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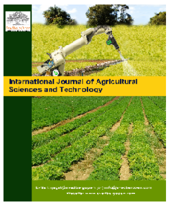

Research Paper

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# Effectiveness of Integrated Management Packages Against Pod Borer Complex on Mungbean

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## Abstract

Experiment was carried out in the farmer's field at Sonakhali, Barguna sadar, Barguna district of Bangladesh during January to April 2018 to evaluate the effectiveness of different IPM packages against pod borer complex of mungbean. Results revealed that the lowest number of pod borer (1.33/m$^2$), the highest percent (93.56%) pod borer reduction over control, lowest pod damaged (5.33/m$^2$), highest percent (87.70%) pod damaged reduction over control at 65 DAS were recorded in Package 5 (Bioneem plus 1% EC @ 1 mL/l of water + sex pheromone trap) treated plots. The highest yield (1,416 kg/ha), percent yield increase over control (40.26%), highest net return come (Tk. 23,146/ha) and highest marginal benefit cost ratio (4.35) were obtained from Package 3 (Sex pheromone trap + white sticky trap) treated plots followed by Package 5 (1,319 kg/ha and 27.33%) and the lowest yield (1,010 kg/ha) from untreated control. From this experiment Package 3 (Sex pheromone trap + White sticky trap) was found to be the best integrated management package for the suppression of pod borer complex and produced maximum yield of mungbean. Integration of IPM components revealed that installation of sex pheromone trap along with white sticky trap (package 3) was found to be the best IPM package for the management pod borer complex producing maximum yield and providing highest marginal benefit cost ratio of mungbean.

***Keywords:*** *Bioneem plus, Helicoverpa armigera, Maruca vitrata, Mungbean, Sex pheromone trap, White sticky trap*



## 1. Introduction

Mungbean (*Vigna radiata* L.) is originated in South East Asia (India, Burma, and Thailand region) and widely grown in India, Pakistan, Bangladesh, Burma, Thailand, Philippines, China, Indonesia and in parts of East and Central Africa, West Indies, USA and Australia (Gowda and Kaul, 1982). It is an excellent and easily digestible dietary source of vegetable protein. This pulse protein is rich in lysine that is deficient in rice. When it is eaten in combination with wheat,

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rice and other cereals, it provides a balanced diet for millions of people. Hence pulses have been considered as poor man's meat for the underprivileged people who can't afford animal protein (Ali and Gupta, 2012). According to FAO (2013) recommendation, a minimum intake of pulse by human should be 80 g per day, whereas it is only 7.92 g in Bangladesh (BBS, 2014). This is because of the fact that national production of the pulses is not adequate to meet our national demand. Mungbean seed contains 52% carbohydrate, 26% protein, 10% moisture, 4% minerals and 3% vitamins (Kaul, 1982). In Bangladesh mungbean is grown three times in a year covering 39,302 ha with total yield of 31,610 metric tons (BBS, 2014). It contributes only about 11.53% of the total pulse production in Bangladesh and ranks fifth among the pulse crops (BARC, 2013).

There are many constrain responsible for the low yield of mungbean. The poor yield is largely due to varietal aspect, climatic factors, management practices, insect pests and diseases (Rahman *et al.*, 1981). Among insect pests of Mungbean, pod borer complex are the most important limiting factor. In the field, gram pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca vitrata*) are considered to be major insect pests in Bangladesh (Rahman *et al.*, 1981), in India (Sehgal and Ujagir, 1988) and other tropical and sub-tropical countries, pod borer damages flowers, flower buds and developing or mature pods (Poehlman, 1991). The caterpillars bore into the young pods, remain inside and feed on seeds. The yield reduction ranged from 30% to 70% due to thrips attack and 30% to 40% by pod borer in Bangladesh (Afzal *et al.*, 2004). The larvae enter into the inflorescence and start feeding the flowers, later they cripple leaves together making nets and nets with leaves, flowers and young pods. They remain inside the nets hiding themselves and eat the young seeds after boring the pods (Rahman *et al.*, 1981).

