Evaluation of Combined Management Options for Managing Brinjal Shoot and Fruit Borer

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Abstract: The study on the evaluation of some options and their combinations for managing brinjal shoot and fruit borer (Leucinodes orbonalis Guenee) was carried-out at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during 10 October, 2006 to 15 March, 2007. Among the treatments, any single option such as sole mechanical control, schedule spray of Marshal® at 7 days interval or sole sex pheromone trap placed at plant canopy and in the centre of the plot, was inferior to any of other combined options and the combinations of three options was better than that of any two options. Among the single options, routine spray of Marshal® at 7 days interval (T₃) was better than sole sex pheromone trap placed at plant canopy and in the centre of the plot (Tₛ), which, however, was better than sole mechanical control (T₄) in all considerations. But among all combined treatments, T₃ comprised spraying of Marshal® at 2 days interval, mechanical control and using pheromone trap placed at plant canopy and in the centre of the plot, performed the best in all respects ensuring the lowest shoot (6.27%) and fruit (3.19 % by number and 2.83% by weight) infestation, the highest reduction of shoot (79.65%) and fruit (89.03% by number and 90.72% by weight) infestation to compare with control. As a result, the maximum fruit yield (32.71 tons/ha) was produced in T₃, which contributed the highest yield of healthy fruits (30.42 tha⁻¹) as well as gave maximum BCR (2.05). The sex pheromone confused the male adult for mating and thus preventing fertilized egg production vis-à-vis reduces larval and adult population build-up. Marshal® was applied, when adult population reached at alarming phase indicated by monitoring results i.e., 10 to 15 adults caught per pheromone trap. Thus Marshal® killed the BSFB larvae as well as adults by its systemic and contact action. These treatments altogether significantly reduced the BSFB population and its infestation level, which ultimately increased the yield of brinjal.

Key words: Insect control • IPM • Sex pheromone • Marshal® • Mechanical control • Leucinodes orbonalis

INTRODUCTION

In the context of seriousness of the brinjal shoot and fruit borer (BSFB), Leucinodes orbonalis Guenée as a pest. Brinjal plants are very much susceptible to insect attack right from seedling to final harvesting stage. Brinjal is attacked by 53 species of insect pests [1] of which 8 are considered as major pests causing enormous damage to the crop in every season in every year and the remaining ones including one species of mites are considered as minor pests as they generally cause little damage [2]. Among the major insect pests, brinjal shoot and fruit borer (BSFB) is the most destructive pest of brinjal in Bangladesh [3-6] and India [7]. BSFB causes severe infestation by virtue of its reproductive potential, rapid turnover of generations and continuous perpetuation through intensively cultivated brinjal crop in both wet and dry seasons of the year. This pest is active throughout the year at places having moderate climate. They are very active in summer months especially in the rainy season. The damage is sometimes more than 90% [8]. The yield losses have been estimated up to 86% [9], 67% [10] and 95% [11] in Bangladesh. Despite the importance of brinjal and severity of BSFB problem, the management practices to combat BSFB are still limited to frequent sprays of toxic chemical pesticides [12, 13]. For vegetables in general, Sabur and Mollah [14] observed an increased use of pesticides by farmers, a wide range of organophosphorus, carbamate and synthetic pyrethroid insecticides with various spray formulations have been
advocated from time to time against this pest [15-18]. The use of inappropriate pesticides, incorrect timing of application and improper doses have resulted in high pesticide costs with little or no appreciable reduction in target pest populations. Socio-economic studies of current BSFB control practices in Jessore District of Bangladesh indicated that 98% of farmers relied exclusively on the use of insecticides and more than 60% of farmers sprayed their crop 140 times or more in the 6-7 months cropping season [19]. Some farmers believed that excess use of insecticide could solve the insect pest’s problem. They used insecticides freely without considering the level of infestation. They usually sprayed insecticide in their field indiscriminately even without thinking the economic return of their investment. The abuse of pesticides, including the use of excessive rates and non-registered chemicals, as well as a disregard for re-entry and harvest-delay intervals, have resulted in both loss of pesticides’ effectiveness as well as damage to the environment and human health [13]. Such indiscriminate use of insecticides are reported to cause insecticide resistance in insect pests, resurgence or increased infestation by some insect species due to the destruction of natural predators and parasitoids, changed pest status of mites and other minor insect pests, ecological imbalance and danger to health of the pesticide applicator and to consumers. At the advent of such increasing threat, integrated pest management (IPM) practices involving non-chemical alternatives, resistance management etc., have been undertaken in several countries including USA, Canada and Australia [20]. In Bangladesh, efforts are underway to popularize among the farmers the IPM practices involving pheromone traps, mechanical control, cleanliness, resistant varieties etc. in managing BSFB on brinjal.

