# EVALUATION OF INTEGRATED APPROACHES FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER UTILIZING ANTIXENOTIC VARIETY OF BRINJAL

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ABSTRACT: An experiment was conducted to evaluate the effectiveness of 10 integrated approaches comprising Antixenotic variety, mechanical control, repellent crop, sex pheromone and chemical insecticides for the management of BSFB in brinjal grown in the experimental farm of Bangabandhu Shiekh Mujibur Rahman Agricultural University, Gazipur in Winter 2005. The highest shoot infestation reduction over control (84.71%) was recorded in IPM package plots consisting of antixenotic variety +Mechanical control + Marshal 20 EC @ 1ml/L applied at 15 days interval. Among the IPM packages, the package consisting of antixenotic variety +Mechanical control + Marshal 20 EC @ 1ml/L applied at 15 days interval was found as the most effective package and provided the highest shoot (60.97%) and fruit (75.94%) infestation reduction over control. This package resulted significantly the highest healthy brinjsl fruit yield of 39.69 t/ha.IPM package of AV+MC+CS ensured the maximum yield increase (66.88%) of healthy fruit over control. This was followed by 49.94% in (AV+SP) 42.03% in AV+MC+SP, 32.59% in AV+CS, 24.40% in AV+MC+ Soluk, and, 23.79% in AV+MC+NS IPM packages. Similarly the maximum reduction of 88.04% infested fruit yield was observed in IPM package, AV+MC+CS. The adjusted net return was the highest (Tk 2,33920.0) in IPM package consisting of AV+ MC+ Spray of Marshal 20EC @ 1mi/L of water and was followed by Tk. 158820.0 in AV+MC+SP Tk 127040.0 in AV+CS Tk 93560in AV+MC+ Soluk Tk 91020.0 in AV+MC+NS treatment. Similarly it is revealed that the BCR was the highest (72.35) in case of AV+NS due to low cost of seed price of neem. It is evident from the analysis that the use of pesticide gave higher return than the non chemical packages (AV+MC+Soluk, AV+MC+SP, AV+MC+NS). The total number of lady bird beetle and spider was highest (24.32%) in the plot of IPM package consisting of AV+soluk followed by untreated control (18.39%)having only antixenotic variety and in plots of AV+MC+Soluk (22.32). It was lowest (12.46%) in AV+MC+CS and 12.61% in IPM package with AV+SP. In case of spider, the total number of spider is lower than the untreated control except IPM package containing brinjal planted with umbellifer. Highest percent parasitazation was recorded in the untreated control (9.67%) plots followed by IPM package having AV+MC (8.57%), package with AV+SP (8.33%), AV+ MC +sex pheromone (9.33%) . But lowest percent parasitization was recorded from IPM package plots of AV+ MC+ Chemical spray (6.25%).

KEY WORDS: Management of BSFB, brinjal, India

Brinjal shoot and fruit borer *Lucinodes orbonalis* Guen. is the major insect pest of brinjal in Bangladesh and also in many other countries. The caterpillar bore into the shoot which ultimately withers as a result of reduced sap movement in the affected plant parts. During the fruiting stage the larvae infest both the shoot and fruit but prefer fruits to shoot. Secondary infection caused by certain bacteria further deteriorates by rotting the fruits. In Bangladesh the percentage of BSFB infestation to fruit and shoot may be 20-63% and 12-16% (Alam, 1969).

Currently insecticides are the only means to control the pest with varying degree of success. The vegetable growers of Jessore region spray insecticide almost everyday or every alternate day in the brinjal field with as many as 84 time in a season (Anon., 1994). This is also a common practices in other Asian countries where at least 50% of the farmer spray 2-3 time per week against dimond back moth . In many parts of Asia farmer feel that without massive use of pesticides or pesticide mixture vegetable cultivation is impossible (Guan Soon, 1990).

The indiscriminate and over use of pesticides has created many problem like excessive residue on market vegetables that concern general consumer health and the environment, pesticide resistance, trade implication, poisoning, hazard to non target organism especially parasitoid and predators, rise in production cost etc. (GuanSoon, 1990; Tabashnik et al., 1987; Phillip et al., 1990). The growing awareness of shortcoming of chemical insecticide has necessitated the exploration of alternate method of pest control which is relatively free from adverse side effects.