Several management practices have been reported to control pod borers on Mungbean. Sarkar *et al.* (2006) conducted an experiment for effective control of the chickpea pod borer (*Helicoverpa armigera* Hubner) by various means, including chemicals, botanicals and biocontrol agent and found *Helicoverpa* Nuclear Polyhedrosis Virus (HNPV) significantly reduced pod borer population which led to the lowest pod damage, followed by chemical insecticides and botanicals. HNPV treated plots produced higher grain yield compared to chemical insecticides and botanicals. Prodhan *et al*. (2008) conducted an experiment to develop integrated management approaches against insect pest complex of mungbean and reported that Seed treatment with Imidachlorpid (5 g/kg seeds) + Poultry manure (3 t/ha) + Spray with Quinalphos @ 1 mL / l of water produced highest yield. In spite of resulting in insecticide resistance, toxicity to non-target organisms like pollinators and natural enemies of the pests, residues on food and environmental pollution (Desneux *et al*, 2007), the use of synthetic insecticides as a component of IPM has been incorporated for the management of insect pests. Considering above facts the present experiment was undertaken to evaluate the effectiveness of different integrated management packages against pod borer complex of Mungbean.

## 2. Materials and Methods

The experiment was carried out in the farmer's field at Sonakhali, Barguna sadar, Barguna district of Bangladesh during January to April 2018 to evaluate the effectiveness of different IPM packages against pod borer complex of mungbean. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications (Gomez and Gomez, 1984). The whole field was divided into four unit blocks represented replications and each unit block was divided into six sub unit plots (Figure 1). The total number of plots was 24 and the size of the individual plot was 4.0 m x 3.0 m. The distance between two unit plots was 0.75 m and between block to block was 1 m. The treatments were randomly distributed to the plots within a block. BARI Mung-6 was used as study material. The seeds were sown on January 3, 2018 at the rate of 20 kg/ha. The seeds were placed in the line continuously at a depth of 4-5 cm and covered by loose soil with the help of hand. The spacing was 15 cm between rows and 10 cm between plants. At first trifoliate stage seedling was carefully thinned to retain on seedling hill. Seed germination occurred from $10^{th}$ day of sowing. On the $15^{th}$ day the percentage of germination was more than 80% and on the $18^{th}$ day nearly all the seedlings came out from the soil.

The experiment comprised of five IPM packages and one untreated control. The packages were: Package 1- Bioneem plus 1% EC @ 1 mL/liter of water + White sticky trap, Package 2 - Virtako 40 WG @ 0.15 g/liter of water + White sticky trap, Package 3- Sex pheromone trap + White sticky trap, Package 4 - Nitro 505 EC @ 1 mL/liter + White sticky trap, Package 5- Bioneem plus 1% EC @ 1 mL/liter of water + Sex pheromone trap.

**Procedure of Spray Application:** Insecticides were procured from Biotech division, Ispahani agro Ltd. and local market. The spray solutions at the pre fixed concentration of the respective treatments were prepared in Knapsack sprayer by mixing with water as required just before spraying in the afternoon. The spray solutions thus prepared were sprayed in the assigned plots as per the treatment design. The spray was always done in the afternoon to avoid bright sunlight. The sprays were applied uniformly to obtain complete coverage of whole plants of the assigned plots. Caution was taken to avoid any drift of any spray mixture to the adjacent plots at the time of the spray.

**Plate 1: Field View of Experimental Plots with Integrated Management Packages**


**Intercultural Operations:** Intercultural operations were done as and when necessary to ensure normal growth and development of crops. The detail intercultural operations were as below:

**Irrigation and Drainage:** Irrigation was used as and when irrigation needed. If moisture is needed, water should be supplied at the experimental plots. Proper drainage system was also developed for draining out excess water.

**Thinning:** As the seeds were sown continuously into the line, so there were so many seedlings, which need thinning. Emergence of seedling was completed within 10 days after sowing. Over crowded seedlings were thinned out twice to keep plant-to-plant distance 10 cm. First thinning was done after 15 days of sowing which is done to remove unhealthy and out of line seedlings. The second thinning was done 10 days after first thinning.

**Weeding:** There were some common weeds found in the mungbean field. First weeding was done at 30 Days After Sowing (DAS) and then once a week to keep the plots free from weeds and to keep the soil loose and aerated for the whole period of the crop growth.