Under the above context, the present experiment comprising different combinations of sex pheromone trap, cultural method, mechanical device and insecticides use based on some indicators has been undertaken with the following objectives to identify the most effective treatment combination(s) for managing BSFB and to recommend the best integrated practice for managing BSFB at farmer level.

**MATERIALS AND METHODS**

The experiment on the evaluation of some management options and their combinations for managing brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee, was carried out at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during 10 October, 2006 to 15 March, 2007. In the study, cow dung and other chemical fertilizer were applied as recommended by Rashid [21] for brinjal cultivation @ 15 tons of cow dung and 115, 72 and 75 kg of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, respectively per hectare. The half of cow dung and P<sub>2</sub>O<sub>5</sub> were applied as basal dose during land preparation. The remaining cow dung, P<sub>2</sub>O<sub>5</sub> and one-third of K<sub>2</sub>O was applied in the pits at transplanting of brinjal seedlings. The entire dose of N and the rest of K<sub>2</sub>O were applied as top dressing. The first top dressing of urea (one third) was made at 15 days after transplanting. One-third of N and one-third of K<sub>2</sub>O were applied at the time of flower initiation and rest of urea and MP and MP at the time of fruit initiation were applied to keep the plants at normal growth, development and production. The whole field was divided into three blocks of equal size having 2 m space between the blocks and each block was again sub-divided into 10 plots (3 m × 3 m) with 2 m space between the plots. Fifteen pits were made in each plot at a distance of 100 cm between rows and 60 cm between pits on a row. Forty day old healthy seedlings (3/4 leaf stage) were transplanted in the experimental plots.

**Design of Experiment:** The experiment comprised 9 treatments including sex pheromone trapping, mechanical control, application of insecticide based on number of BSFB adults monitored using sex pheromone, routine spray of carbosulfan and a control, laid out in a Randomized Complete Block Design (RCBD) with 3 replications.

**Details of the Treatments:**

T<sub>1</sub>: Spraying of Marshal® 20 EC at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot,

T<sub>2</sub>: Mechanical control,

T<sub>3</sub>: Spraying of Marshal® 20 EC at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot,

T<sub>4</sub>: Spraying of Marshal® 20 EC at 10 adult catch in pheromone trap + Mechanical control,

T<sub>5</sub>: Spraying of Marshal® 20 EC at 12 adult catch in pheromone trap + Mechanical control,

T<sub>6</sub>: Spraying of Marshal® 20 EC at 15 adult catch in pheromone trap + Mechanical control,

T<sub>7</sub>: Spraying of Marshal® 20 EC at 7 days interval (Routine spray),
T1: Spraying of Marshal® 20 EC at 7 days interval (Routine spray) + Mechanical control,
T2: Pheromone trap placed at plant canopy and in the centre of the plot
T10: Treatment having no pheromone trap and other options

The plots having pheromone traps (T1 and T2) in combinations with insecticides were set at the extreme end of the farm (half kilometer away) from the plots with treatments having no pheromone trap. The BSFB adults were monitored through 3 sex pheromone traps set in a plot half kilometer away from the experimental plots to keep the experimental plots out of pheromone influence zone.

Mechanical Control: Mechanical control comprised scouting the mechanical control labeled plots every alternate day to locate the infested shoot and/or twig if any, tearing-off them and destroying by hand any stage of the BSFB inside the infested shoot and/or twig, if any.

Insecticides application

Marshal® 20EC was collected from the local market of Gazipur District. Marshal® 20EC was applied by a Knapsack sprayer @ 1 ml per liter of water i.e., 0.1% (by mixing 6 ml of insecticide with 6 liter of water). The mixture in the spray machine was shaken well and sprayed covering the whole plants. Six liters spray material was required to spray three plots.