To overcome these problems the Ecologist, Entomologist and Zoologist gave great importance on IPM programme. Scientist are relentlessly working for finding a suitable and safe means against this pest among which use of resistant variety, use of natural enemies, grafting with wild solanum, mechanical control including removal of infested shoot and fruit, using net barrier, cultivation of repellant crop, use of neem product, trapping male with female sex pheromone are important. But the dependency on insecticide can not be ignored for the management of BSFB. Integration of different method with susceptible varieties has been practiced but with tolerant or resistant variety had not been tested. For minimizing dependency on insecticide use the brinjal variety with favourable antixenotic properties may be explored and use it as a possible option for managing BSFB.With this end in view the present styudy was undertaken with the following objectives:

1. to determine the effective IPM package for the management of BSFB,
2. to measure the species diversity and equitability of brinjal under different IPM packages,
3. to study the economics of various treatment in combination with other components and
4. to investigate the impact of different treatment on the field biology of the brinjal shoot and fruit borer along with their natural enemies.

## MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the department of Entomology Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, during the period from September 2005 to April 2006. The materials and method used in the study are described below:

**Experimental site and duration**

The location of the experimental site was 24.09°N latitude and 90.26° E longitude with an elevation of 8.5 m from the sae level. Previously the land was under shal forest and was developed later for research purpose. The site was situated in the sub tropical climate zone, characterize by heavy rainfall during the month of May to September and scanty rainfall during the rest of the year. The soil of the experimental field was clay loam in texture and acidic in nature with a pH of around 5.8 with poor fertility status. It belongs to the shallow red brown terrace soil of Salna series under Madhupur tract (Brammer, 1971).The

experiment was conducted during the winter (2005) season under prevailing weather condition.

**Design of experiment**

The experiment was laid out in Randomized Complete Block Design with three replication in the field.

**Land preparation**

The land was first opened by a tractor with disc harrow 20 days before transplanting then the land was prepared thoroughly by ploughing and cross ploughing followed by laddering to have a good tilth. All weeds debris of previous crops were removed and the land was finally prepared with the addition of basal dose of cow dung (15 t/ha). Raised plots of 3m X 3m were prepared accomoding 15 number of seedling per plot.

**Manuring and fertilization**

The following doses of manure and fertilizer was applied as per recommendation Rashid (1993): Cowdung @15t/ha, Urea 250 kg/ha, TSP 50 kg/ha and MP 125 kg/ha.

The full amount of cowdung and TSP, half of MP were applied basally in the plot on week before transplanting and mixed with soil. The remaining half of MP and urea were applied in three equal installments as top dressing at 20 DAT, 2$^{nd}$ at flowering initiation and 3$^{rd}$ at fruit initiation stages.

**Collection of seed, raising seedling and transplanting**

Seeds of BARI-brinjal-6 were collected from the Horticulture Research centre BARI, Gazipur. A seed bed measuring 3mX1m was prepared and seeds were shown on 28$^{th}$ Septrmber 2005. The seed bed were regularly monitored for proper growth and development of the seedlings. Thirty three days old healthy seedlings were transplanted on 31$^{st}$ October in the main field. A total of 450 seedling was transplanted in 30 plots at the rate of 15 seedling per plot.

**Cultural operation**

Pit with transplanted seedling were immediately irrigated lightly. Refilling was done with healthy seedlings in place of any damaged seedlings. Supplementary irrigation was applied at an interval of 2-3 days. Weeding in the plot was done 4 times. The MP and urea fertilizer were top dressed at 3 splits as described earlier.