**Incidence of Pod Borer and Pod Infestation:** The data on the population of pod borers and pod infestation were collected at 55 and 65 DAS, respectively. Pod borer infested pods and healthy pods were recorded separately for each plot.

**Harvesting:** Pod maturity in mungbean is not uniform because the plants flower over an extended period. This makes it difficult to decide when to harvest. Generally, harvest should begin when one-half to two-thirds of the pods are mature. In Late, rabi season pod should be picked after it become black in color. Mungbean was harvested two times at 67 DAS when about 80% of the pods became black in color and at 74 DAS after ripening. The harvested crop of 1 $m^2$ area from each unit plot was bundled separately.

Infested pod were collected randomly and opened, and the damaged seeds were recorded. Plants were uprooted from each plots and plant height (cm), number of pods/plant, pod length (cm), number of healthy seeds/pod, number of damaged seeds/infested pod, 1000 seeds weight (g) and seed yield per meter square from each plot were recorded. The yield of each plot was calculated and expressed as kg $ha^{-1}$.

**Calculation of the Percentage of Infested Pods by Pod Borers:** For collecting data on the percentage of pod borer infested pods, the number of infested pods and the total number of pods from per square meter of each plot were counted at ripening stage and recorded. The data were collected two times (67 DAS and 74 DAS) from pod development to harvest. The percent pod infestation was calculated using the following formula:

$$\textit{Pod infestation (\%)} = \frac{\textit{Total number of infested pods/m}^2}{\textit{Total number of pods/m}^2} \times 100$$

**Calculation of Percentage of Damaged Seeds by Pod Borers:** The percentage of pod borer infested pods, the number of damaged and total seeds from per square meter infested pods from each plot was counted. The data were collected three times (57 DAS and 65 DAS) from pod development to harvest.

$$\textit{Damage seeds/infested pod (\%)} = \frac{\textit{Number of damaged seeds per infested pod}}{\textit{Total number of seeds per infested pod}} \times 100$$

**Percent Population Reduction Over Control:** The percent insect population reduction over control was calculated by using the following formula (Khosla, 1997):

$$\textit{Percent population reduction over control} = \frac{X_2 - X_1}{X_2} \times 100$$

where, $X_1$= The mean of treated plots

$X_2$= The mean of untreated plots

**Economic Analysis of Integrated Management Packages:** Economic analysis in terms of Benefit Cost Ratio (BCR) was analyzed based on total expenditure of the respective management treatment along with the total return from that particular treatment. In this study BCR was analyzed for a hectare of land. For this analysis following parameters were considered:

**Treatment-Wise Management Cost/Variable Cost:** This cost was calculated by adding all costs incurred for labors and inputs for each management treatment including untreated control during the entre cropping season. The plot yield (kg/ha) of each treatments was converted into ton/ha yield.

**Gross Return (GR):** The yield in terms of money that was measured by multiplying the total yield by the unit price of mungbean ( Tk. 70/kg).

**Net Return (NR):** The net return was calculated by subtracting treatment wise management cost from gross return.

**Adjustment Net Return (ANR):** The ANR was determined by subtracting the net return for a particular treatment from the net return with control plot. Finally, the Marginal Benefit Cost Ratio (MBCR) for each treatment was calculated by using the following formula described by Elias Karim (1984):

$$\textit{Marginal Benefit Cost Ratio (MBCR)} = \frac{\textit{Adjusted net return}}{\textit{Total management cost}} \times 100$$

**Statistical Analysis:** The collected data were statistically analyzed through the Analysis of Variance (ANOVA) using WASP 1.0 software package. Means were separated by Critical Difference (CD) values at 5% level of significance.

## 3. Results and Discussion

### *3.1. Effectiveness of Integrated Management Packages on the Incidence and Pod Infestation of Pod Borer at 55 DAS*

The effect of integrated management packages on pod borer population and pod infestations are presented in Table 1. At 55 DAS, the number of pod borer varied significantly and ranged from 1.00 to 14.67/m$^2$. The lowest mean number of pod borer (1.0/m$^2$) was observed in Package 3 (Sex pheromone trap and white sticky trap) treated plots which was statistically similar to Package 5 (1.67/m$^2$) followed by Package 2 (3.0/m$^2$), Package 4 (3.67/m$^2$) and Package 1 (5.0/m$^2$). The highest number of pod borer was observed in untreated control plots (14.67/Plot), which was statistically different from other treatments. Accordingly, the highest percentage of pod borer population reduction (93.18%) over control was found in Package 3 treated plots followed by Package 5 (88.61%) and Package 2 (79.55%) while the lowest reduction was in Package 1 (65.91%) followed by Package 3 (74.98%).