Before spraying, the spray machine was calibrated to find out the required quantity of spray materials for three plots. The spraying was done in the afternoon to avoid bright sunlight and drift caused by strong wind and adverse effect on pollinating bees.

Data Collection: The comparative effectiveness of the treatments in reducing shoot and fruit borer infestation was evaluated on the basis of some pre-selected parameters. The total number of shoots and the number shoots infested by the BSFB was recorded at weekly intervals from 5 plants of each plots. In case of mechanical control, the infested shoots were clipped, removed and destroyed after counting.

\[
\text{Shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100
\]

The marketable fruits were harvested at 7 days interval at early, mid and late fruiting stages and counted. Number of the healthy fruits (HF) and infested fruits (IF) harvested at early, mid and late fruiting stages of the plant. There was 4, 4 and 3 harvest at early, mid and late fruiting stage, respectively. In total, eleven 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. The weight of healthy and infested fruits at early, mid and late fruiting stage of eggplants was taken separately per plot for each treatment.

The overall percent fruit infestations and those at 3 different fruiting stages were calculated using the following formulae.

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

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

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

The stage-wise percent fruit infestation was calculated on the basis of the infestation occurred at each fruiting stage of the crop. 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.

The healthy and total yield of brinjal per hectare for each treatment was calculated in tha⁻¹ from the cumulative fruit production in a plot. Effect of different treatments on the increase and decrease of brinjal yield over control was also calculated.

The data were analyzed statistically for important parameters like percent shoot and fruit infestation, healthy and infested yield, extent of damage, fruit bearing capabilities, intensity of attack, etc. The analysis of variance (ANOVA) of different parameters was performed and the range test of the means was done by using Duncan's Multiple Range Test (DMRT). Before statistical analysis, the data transformation was done where appropriate using square root and arcsine transformation procedures for the accuracy of results. For benefit cost analysis record of costs incurred in each treatment and that of control were maintained. Similarly, the price of the 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).
RESULTS AND DISCUSSION

The comparative effectiveness of ten treatment combinations of various control options in managing the brinjal shoot and fruit borer (BSFB) in terms of shoot and fruit infestation, infested and healthy fruit yield, total yield and BCR, was assessed. The findings are presented under the following headings. The comparative effectiveness of various control options along with schedule spray on percent shoot infestation by the BSFB has been presented in Table 1. The results revealed that all treatments ensured significantly less infestation in shoot to compare with control (T₀), which had the highest shoot infestation (30.83%). Among the treatments, the lowest shoot infestation (6.27%) was recorded from T₁ (spraying of Marshal® 20 EC at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot you have notice the methods that are used in T₁ before, so it is not necessary to repeat again), followed by T₃ (spraying of Marshal® at 7 days interval + Mechanical control) (9.67%), followed by T₄ (spraying of Marshal® at 7 days interval + mechanical control) (11.12%), T₁ (schedule spray of Marshal® at 7 days interval) and T₈ (spraying of Marshal® at 10 adult catch in pheromone trap + mechanical control). Accordingly, the shoot infestation reduction over control was the highest (79.65%) in T₁ followed by T₈ (68.64%). The shoot infestation reduction over control was the lowest (22.24%) in T₃ (sole mechanical control), which differed significantly from all other treatments. Similar trend has been reported for shoot infestation, all tested treatments showed significant effects on fruit infestation as compared to the control, which had the highest rate of fruit infestation (29.14% by number and 30.48% by weight) as shown in Table 2. As was in case of shoot, the lowest fruit infestation (3.19% by number and 2.83% by weight) was recorded in T₁ followed by T₈ (4.94% by number and 6.36% by weight), T₀, T₉ (9.36% by number and 13.26% by weight).

T₀: Spraying of Marshal® at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; T₁: Mechanical control; T₂: Spraying of Marshal® at 7 (Routine spray) days interval + Mechanical control; T₃: Pheromone trap placed at plant canopy and in the centre of the plot; T₄: Untreated control.

