6612.36 and 1324.07 gm/plot respectively, T2 (Pheromone trap placed at the plant canopy + mechanical control) (17.18%) with a total healthy and infested fruit weight of 6430.14 and 1371.85 gm/plot respectively, which is also statistically similar among them. These were followed by T1 (Pheromone trap placed at the plant canopy) (20.31%) with total healthy and infested fruit weight of 5883.17 and 1499.77 gm/plot respectively, which was statistically similar to the highest percent of fruit infestation by weight as found in T8 (untreated plot) (24.75%) with total healthy and infested fruit of 3065.87 and 1003.94 gm/plot respectively.

Table 3. Effect of different treatments on total healthy fruit weight and total infested fruit weight (gm/plot) grown from 5th July to 30th October

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of spray</th>
<th>Total healthy fruit weight (gm/plot)</th>
<th>Total infected fruit weight (gm/plot)</th>
<th>%infestation</th>
<th>Increase/decrease over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>5883.17 d</td>
<td>1499.77 ab</td>
<td>20.31 b</td>
<td>17.92</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>7615.07 b</td>
<td>1570.87 a</td>
<td>17.18 c</td>
<td>30.59</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>11255.98 a</td>
<td>1021.45 d</td>
<td>8.30 e</td>
<td>66.45</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>7941.50 b</td>
<td>1102.07 cd</td>
<td>12.17 d</td>
<td>50.81</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>7661.27 b</td>
<td>1501.40 ab</td>
<td>16.30 c</td>
<td>34.11</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>6612.36 c</td>
<td>1324.07 bc</td>
<td>16.67 c</td>
<td>32.62</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>6430.14 cd</td>
<td>1371.85 ab</td>
<td>17.60 c</td>
<td>28.89</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>3065.87 e</td>
<td>1003.94 d</td>
<td>24.75 a</td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td>7.52</td>
<td>9.87</td>
<td>8.60</td>
<td></td>
</tr>
</tbody>
</table>

In a column means having similar letter(s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

T1 = Pheromone trap placed at the plant canopy

T2 = Pheromone trap placed at the plant canopy + mechanical control

T3 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering

T4 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 5 adults found in the monitoring trap

T5 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 10 adults found in the monitoring trap

T6 = Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 15 adults found in the monitoring trap

T7 = Routine spray of Marshal 20 EC @ 2ml per liter of water at seven days interval

T8 = Untreated control
Effect on yield and income:
Yield is the ultimate goal for all the production processes. Therefore, to finally identify the superior treatments, their effects were evaluated based on calculation of ultimate marketable yield, and benefit cost ratio (BCR) accrued to each of them. All the treatments thus differed significantly from untreated plot as presented in control (Table 4). Consistent with the higher healthy fruit yield in different treatments, the gross return was in descending order as $T_3 > T_7 > T_5 > T_3 > T_6 > T_1 > T_2$, the highest being Tk. 4,54,858.00 in $T_3$ and lowest being Tk. 1,00,538.00 in $T_5$ among the treatments. But due to variation in the management cost, the order of net return in some cases changed, and thus the order of BCR also changed in some cases. However, among the treatments, $T_3$ provided the highest BCR (2.09), followed by $T_7$ (1.69), followed by $T_2$ (1.49), followed by $T_4$ (1.28), followed by $T_5$ (1.26), followed by $T_6$ (1.15), while it was the lowest (1.08) in $T_1$. Consistent with its effects on all other yield contributing parameters, the BCR of $T_1$ was very low.

Table 4. Cost benefit analysis for managing BSFB in Brinjal grown in BSMRAU from 5th July to 30th October

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of spray</th>
<th>Cost of management (Tk.)</th>
<th>Yield(t/ha)</th>
<th>Gross return (Tk.)</th>
<th>Net return (Tk.)</th>
<th>Adjusted net return (Tk.)</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Healthy</td>
<td>Infested</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_1$</td>
<td>-</td>
<td>44505</td>
<td>6.101 d</td>
<td>1.666 ab</td>
<td>25462</td>
<td>210124</td>
<td>109586</td>
</tr>
<tr>
<td>$T_2$</td>
<td>-</td>
<td>50000</td>
<td>6.716 c</td>
<td>1.745 a</td>
<td>279374</td>
<td>229374</td>
<td>128836</td>
</tr>
<tr>
<td>$T_3$</td>
<td>27</td>
<td>144196</td>
<td>11.372 a</td>
<td>1.135 d</td>
<td>454858</td>
<td>310662</td>
<td>210124</td>
</tr>
<tr>
<td>$T_4$</td>
<td>3</td>
<td>57645</td>
<td>7.599 b</td>
<td>1.225 cd</td>
<td>308611</td>
<td>250966</td>
<td>150428</td>
</tr>
<tr>
<td>$T_5$</td>
<td>1</td>
<td>55600</td>
<td>6.845 c</td>
<td>1.668 ab</td>
<td>283635</td>
<td>228035</td>
<td>127497</td>
</tr>
<tr>
<td>$T_6$</td>
<td>1</td>
<td>54000</td>
<td>6.549 cd</td>
<td>1.471 bc</td>
<td>270156</td>
<td>216156</td>
<td>115618</td>
</tr>
<tr>
<td>$T_7$</td>
<td>11</td>
<td>52800</td>
<td>7.897 b</td>
<td>1.524 ab</td>
<td>323247</td>
<td>270447</td>
<td>169909</td>
</tr>
<tr>
<td>$T_8$</td>
<td>-</td>
<td>-</td>
<td>2.292 e</td>
<td>1.115 d</td>
<td>100538</td>
<td>100538</td>
<td>-</td>
</tr>
</tbody>
</table>

Healthy fruit Tk. 39/Kg and infested fruit Tk. 10/Kg

$T_1 = $ Pheromone trap placed at the plant canopy

$T_2 = $ Pheromone trap placed at the plant canopy + mechanical control

$T_3 = $ Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water 2 days interval just from the flowering

$T_4 = $ Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 5 adults found in the monitoring trap

$T_5 = $ Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 10 adults found in the monitoring trap

$T_6 = $ Pheromone trap placed at the plant canopy + mechanical control + spray of Marshal 20 EC @ 2ml per liter of water when 15 adults found in the monitoring trap

$T_7 = $ Routine spray of Marshal 20 EC @ 2ml per liter of water at seven days interval

$T_8 = $ Untreated control

III. Conclusions

From the above findings of the field research work, the infestation of BSFB on brinjal plant controlling by sole mechanical control, Marshal 20 EC, sex pheromone and a combination of Pheromone trap placed at the plant canopy + Mechanical control + Spray of Marshal 20 EC @ 2ml a.i. per liter of water when 15 adults found in the monitoring trap. Combination (Pheromone trap placed at the plant canopy + Mechanical control + Spray of...
Marshall 20 EC @ 2ml a. i. per liter of water when adult found in the monitoring trap) of 2 days interval just from the flowering was judged the best practice from the economic point of view that ensured highest total fruit yield (12.507 tons/ha), and highest BCR (2.09).

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REFERENCES