In case of pod infestation, the number of pod infestation varied significantly with the efficacy of IPM packages and it ranged from 3.0 to 25.33/plant. The lowest pod damaged (3.0/plant) was observed in Package 5 (Bioneem plus 1% EC @ 1 mL/liter of water + Sex pheromone trap) treated plots followed by Package 3 (4.0/plant), Package 2 (5.67/plant), Package 4 (6.33/plant) and Package 1 (7.67/plant). The highest number of pod infestation was observed in untreated control plots (25.33/plant) which were statistically different from other treatments. Accordingly, the highest percentage of pod damaged reduction (88.15%) over control was found in Package 5 treated plots followed by Package 3 (84.20%) and Package 4 (75.0%). While the lowest pod damaged reduction (49.98%) over control was found in Package 1 (Bioneem plus 1% EC @ 1ml/liter of water + white sticky trap) treated plots followed by Package 2 (55.64%) (Table 1).

**Table 1: Effectiveness of Different Integrated Management Packages on the Incidence of Pod Borer and Pod Infestation on Mungbean at 55 DAS**

| IPM Packages | Number of Pod Borer/m$^2$ | Reduction of Pod Borer Population Over Control (%) | Number of Pod Infestation/ Plant | Reduction of Pod Infestation Over Control (%) |
|---|---|---|---|---|
| Package 1 | 5.00$^b$ | 65.91 | 7.67$^b$ | 49.98 |
| Package 2 | 3.00$^{cd}$ | 79.55 | 5.67$^{cd}$ | 55.64 |
| Package 3 | 1.00$^e$ | 93.18 | 4.00$^{de}$ | 84.20 |
| Package 4 | 3.67$^{bc}$ | 74.98 | 6.33$^{bc}$ | 75.00 |
| Package 5 | 1.67$^{de}$ | 88.61 | 3.00$^e$ | 88.15 |
| Untreated Control (Water Spray) | 14.67$^a$ | - | 25.33$^a$ | - |
| Level of Significance | ** | - | ** | - |
| **CV (%)** | **21.69** | **-** | **8.99** | **-** |

**Note:** ** Significant at 1% level
Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.
Package 1 - Bioneem plus 1% EC @ 1 mL/liter of water + white sticky trap
Package 2 - Virtako 40 WG @ 0.15 g/liter of water + white sticky trap
Package 3 - Sex pheromone trap + white sticky trap
Package 4 - Nitro 505 EC @ 1 mL/liter + white sticky trap
Package 5 - Bioneem plus 1% EC @ 1ml/liter of water + sex pheromone trap
Untreated control - only spray water.

### *3.2. Effectiveness of Integrated Management Packages on the Incidence and Pod Infestation of Pod Borer on Mungbean at 65 DAS*

The effect of integrated management packages on pod bore population and pod infestations are presented in Table 2. At 65 DAS, the number of pod borer varied significantly and ranged from 1.00 to 20.67. The lowest number of pod borer (1.33/m$^2$) was observed in Package 5 (Bioneem plus 1% EC @ 1 mL/liter of water + sex pheromone trap) treated plots followed by Package 3 (2.33/m$^2$), Package 2 (3.33/m$^2$), Package 4 (4.33/m$^2$) and Package 1 (5.67/m$^2$). The highest number of pod borer was observed in untreated control plots (20.67/m$^2$), which was statistically different from other treatments. Accordingly, the highest percentage of pod borer reduction (93.56%) over control was found in Package 5 treated plots followed by Package 3 (88.72%) and Package 2 (83.88%) while the lowest percent reduction was in Package 1 (72.56%) followed by Package 4 (79.05%).