**Details of treatment**

The brinjal variety was selected based on the earlier findings. BARI brinjal -6 was selected as a variety with favourable antixenotic properties.The following IPM packages including the control was considerd and evaluated to select the best one for economic management of BSFB:

Treatment $T_1$ = Variety with favourable antixenotic properties (A.V.) as control
Treatment $T_2$ = $T_1$ + Mechanical control comprising clean cultivation, weekly removal of infested shoots and fruits
Treatment $T_3$ = $T_1$ +Repellant crop (Soluk)
Treatment $T_4$ = $T_1$ + Sex pheromone setting in BARI water trap @ 100/h
Treatment $T_5$= $T_1$ +Spray neem seed karnel extract @ 10 gm powder/litre of water at 15 days interval
Treatment $T_6$= $T_1$ +Application of Marshal 20 EC @1 ml/L of water at 15 days interval
Treatment $T_7$= $T_2$ + Repellant crop (Soluk)
Treatment $T_8$= $T_2$ + Sex pheromone setting in BARI water trap @ 100/h
Treatment $T_9$= $T_2$ + Spray neem seed karnel extract @ 10 gm powder/litre of water at 15 days interval
Treatment $T_{10}$= $T_2$ + Application of Marshal 20 EC @1 ml/L of water at 15 days Interval

**Mechanical control**

Infested shoots were cut with sharp knife after collecting data each week starting from first notice of shoot infestation.Then all the infested shoot and fruit were buried under the soil.

**Sowing of Umbellifer (Soluk seed)**

Soluk was selected as best umbellifer from the result of the previous study. The seeds were collected from Thakurgaon and were sown @ 0.7 t /ha at the center line between two rows of brinjal after the establishment of brinjal seedling.

**Insecticide application**

Marshal 20 EC is a brand product of carbo sulphun group was selected on the basis of findings of previous worker and applied 5 timea at 15 days interval starting after first appearance of shoot infestation.

**Neem seed karnel extract application**

Mature seeds of neem were collected from Porabari bazar, Gazipur and then dried in sunshine. After drying the seeds were crushed in the laboratory and the crushed neem seed were soaked overnight @ 10 gm/l of water. It was then filtered with nylon net and the solution was sprayed with a spray machine. This treatment was selected from the results of the works of the previous workers.

**Female sex pheromone trap setting**

When the shoot infestation was first observed in the field then thesex pheromone collected from BARI Entomology division and was hanged inside BARI water trap was placed in the field @100 trap /ha with the help of two bamboo stick. The bottom of the BARI trap (plastic pot) was filled with detergent mixed water for trapping the insect. The water was changed at 3 days interval. The trap was fixed at plant canopy level and raised with the growth of brinjal plant.

**Data recording**

The efficiency of each treatment in suppressing infestation caused by brinjal shoot and fruit borer and was determined by recording the following parameters:

**Percent shoot infestation**

The total number of shoots and the number of infested shoot were recorded from 5 plants from each plot at 7 days intervals during the period from 11$^{th}$ January 2006 to 15$^{th}$ February 2006. Shoot infestation was expressed in percent using the following formula:

$$\% \text{ shoot infestation} = \frac{\text{Number of infested shoot}}{\text{Number of total shoots}} \times 100$$

**Percent Fruit infestation and yield**

At each harvest data on the number of healthy and infested fruits and their weight per plot per treatment were recorded seperately from 15 plants. Eight harvests were done throughout the fruiting season i. e. during 6$^{th}$ February to 10$^{th}$ April 2006. Fruit were harvested at 7 days interval. Fruit infestation was calculated using the following formula.

$$\% \text{ fruit infestation (by number)} = \frac{\text{Number of infested fruit}}{\text{Number of total fruit}} \times 100$$

$$\% \text{ fruit infestation (by weight)} = \frac{\text{Weight of infested fruit}}{\text{Weight of total fruit}} \times 100$$

The cumulative plot yield of healthy and infested fruit of 8 harvests were added and determined the transferred into healthy yield and total yield per ha in tons.

**Incidence of natural enemies in the field**

**a) Predator**

The total number of lady bird beetle and spider from 5 plants of each plots were recorded by visual observation during the cropping period at 7 days interval.

**b) Natural parasitization of BSFB:**

After recording the fruit infestation data at each harvest all the infested fruits from all the treated plots were collected and brought to the laboratory and spread over a wooden tray having a layer of 5cm sand. Pupae were collected everyday and put in a cage for subsequent adult/parasitoid emerge. The number of adults/ parasitoid emerged were recorded. The percent parasitization was calculated by using the formula:

$$\text{Parasitization (\%)} = \frac{\text{Number of parasitoid adults}}{\text{Number of BSFB and Parasitoid adults}} \times 100$$

**Data analysis:**

All the data collected & processed as stated above and analyzed statistically after necessary appropriate transformation. The analysis of variance (ANOVA) of different parameters was done and the means were separated by using the Duncan's Multiple Range Test (DMRT).