Accordingly, T₁ rendered the highest fruit infestation reduction (89.03% by number and 90.72% by weight) over control which was followed by T₃ (83.03% by number and 79.13% by weight), T₄ (78.52% by number and 77.19% by weight), T₀ and T₉, while it was the lowest in T₉ (41.51% by number and 39.01% by weight) and T₈ (50%). Interestingly, the reduction in fruit infestation in all treatments was higher than those in case of shoot infestation and only T₀ and T₉ could reduce fruit infestation over 80% while none could reduce shoot infestation even at the level of 80%. Consistent with the effectiveness in reducing the infestation both in shoot and fruits, T₁ was resulted in the highest healthy fruit yield (30.42 t ha⁻¹), which was followed by T₈ (25.68 t ha⁻¹) and T₉ (24.34 t ha⁻¹) (Table 3). The lowest healthy fruit yield (13.92 t/ha) was recorded from untreated control.

T₀: Spraying of Marshal® at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; T₁: Mechanical control; T₂: Spraying of Marshal® at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot; T₃: Spraying of Marshal® at 10 adult catch in Pheromone trap + Mechanical control; T₄: Spraying of Marshal® at 12 adult catch in Pheromone trap + Mechanical control; T₅: Spraying of Marshal® at 15 adult catch in Pheromone trap + Mechanical control; T₆: Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; T₇: Spraying of Marshal® at 2 days interval + Mechanical control; T₈: Spraying of Marshal® at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot; T₉: Spraying of Marshal® at 10 adult catch in Pheromone trap + Mechanical control; T₁₀: Spraying of Marshal® at 15 adult catch in Pheromone trap + Mechanical control; T₁¹: Spraying of Marshal® at 2 days interval + Mechanical control; T₁₂: Spraying of Marshal® at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot; T₁₃: Spraying of Marshal® at 10 adult catch in Pheromone trap + Mechanical control; T₁₄: Spraying of Marshal® at 15 adult catch in Pheromone trap + Mechanical control; T₁₅: Pheromone trap placed at plant canopy at the centre of the plot; T₁₆: Untreated control.

Conversely, the lowest infested fruit yield (2.29 t ha⁻¹) was harvested from T₁, which was followed by T₉ (4.43 t/ha) and T₈ (4.63 t ha⁻¹) and T₁ (5.70 t ha⁻¹). The highest infested fruit yield (9.27 t ha⁻¹) was recorded in untreated control. Accordingly was the trend of total yield in different treatments, the highest being 32.71 t ha⁻¹ in T₁ and the lowest being 26.76 tons/ha in T₉ among the treatments and being only 23.19 t ha⁻¹ in control.

The benefit cost ratio (BCR) calculated from the cost incurred in different treatments and the return from the fruit harvest showed significant variations among the treatments, all of which differed significantly from the control (Table 4). Consistent with the higher healthy fruit
Table 1: Effect of different management options on shoot infestation in brinjal

<table>
<thead>
<tr>
<th>Treatments</th>
<th>% infestation</th>
<th>Decrease over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>6.27 h</td>
<td>79.65</td>
</tr>
<tr>
<td>T2</td>
<td>23.97 b</td>
<td>45.18</td>
</tr>
<tr>
<td>T3</td>
<td>9.67 g</td>
<td>68.64</td>
</tr>
<tr>
<td>T4</td>
<td>13.87 e</td>
<td>55.01</td>
</tr>
<tr>
<td>T5</td>
<td>16.90 d</td>
<td>42.40</td>
</tr>
<tr>
<td>T6</td>
<td>11.12 fg</td>
<td>63.91</td>
</tr>
<tr>
<td>T7</td>
<td>12.22 c</td>
<td>37.66</td>
</tr>
<tr>
<td>T8</td>
<td>30.83 a</td>
<td>--</td>
</tr>
</tbody>
</table>

In a column, numeric data represent the mean value of three replications; each replication is derived from 10 plants per treatment in 3 harvests.

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.

Table 2: Effect of different management options on fruit infestation in brinjal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% infestation</th>
<th>Decrease over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3.19 g</td>
<td>89.03</td>
</tr>
<tr>
<td>T2</td>
<td>17.04 b</td>
<td>41.51</td>
</tr>
<tr>
<td>T3</td>
<td>4.94 f</td>
<td>83.03</td>
</tr>
<tr>
<td>T4</td>
<td>9.36 e</td>
<td>67.86</td>
</tr>
<tr>
<td>T5</td>
<td>11.80 d</td>
<td>59.49</td>
</tr>
<tr>
<td>T6</td>
<td>2.83 f</td>
<td>79.02</td>
</tr>
<tr>
<td>T7</td>
<td>4.94 f</td>
<td>83.03</td>
</tr>
<tr>
<td>T8</td>
<td>9.36 e</td>
<td>67.86</td>
</tr>
<tr>
<td>T9</td>
<td>14.54 c</td>
<td>50.10</td>
</tr>
<tr>
<td>T10</td>
<td>29.14 a</td>
<td>30.48 a</td>
</tr>
</tbody>
</table>

In a column, numeric data represent the mean value of three replications; each replication is derived from 10 plants per treatment in 3 harvests.