In case of pod infestation, the number of pod infestation varied significantly and ranged from 5.33 to 30.33. The lowest pod infestation (5.33/plant) observed in Package 5 (Bioneem plus 1% EC @ 1 mL/liter of water + sex pheromone trap) treated plots followed by Package 3 (7.0/plant), Package 2 (8.67/plant), Package 4 (10.67/plant) and Package 1 (11.67/plant). The highest number of pod infestation was observed in untreated control plots (30.33/plant) which were statistically different from other treatments. Accordingly, the highest percentage of pod infestation reduction (83.84%) over control was found in Package 3 (Sex pheromone trap + white sticky trap) treated plots followed by Package 5 (82.42%), Package 4 (76.92%) and Package 2 (71.41%). While the lowest pod infestation reduction (61.52%) over control was observed in Package 1 (Bioneem plus 1% EC @ 1 mL/liter of water + white sticky trap) treated plots (Table 2).

**Table 2: Effectiveness of Integrated Management Packages on Pod Borer Population and Pod Infestation on Mungbean at 65 DAS**

| Management Packages | Number of Pod Borer/m$^2$ | Reduction of Pod Borer Population Over Control (%) | Number of Pod Infestation / Plant | Reduction of Pod Infestation Over Control (%) |
|---|---|---|---|---|
| Package 1 | 5.67$^b$ | 72.56 | 11.67$^b$ | 61.52 |
| Package 2 | 3.33$^{cd}$ | 83.88 | 8.67$^{cd}$ | 71.41 |
| Package 3 | 2.33$^{de}$ | 88.72 | 7.00$^{de}$ | 83.84 |
| Package 4 | 4.33$^c$ | 79.05 | 10.67$^{bc}$ | 76.92 |
| Package 5 | 1.33$^e$ | 93.56 | 5.33$^e$ | 82.42 |
| Untreated Control-Only Spray Water | 20.67$^a$ | - | 30.33$^a$ | - |
| **Level of Significance** | ** | - | ** | - |
| **CV (%)** | **15.33** | **-** | **9.43** | **-** |

**Note:** ** Significant at 1% level
Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.
Package 1 - Bioneem plus 1% EC @ 1 mL/liter of water + white sticky trap
Package 2 - Virtako 40 WG @ 0.15 g/liter of water + white sticky trap
Package 3 - Sex pheromone trap + white sticky trap
Package 4 - Nitro 505 EC @ 1 mL/liter + white sticky trap
Package 5 - Bioneem plus 1% EC @ 1 mL/liter of water + sex pheromone trap
Untreated control- only spray water.

### *3.3. Effect of Different Integrated Management Packages on Pod Infestation, Seed Damage and Yield of Mungbean*

Effect of integrated management packages on pod infestation, seed damage and yield of mungbean at harvest are presented in Table 3. The percent pod infestation varied significantly and ranged from 1.33 to 31.67%. The lowest percentage of pod infestaton (1.33%) was observed in Package 3 (Sex pheromone trap + White sticky trap) treated plots which was statistically similar to Package 5 followed by Package 2, Package 4 and Package 1 (5.33/m$^2$). The highest percent pod damage was recorded in untreated control plots (31.67%) which were statistically different from other treatments. Accordingly, the highest percent pod infestation reduction (95.80%) over control was found in Package 3 followed by Package 5 (92.64%), Package 2 (88.41%) and the lowest percent reduction was in Package 3 (83.17%) followed by Package 4 (86.32%).

In case of percent seed damaged, seed damaged also varied significantly and ranged from 6.67 to 80.0%. The lowest percent seed damage (6.67% per infestated pod) was recorded in Package 5 (Bioneem plus 1% EC @ 1 mL/liter of water

+ Sex pheromone trap) treated plots which was stattically at par with Package 3 (11.67%/infested pod) followed by Package 2 (20.0% per infestated pod), Package 4 (25.0% per infested pod) and Package 1 (37.0 % per infestated pod. Significantly the highest percent seed damage was observed in untreated control plots (80.0% per infestated pod) which were statistically different from other treatments. Accordingly, the highest percentage of seed damaged reduction over control (91.66%) was found in Package 5 treated plots followed by Package 3 (85.41%) while the lowest percent reduction was in Package 1 (53.75%) followed by Package 4 (68.75%) and Package 2 (75.0%) (Table 3).