Linear regression analysis was also performed to explore the relationships between the number of taxonomic categories of different arthropod species and diversity index and equitability.

## RESULTS AND DISCUSSION

The results on the comparative effectiveness of different IPM packages for the management of BSFB infestation along with their benefit cost ratio analysis have been presented. Diversity of arthropod community in different IPM package were measured and presented in this section. The impact of different IPM packages on the natural enemies of BSFB has also been reported.

**Effect of different IPM packages on brinjal shoot infestation**

The comparative effectiveness of different IPM packages on percent shoot infestation by BSFB has been evaluated in term of their efficiency in reducing the shoot infestation over control are presented in Table 1.1.

The result showed that significantly the highest percent of shoot infestation was obtained in the untreated control treatment (3.27) and the treatment, Antixenitic Variety (AV)+ Mechanical control (MC), Antixenitic Variety (AV) + Repellant crop (Soluk), Antixenitic Variety (AV) + Spray neem seed karnel extract @ 10 gm powder/litre of water at 15 days interval, Antixenitic Variety (AV) + Application of Marshal 20 EC @1 ml/L of water at 15 days Interval (CS), Antixenitic Variety (AV)+ Mechanical control (MC) + Repellant crop (Soluk) and Antixenitic Variety (AV)+ Mechanical control (MC) + Spray neem seed karnel extract @ 10 gm powder/litre of water at 15 days interval had no significance difference with that of control. Significantly the lowest percent (0.50%) shoot infestation was observed in the IPM package , plot consisting of AV+MC+CS. The second lowest percent shoot infestation (0.69%) was observed in the IPM package plot having AV+MC+Sex Pheromone (SP) which was statistically similar to that of

IPM package utilizing AV+SP (0.72%) (Table 6.1). Accordingly the percent shoot infestation reduction over control was the highest (84.71%) in the IPM package of AV+MC+CS and lowest reduction over control was obtained (24.42%) from IPM package using AV+Soluk (Umbellifer).In the present study most of the tested IPM packages reduced percent shoot infestation over control (Table 1.1).

The performance of trappingmale moth with female sex pheromone observed in this experiment was in conformity with the finding of Alam et al. (2003). They also found that the pheromone bated trap significantly reduced BSFB damage to brinjal shoot and fruit.

**Effect of different IPM packages on fruit infestation**

The comparative effectiveness of various IPM packages on fruit infestation calculated in term of percent fruit infestation by number and weight as well as in percent reduction in infestation over control are presented in Table 1.2.

The results revealed that the lowest fruit infestation of 20.18% by number and 10.21% by weight was observed in the plots of IPM package consisting of AV+MC+CS followed by 25.45% and 27.36% fruit infestation by number and 15.70% and 17.67% by weight in the plots of IPM package using AV+MC+SPand in the plots of AV+CS (number 27.36 ; weight 17.67). Performance of IPM package of AV+MC+Soluk, AV+MC+SP, AV+MC+NS and AV+MC+CS were significantly different from that of untreated plot using only the Antixenotic variety of brinjal (51.71%, 42.43%).

In terms of reduction in fruit infestation over control the IPM package consisting of AV+MC+CS provided the highest reduction in fruit infestation by number (60.97%) and weight (75.94%). This was followed by A.V.+M.C.+S.P (50.78%), A.V.+CS (47.08%), A.V.+M.C.+N.S. (42.74%) A.V.+M.C.+Soluk (33.18%) by number and A.V.+M.C.+S.P (63%), A.V.+CS (58.35%), A.V.+M.C.+ N.S. (53.57%) A.V.+M.C.+Soluk (41.75%) in respect of reduction in fruit infestation by weight.