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.

Table 3: Effect of different management options on total, healthy and infested fruit yields of brinjal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Healthy fruit yield (t/ha)</th>
<th>Infested fruit yield (t/ha)</th>
<th>Increase/ decrease over control</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>30.42 a</td>
<td>2.29 e</td>
<td>32.71</td>
</tr>
<tr>
<td>T2</td>
<td>19.84 d</td>
<td>7.35 b</td>
<td>27.19</td>
</tr>
<tr>
<td>T3</td>
<td>25.68 b</td>
<td>4.43 d</td>
<td>30.11</td>
</tr>
<tr>
<td>T4</td>
<td>21.67 cd</td>
<td>6.91 b</td>
<td>28.58</td>
</tr>
<tr>
<td>T5</td>
<td>22.17 cd</td>
<td>7.31 b</td>
<td>29.84</td>
</tr>
<tr>
<td>T6</td>
<td>21.86 cd</td>
<td>7.21 b</td>
<td>29.07</td>
</tr>
<tr>
<td>T7</td>
<td>21.63 cd</td>
<td>5.70 c</td>
<td>27.33</td>
</tr>
<tr>
<td>T8</td>
<td>24.34 bc</td>
<td>6.43 d</td>
<td>28.97</td>
</tr>
<tr>
<td>T9</td>
<td>20.55 d</td>
<td>6.21 c</td>
<td>26.76</td>
</tr>
<tr>
<td>T10</td>
<td>22.17 cd</td>
<td>7.21 b</td>
<td>29.07</td>
</tr>
</tbody>
</table>

In a column, numeric data represent the mean value of three replications; each replication is derived from 10 plants per treatment in 3 harvests.

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.

Table 4: Cost and benefit analysis for management options for managing BSFB in brinjal

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cost of pest management (Tk.)</th>
<th>Net Return (Tk.)</th>
<th>Adjusted net return (Tk.)</th>
<th>Benefit: cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>33</td>
<td>85400</td>
<td>631300</td>
<td>545900</td>
</tr>
<tr>
<td>T2</td>
<td>-</td>
<td>38500</td>
<td>470300</td>
<td>431800</td>
</tr>
<tr>
<td>T3</td>
<td>23</td>
<td>65600</td>
<td>557900</td>
<td>492300</td>
</tr>
<tr>
<td>T4</td>
<td>11</td>
<td>55600</td>
<td>502500</td>
<td>446900</td>
</tr>
<tr>
<td>T5</td>
<td>10</td>
<td>55000</td>
<td>516500</td>
<td>461500</td>
</tr>
<tr>
<td>T6</td>
<td>9</td>
<td>54000</td>
<td>509300</td>
<td>455300</td>
</tr>
<tr>
<td>T7</td>
<td>11</td>
<td>44500</td>
<td>473100</td>
<td>428600</td>
</tr>
<tr>
<td>T8</td>
<td>11</td>
<td>52800</td>
<td>489600</td>
<td>436800</td>
</tr>
<tr>
<td>T9</td>
<td>-</td>
<td>66400</td>
<td>533100</td>
<td>466700</td>
</tr>
<tr>
<td>T10</td>
<td>-</td>
<td>--</td>
<td>371100</td>
<td>371100</td>
</tr>
</tbody>
</table>

Healthy fruits Tk. 20/- per kg. and infested fruits Tk. 10/- per kg.
yield in different treatments, the gross return was in descending order as $T_3 > T_8 > T_9 > T_3 > T_8 > T_9 > T_3$, the highest being Tk. 6,31,300.00 in $T_3$ and the lowest being Tk. 5,33,100.00 in $T_8$, among the treatments. But due to variations in costs of treatments, the order of net return in some cases changed and thus the order of BCR also changed in some cases. Among the treatments, $T_4$ provided the highest BCR (2.05), $T_4$ (1.85), while it was the lowest (1.29) in $T_9$. Although the BCR in $T_9$ was close to $T_4$, the healthy fruit yield in $T_4$ (25.68 t ha$^{-1}$) was much less than $T_9$ (30.42 t ha$^{-1}$). Similarly, the healthy fruit yield in $T_9$ (21.63 t ha$^{-1}$) was also much less than $T_4$ (24.34 t ha$^{-1}$) although its BCR was higher (1.66) than $T_4$. Consistent with its effect on all other yield contributing parameters, the BCR of $T_4$ was very low (1.29).