Significantly the highest yield (1,416 kg/ha) and percent yield increase over control (40.26%) was recorded in Package 3 (Sex pheromone trap + white sticky trap) treated plots followed by Package 5 (1,390 kg/ha and 27.33%), Package 1 (1,240 kg/ha and 18.54 %), Package 2 (1,193.33 kg/ha and 15.33 %) and Package 4 (1,133.33 kg/ha and 10.88%), while the lowest yield was obtained from untreated control (1,010 kg/ha) plots. Thus the order of IPM packages efficiency in increasing yield (kg/ha) of mungbean over control was Package 3> Package 5> Package 1> Package 2> Package 4> untreated control (Table 3).

**Table 3: Effectiveness Of Integrated Management Packages on Pod Infestation, Seed Damage and Yield of Mungbean at Harvest**

| IPM Packages | % Pod Infestation | % pod Infestation Reduction Over Control | % Seed Damaged Per Pod | % Seed Damaged Reduction Over Control | Yield (kg/ha) | % Yield Increased Over Control |
|---|---|---|---|---|---|---|
| Package 1 | 5.33[b] | 83.17 | 37.00[b] | 53.75 | 1,240.00[c] | 18.54 |
| Package 2 | 3.67[cd] | 88.41 | 20.00[cd] | 75.00 | 1,193.33[cd] | 15.33 |
| Package 3 | 1.33[e] | 95.80 | 11.67[de] | 85.41 | 1,416.67[a] | 40.26 |
| Package 4 | 4.33[bc] | 86.32 | 25.00[c] | 68.75 | 1,133.33[d] | 10.88 |
| Package 5 | 2.33[de] | 92.64 | 6.67[e] | 91.66 | 1,390.00[b] | 27.33 |
| Untreated Control | 31.67[a] | - | 80.00[a] | - | 1,010.00[e] | - |
| Level of Significance | ** | - | ** | - | ** | - |
| **CV (%)** | **10.47** | **-** | **19.32** | **-** | **2.85** | **-** |

**Note:** ** Significant at 1% level

Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.

Package 1 - Bioneem plus 1% EC @ 1 mL/liter of water + white sticky trap
Package 2 - Virtako 40 WG @ 0.15 g/liter of water + white sticky trap
Package 3 - Sex pheromone trap + white sticky trap
Package 4 - Nitro 505 EC @ 1 mL/liter + white sticky trap
Package 5 - Bioneem plus 1% EC @ 1 mL/liter of water + sex pheromone trap
Untreated control - only spray water.

### *3.4. Relationship Between Pod Borer Population and Yield of Mungbean*

There was a moderate negative correlation between number of pod borer and total yield. It indicated that there was progressive fall in the yield with the increase of pod borer. A linear regression was fitted between pod borer population and total yield (Figure 1). The correlation coeffcient (r) was 0.78 and the contribution of the regression ($R^2 = 0.6236$, when $Y = -16.937x + 1336.9$) was 62.36%.

### *3.5. Economic Analysis of Integrated Management Packages*

Return and marginal benefit cost ratio are presented in Table 4. The net return and marginal benefit cost ratio was varied depending on the cost of treatment application. The highest net return (Tk. 23,146/ha) was obtained from Package 3 (Sex pheromone trap + white sticky trap) followed by Package 5 (Tk. 18,226/ha), Package 1(Tk. 7646/ha), Package 2 (Tk. 6433/ ha) and the lowest net return was obtained from Package 4 (Tk. 1903/ha). The highest marginal benefit cost ratio (MBCR 4.35) was calculated from Package 3 (Sex pheromone trap + White sticky trap) followed by Package 5 (MBCR 2.18), Package 1 (MBCR 1.0), Package 2 (MBCR 0.90) and the lowest was in Package 4 (MBCR 0.28) (Table 4). This was mainly due to incurring costs of these treatments. Though Package 5 (Bioneem plus 1% EC @ 1 mL/liter of water + Sex