The efficiency of Marshal 20 EC, sex pheromone, neem seed karnel extract and repellent crop with mechanical control used against the BSFB as observed in the present study is in partial agreement with those reported by other workers. Sandeep et al. (2004) conducted an experiment in India to reduce the insecticidal use against BSFB with less susceptible variety of brinjal. Five alternate spray of recommended insecticide were given at fortnightly intervals on pest appearance. Clean cultivation and shoot clipping of infested shoots having larvae was done at weekly interval and infested fruits were collect and destroyed at each picking. Significantly lowest number of fruit infestation were recorded from the treated plot than that of untreated control.

Rath et al. (2005) reported that IPM component viz. application of neem oil cake @247kg/ha at transplanting, installation of sex pheromone trap @ 61.75kg/ha at 45 days crop age, clipping of infested shoot at weekly interval and spraying of neem oil (Multineem ) at 10-12 days interval significantly reduced the shoot and fruit infestation on brinjal when compared with non IPM plots. Rabindra & Proshad (2001) observed significant suppression of the incidence of BSFB when brinjal was grown in association with either marigold or okra. The effect of crop association on the incidence of the shoot and fruit borer revealed that marigold was found to be comparable in terms of reduction in pest incidence.

**Effect of different IPM packages on the yield of brinjal**

The effect of different IPM package on yield of brinjal has been evaluated in terms of total fruit yield , healthy fruit yield and infested fruit yield obtained during the entire harvesting period of the crop are presented in Table 1.3.Healthy fruit yield was lowest (24.67 t/ha) in the control plots where only antixenotic

variety was used and it was significantly different from all other packages except IPM package provided with AV+Umbellifer crop (25.04 t/ha). The infested fruit yield was significantly minimum in IPM package consisting of AV+MC+CS (2.97t/ha) and IPM package using AV+CS (2.88t/ha). This was followed by AV+MC+SP (6.69t/ha), AV+MC (7.29t/ha), AV+SP (7.93 t/ha) and AV+MC+NS (9.45 t/ha).

Further analysis of yield was done to asses the impact of each package on yield increase or decrease over control and presented in Table (1.4). The result suggested that IPM package of AV+MC+CS ensured the maximum yield increase (66.88%) of healthy fruit over control. This was followed by 49.94% in (AV+SP) 42.03% in AV+MC+SP, 32.59% in AV+CS, 24.40% in AV+MC+Soluk,and, 23.79% in AV+MC+NS IPM packages. Similarly the maximum reduction of 88.04% infested fruit yield was observed in IPM package, AV+MC+CS.

Direct comparison of the present finding could not be done with those of other workers due to lack of references. However, several worker have reported similar impact of insecticide (carbofuran), sex pheromone, neem seed karnel, repellant crop with mechanical control against BSFB. Rath et al. (2005) reported that the ecofriendly approaches for the management of BSFB increased the yield of healthy marketable fruit of brinjal.

**Benefit/cost analysis:**

The benefit/cost ratio (BCR) was worked out based on the expenses incurred and value of crop obtained against the IPM packages used in the present study for the control of brinjal shoot and fruit borer and presented in Table 1.5. It is to be noted here that the expense incurred referred to those only on pest control. It is revealed from the Table 6.5 that the adjusted net return was the highest (Tk 2,33920.0) in IPM package consisting of AV+ MC+ Spray of Marshal 20EC @ 1mi/L of water and was followed by Tk. 158820.0 in AV+MC+SP Tk 127040.0 in AV+CS Tk 93560in AV+MC+Soluk Tk 91020.0 in AV+MC+NS treatment. Similarly it is revealed that the BCR was the highest (72.35) in case of AV+NS due to low cost of seed price of neem. It is evident from the analysis that the use of pesticide gave higher return than the non chemical packages (AV+MC+Soluk, AV+MC+SP, AV+MC+NS).But since the hazards of pesticides are well known, the higher cost of management with non chemical method may be justified and compensated by low risk to health and environment. A compromise between the higher economic gain and reduced risk to health and environment may be contempted for the sake of the safety of human and environment. Thus based on BCR the IPM packages AV+MC+Soluk, AV+MC+SP, AV+MC+NS could be preferred because these give the more or less similar BCR. The BCR thus obtained in AV+MC+SP, AV+MC+NS in the present study is more or less in conformity with the finding of an experiment conducted in India by Rath *et al.* (2005). They observed highest cost benefit ratio in IPM plot containing sex pheromone, neem oil and mechanical control.