$T_1$: Spraying of Marshal® at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; $T_7$: Mechanical control; $T_9$: Spraying of Marshal® at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; $T_4$: Spraying of Marshal® at 10 adult catch in Pheromone trap + Mechanical control; $T_5$: Spraying of Marshal® at 12 adult catch in Pheromone trap + Mechanical control; $T_8$: Spraying of Marshal® at 15 adult catch in Pheromone trap + Mechanical control; $T_3$: Spraying of Marshal® at 7 (Routine spray) days interval; $T_9$: Spraying of Marshal® at 7 (Routine spray) days interval + Mechanical control; $T_6$: Mechanical control + Pheromone trap placed at plant canopy and in the centre of the plot; $T_{10}$: Untreated control.

$T_1$: Spraying of Marshal® at 2 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; $T_7$: Mechanical control; $T_9$: Spraying of Marshal® at 3 days interval + Mechanical control + Pheromone trap placed at plant canopy at the centre of the plot; $T_4$: Spraying of Marshal® at 10 adult catch in Pheromone trap + Mechanical control; $T_5$: Spraying of Marshal® at 12 adult catch in Pheromone trap + Mechanical control; $T_8$: Spraying of Marshal® at 15 adult catch in Pheromone trap + Mechanical control; $T_3$: Spraying of Marshal® at 7 (Routine spray) days interval; $T_6$: Spraying of Marshal® at 7 (Routine spray) days interval + Mechanical control; $T_2$: Pheromone trap placed at plant canopy and in the centre of the plot; $T_{10}$: Untreated control.

The findings presented under different parameters (e.g., shoot and fruit infestation, healthy and infested fruit yield, total fruit yield and BCR) indicate that any single option such as sole mechanical control, schedule spray of Marshal® at 7 days interval or sole sex pheromone trap placed at plant canopy and in the centre of the plot was inferior to any of the combined options and that the combinations of three options was better than that of two options. Among the single options, schedule spray of Marshal® at 7 days interval ($T_3$) was better than sole sex pheromone trap placed at plant canopy and in the centre of the plot ($T_3$), which, however, was better than sole mechanical control ($T_3$) in all considerations. The most fascinating finding is that the treatment $T_1$ attained superiority to $T_1$ in all aspects such as reduction in shoot and fruit infestation and infested fruit yield, increase of healthy fruit and total fruit yield and increase of BCR, just due to one day less interval of spraying Marshal® (the former having Marshal® spraying at 2 days interval and the later having the spraying at 3 days interval) although both had in common the mechanical control and the pheromone trap placed at plant canopy and in the centre of the plot. The above findings have resemblance with the findings of other researchers. It was reported that sanitation, sex pheromone and biological control put together in an integrated package of practices would help combat ESFB on a sustainable basis when in many instances the insecticides did not provide satisfactory control of the target pest timely. Duara et al. [22] reported that IPM gave effective control of shoot and fruit borers, as well as the highest BCR. Maleque et al. [23] observed that combination of mechanical and chemical gave the highest benefit cost ratio than untreated control and sole one. Amin [24] reported that spraying of Marshal® 20 EC at 1 ml L$^{-1}$ of water + mechanical control produced the highest yield (39.69 t ha$^{-1}$), which was followed by use of sex pheromone (35.04 t ha$^{-1}$) with mechanical control. Thus either $T_1$ to harvest the highest healthy fruit yield and total fruit yield (30.42 tons and 32.71 t ha$^{-1}$ respectively) would be the best choice from economics point of view, or for consumers’ safety either $T_9$, $T_9$ or $T_9$ (only pheromone requiring no spray) at the sacrifice of 6 tons, 8 tons or 10 tons potential healthy yield per ha respectively, may be an alternative choice.

**REFERENCES**