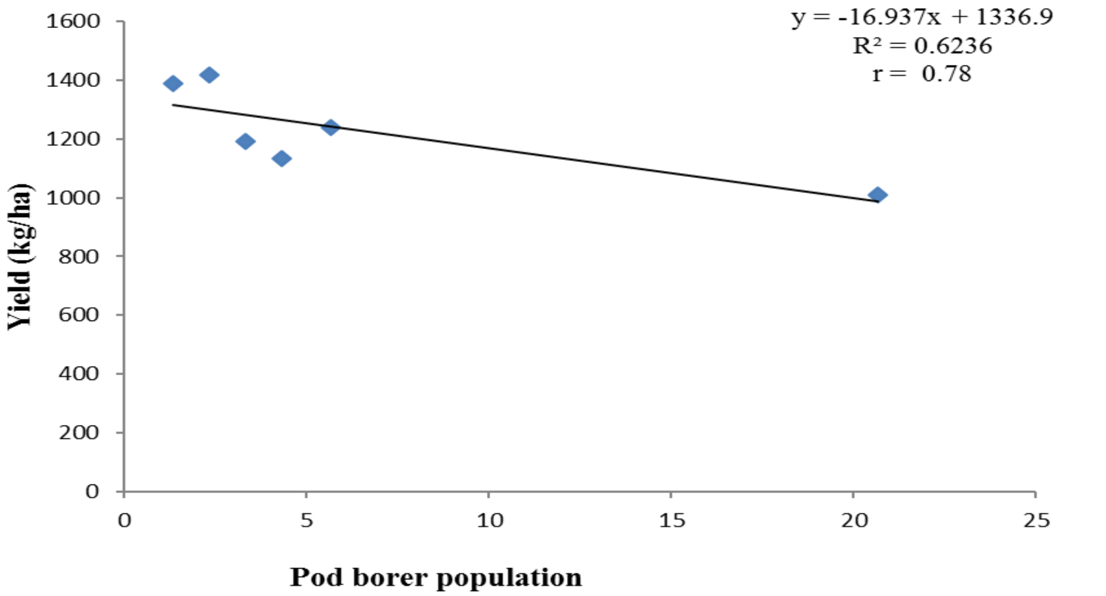


**Figure 1: Relationship Between Pod Borer Population and Yield of Mungbean**

**Table 4: Effectiveness of Integrated Management Packages on Net Return And Marginal Benefit Cost Ratio in Mungbean**

| IPM Packages | % Pod Infestation | % Pod Infestation Reduction Over Control | % Seed Damaged Per Pod | % Seed Damaged Reduction Over Control | Yield (kg/ha) | % Yield Increased Over Control |
|---|---|---|---|---|---|---|
| Package 1 | 1,240.00[c] | 230.00 | 1,6100 | 8,454 | 7,646 | 0.90 |
| Package 2 | 1,193.33[cd] | 183.33 | 12,833 | 6,400 | 6,433 | 1.00 |
| Package 3 | 1,416.67[a] | 406.67 | 28,466 | 5,320 | 23,146 | 4.35 |
| Package 4 | 1,133.33[d] | 123.33 | 8,633 | 6,730 | 1,903 | 0.28 |
| Package 5 | 1,390.00[b] | 380.00 | 26,600 | 8,374 | 18,226 | 2.18 |
| Untreated Control (Water Spray) | 1,010.00[e] | - | - | - | - | - |
| Level of Significance | ** | - | - | - | - | - |
| **CV (%)** | **2.85** | - | - | - | - | - |

**Note:** ** Significant at 1% level
Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.
Package 1 - Bioneem plus 1% EC @ 1 mL/liter of water + white sticky trap
Package 2 - Virtako 40 WG @ 0.15 g/liter of water + white sticky trap
Package 3 - Sex pheromone trap + white sticky trap
Package 4 - Nitro 505 EC @ 1 mL/liter + white sticky trap
Package 5 - Bioneem plus 1% EC @ 1 mL/liter of water + sex pheromone trap
Untreated control - only spray water.

pheromone trap) provided the highest MBCR as well as moderate level of pod borer infestation. IPM Package 3 (Sex pheromone trap + White sticky trap) was found to be very promising and eco-friendly for the management of pod borer complex on mungbean.