**Effect of different IPM package on the incidence of natural enemies of BSFB**

**Predator**

The effect of different IPM packages on natural enemies has been evaluated in term of population of two most common predators, the lady bird beetle and spider, during the cropping season and are presented in Table 1.6. The total number of lady bird beetle and spider was highest (24.32%) in the plot of IPM packageconsisting of AV+soluk followed by untreated control (18.39%)having only antixenotic variety and in plots of AV+MC+Soluk (22.32). It was lowest(12.46%) in AV+MC+CS and 12.61% in IPM package with AV+SP. However

the number of lady beetle in AV+MC+NS, AV+MC+SP, AV+CS and AV+NS was statistically similar to that untreated control meaning minimum effect (19.31%). In case of spider, the total number of spider is lower than the untreated control except IPM package containing brinjal planted with umbellifer. It is evident from the Table 6.6 that a number of spider and lady bird beetles were found in brinjal with umbellifer plots in comparison to that of sole crop. This is might be due to the fact that diversity of plant species provided important resources such as alternate prey, nectar and pollen or breeding sitefor natural eemies. It was also pointed by Russel (1989). Because of poor availability of research finding it is difficult to explain the present results. However, Islam et al. (1999) reported that natural enemies of brinjal shoot and fruit borer were less affected in the IPM intervention plots than in the scheduled spray plots.

**Parasitization**

Effect of different IPM packages on the larval parasitization of BSFB by *Trathala flavoorbitalis* was also observed and presented. The number of BSFB adults and their ichneumonid parasitoid wasps emerged in the laboratory from the larvae collected from all the IPM package plots and are presented in Table 1.7. The total number of BSFB pupae obtained from the infested fruits ranged from 26-240 and total number of BSFB emerged ranged 15-196 from all the IPM package plots including untreated control. The number of parasitoid adults emerged were 1.21. Highest percent parasitazation was recorded in the untreated control (9.67%) plots followed by IPM package having AV+MC (8.57%), package with AV+SP (8.33%), AV+ MC +sex pheromone (9.33%) . But lowest percent parasitization was recorded from IPM package plots of AV+ MC+ Chemical spray (6.25%). Results of Table 6.7 indicated that the insecticide application had adverse effect on the parasitoid population. The highest percent parasitization reduction over control plot were recorded in the chemical spray field (35.37%). Mallik et al. (1989) reported 3.57 and 9.06% parasitization of BSFB larvae by *T.flavoorbitalis* with an increased pupal period. Sandanyake & Edirisiyhe (1992) reported that *T. flavoorbitalis* was found as larval parasitoid of BSFB causing an average parasitism of 36.2% in India and Srilanka. The result of this study indicated that when insecticide sprayed plot decreased the natural parasitazation substantially. But the plots with IPM package are suitable for the incidence of natural enemies of BSFB.

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Table 1.1. Comperative effectiveness of different IPM packages in suppressing shoot infestation of Brinjal caused by brinjal shoot and fruit borer during winter 2005.

| IPM packages | Shoot infestation % | Shoot infestation reduction over control % |
|---|---|---|
| Antixenotic variety(A.V.) (Control) | 3.27a (1.94) | |
| A.V. +Mechanical control(M.C.) | 1.76abc (1.49) | 46.17 |
| A.V. +Umbellifer (Soluk) | 2.47ab (1.69) | 24.46 |
| A.V. +Sex pheromone(S. P.) | 0.72bc (1.09) | 77.98 |
| A.V. +Neem seed spray(N. S.) | 2.23abc (1.62) | 31.80 |
| A.V. +Chemical spray(C. S.) | 1.58abc (1.43) | 51.68 |
| A.V. +M.C.+ Soluk | 2.14abc (1.60) | 34.56 |
| A.V. +M.C.+ S. P | 0.69bc (1.08) | 78.90 |
| A.V. +M.C.+ N. S. | 1.89abc (1.53) | 42.20 |
| A.V. +M.C.+C.S. | 0.50c (0.99) | 84.71 |

Figures in the same column carrying the same letter(s) are not significantly different at 5% level by DMRT. Values are means of three replications. Values within parentheses are the transformed values based on Square root transformation {√(x +0.5)}.

Table 1.2. Effect of different IPM packages for suppressing fruit infestation by brinjal shoot and fruit borer during winter 2005.

| IPM packages | Fruit infestation (%) | | Reducing fruit infestation over control% | |
|---|---|---|---|---|
| | by number | by weight | by number | by weight |
| Antixenotic variety(A.V.) (Control) | 51.71a (7.22) | 42.43a (6.53) | | |
| A.V. +Mechanical control(M.C.) | 39.46abc (6.31) | 29.70abc (5.49) | 23.69 | 30.00 |
| A.V. +Umbellifer (Soluk | 44.82ab (6.73) | 35.46ab (5.94) | 13.32 | 16.43 |
| A.V. +Sex pheromone(S. P.) | 36.82abcd (6.09) | 26.85abcd (5.22) | 28.80 | 36.72 |
| A.V. +Neem seed spray(N. S.) | 40.33abc (6.37) | 30.30abc (5.50) | 22.00 | 28.59 |
| A.V. +Chemical spray(C. S.) | 27.36cde (5.26) | 17.67cde (4.25) | 47.08 | 58.35 |
| A.V. +M.C.+ Soluk | 34.55bcd (5.90) | 24.70bcd (5.00) | 33.18 | 41.75 |
| A.V. +M.C.+ S. P | 25.45de (5.06) | 15.70de (3.98) | 50.78 | 63.00 |
| A.V. +M.C.+ N. S. | 29.61cde (5.45) | 19.70cde (4.45) | 42.74 | 53.57 |
| A.V. +M.C.+C.S. | 20.18e (4.54) | 10.21e (3.26) | 60.97 | 75.94 |

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level by DMRT. Values are means of three replications. Values within parentheses are the transformed values based on Square root transformation {√(x +0.5)}

Table 1.3. Effect of different IPM packages on yield of brinjal during winter 2005.

| IPM packages | Yield (t/ha) | | |
|---|---|---|---|
| | Healthy | Infested | Total |
| Antixenotic variety(A.V.) (Control) | 24.67f | 16.47a (4.12) | 41.14d |
| A.V. +Mechanical control(M.C.) | 27.77e | 7.29d (2.79) | 35.06f |
| A.V. +Umbellifer (Soluk) | 25.04f | 14.43ab (3.86) | 39.47e |
| A.V. +Sex pheromone(S. P.) | 31.99c | 7.93cd (2.89) | 39.92e |
| A.V. +Neem seed spray(N. S.) | 30.43d | 12.41b (3.59) | 42.84bc |
| A.V. +Chemical spray(C. S.) | 32.71c | 2.88e (1.83) | 35.59f |
| A.V. +M.C.+ Soluk | 30.69cd | 12.67b (3.63) | 43.36ab |
| A.V. +M.C.+ S. P | 35.04b | 6.69d (2.68) | 41.73c |
| A.V. +M.C.+ N. S. | 30.54d | 9.45c (3.15) | 39.99e |
| A.V. +M.C.+C.S. | 39.69a | 1.97e (1.57) | 41.66e |

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level by DMRT. Values are means of three replications. Values within parentheses are the transformed values based on Square root transformation {√(x +0.5)}.

Table 1.4. Effect of different IPM packages on the increase/decrease in yield of brinjal over control during winter 2005.