For calculating income and benefit, the following market prices were used: Mungbean = Tk. 70/kg, Sex pheromone trap = Tk. 60/trap, White sticky trap = Tk. 30/trap, Bioneem plus 1% EC = Tk. 280/100 mL, Virtako 40 WG = Tk. 140/10 g, Nitro 505 EC = Tk. 100/100 mL, Labor wage for spraying pesticides =Tk. 400/day/laborer (8 h/ day).

The lowest number of pod borer (1.33/plot), pod damaged (5.33/plant), seed damaged (6.67/infested pod), the highest percentage of pod borer (94.60%), pod damaged (93.56%) and seed damaged (91.67%) reduction over control were recorded from Package 5 treated plots. The highest yield (1,416 kg/ha) and percent increase over control (40.26%) was recorded in Package 3 treated plots followed by Package 5 (1,390 kg/ha and 27.33%) and the lowest was produced from untreated control (1,010 kg/ha). The highest net return come (Tk. 23,146/ha) was obtained from Package 3 treated plots. The highest marginal benefit cost ratio (MBCR 4.35) was obtained from Package 3 (Sex pheromone trap + white sticky trap) treated plots followed by Package 5 (MBCR 2.18). This was mainly due to incurring costs of these treatments. In the present study, application of Package 3 (Sex pheromone trap + White sticky trap) was found to be very promising for the management of insect pest of mungbean, although Package 5 provided the highest MBCR as well as moderate level of insect pest infestation. The findings of the present experiment are in conformity with the results of Prodhan *et al*. (2008) where they conducted an experiment with five treatment combinations and found that all the treatments significantly reduced insect infestation (except thrips) and produced higher yield compared to control. They found that the highest yield (1,316 kg/ha) was obtained from the treatment $T_3$ (= Seed treatment with Imidachlorpid (5 g/kg seeds) and poultry manure (3 t/ha) and Spray with Quinalphos @ 1 mL / l of water) and the highest marginal benefit cost ratio (1.84) was obtained from the same treatment $T_3$. Sarkar *et al.* (2006) conducted an experiment against effective control measure for the chickpea pod borer (*Helicoverpa armigera* Hubner) by various means, including chemicals, botanicals and biocontrol agent. They observed that application of *Helicoverpa* Nuclear Polyhedrosis Virus (HNPV) significantly reduced pod borer population which led to the lowest pod damage, followed by chemical insecticides and botanicals. HNPV treated plots produced higher grain yield compared to chemical insecticides and botanicals. Alam *et al.* (2013) evaluated four bio-rational management packages against pod borer complex attacking country bean. In their study, there were four treatment packages, viz.,: Package 1 = Sanitation (Hand picking and destruction of infested flowers, pods and larvae) and release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*) + spraying of *Bt*. Powder; Package 2 = Sanitation and release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*) and spraying of Spinosad 45 SC; Package 3 = Sanitation + release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*); Package 4 = Sanitation and spraying of Voliam flexi 300 SC (Chlorantraniliprole and Thiamethoxam) and an untreated control. They reported that the package which appeared as the best package provided 75.93% and 90.17% reduction of flower and pod infestation, respectively over control by pod borers. The highest yield increase over control (84.46%) and BCR (9.55) was also obtained from the same package. Hossain (2015) reported that the highest yield and the highest net return was obtained from Thiamethoxam + Chlorantraniliprole (Voliam flexi 300SC) at the concentration of 0.5 mL/L water. Islam *et al.* (2019) found that the application of Thiamethoxam + Chlorantraniliprole (Voliam flexi 300SC) @ 0.5 mL/L water was the most profitable approach for the management of thrips and pod borers of mungbean followed by Chlorpyrifos + Cypermethrin (Nitro 505 EC) @ 1 mL/L of water. Islam *et al.* (2020) found that the application of Voliam flexi 300SC @ 0.5 mL/L water + Tracer 45 SC @ 0.3 mL/L of water was the most effective combination in reducing the populations of thrips, gram pod boer and legume pod borer and their infestation, and produced maximum yield and highest marginal benefit cost ratio.

## 4. Conclusion

Integrated management package 3 (Installation of sex pheromone trap + white sticky trap) was the best package for the eco-friendly management of pod borer complex for producing maximum yield and providing highest marginal benefit cost ratio on mungbean.

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