| IPM packages | Healthy yield | | Infested yield | | Total yield | |
|---|---|---|---|---|---|---|
| | t/ha | Increase (+) /decrease (-) over control (%) | t/ha | Increase (+) /decrease (-) over control (%) | t/ha | Increase (+) /decrease (-) over control (%) |
| Antixenotic variety(A.V.) (Control) | 24.67f | | 16.47a (4.12) | | 41.14d | |
| A.V. +Mechanical control(M.C.) | 27.77e | +12.57 | 7.29d (2.79) | -55.73 | 35.06f | -14.77 |
| A.V. +Umbellifer (Soluk) | 25.04f | +1.50 | 14.43ab (3.86) | -12.39 | 39.47e | -4.06 |
| A.V. +Sex pheromone(S. P.) | 36.99b | +49.94 | 7.93cd (2.89) | -51.85 | 44.92a | +9.18 |
| A.V. +Neem seed spray(N. S.) | 30.43d | +23.35 | 12.41b (3.59) | -24.65 | 42.84bc | +4.13 |
| A.V. +Chemical spray(C. S.) | 32.71c | +32.59 | 2.88e (1.83) | -82.51 | 35.59f | -13.49 |
| A.V. +M.C.+ Soluk | 30.69cd | +24.40 | 12.67b (3.63) | -23.07 | 43.36ab | +5.40 |
| A.V. +M.C.+ S. P | 35.04b | +42.03 | 6.69d (2.68) | -59.38 | 41.73c | +1.43 |
| A.V. +M.C.+ N. S. | 30.54d | +23.79 | 9.45c (3.15) | -42.62 | 39.99e | -2.80 |
| A.V. +M.C.+C.S. | 39.69a | +60.88 | 1.97e (1.57) | -88.04 | 41.66e | +1.26 |

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level by DMRT. Values are means of three replications. Values within parentheses are the transformed values based on Square root transformation {√(x +0.5)}

Table 1.5. Economic analysis of different IPM packages for the control of brinjal shoot and fruit borer during winter 2005.

| IPM packages | Cost of pest management | Yield t/ha | Gross return (tk/ha) | Net return (tk/ha) | Adjusted net return ( tk) | BCR |
|---|---|---|---|---|---|---|
| Antixenotic variety(A.V.) (Control) | - | 24.67 | 391520.0 | 391520.0 | | |
| A.V. +Mechanical control(M.C.) | 4800.0 | 27.77 | 444320.0 | 439520.0 | 48000.0 | 10.0 |
| A.V. +Umbellifer (Soluk) | 1160.0 | 25.04 | 400640.0 | 399480.0 | 7960.0 | 6.86 |
| A.V. +Sex pheromone(S. P.) | 5500.00 | 31.99 | 511840.0 | 506340.0 | 114820.0 | 20.87 |
| A.V. +Neem seed spray(N. S.) | 1300.0 | 30.43 | 486880.0 | 485580.0 | 94060.0 | 72.35 |
| A.V. +Chemical spray(C. S.) | 4800.0 | 32.71 | 523360.0 | 518560.0 | 127040.0 | 26.46 |
| A.V. +M.C.+ Soluk | 5960.0 | 30.69 | 491040.0 | 485080.0 | 93560.0 | 15.46 |
| A.V. +M.C.+ S. P | 10300.0 | 35.04 | 560640.0 | 550340.0 | 158820.0 | 15.42 |
| A.V. +M.C.+ N. S. | 6100.0 | 30.54 | 488640.0 | 482540.0 | 91020.0 | 14.92 |
| A.V. +M.C.+C.S. | 9600.0 | 39.69 | 635040.0 | 625440.0 | 233920.0 | 24.36 |

Note: Market price of brinjal @Tk 16.00/kg
Labour @ Tk 80/day 12 labour/ha/per operation for mechanical control
2 labour/ha/per operation for chemical and neem extract spray
Marshal 100 EC@ Tk. 80/100ml
Cost of Neem seed @Tk 50/kg
Cost of Soluk seed @ Tk 25/kg
Cost of lure with plastic Boyam @ Tk 55/set

Table 1.6 .Effect of different IPM packages on population density of Lady bird beetle and spider in brinjal during winter 2005.

| IPM packages | Lady bird beetle | | Spider | |
|---|---|---|---|---|
| | No. per 15 plant | % reduction over control | No. per 15 plant | % reduction over control |
| Antixenotic variety(A.V.) (Control) | 19.31abc | | 14.22abc | |
| A.V. +Mechanical control(M.C.) | 15.36bc | 20.46 | 11.49bc | 19.19 |
| A.V. +Umbellifer (Soluk) | 24.32a | +25.89 | 16.34ab | +14.90 |
| A.V. +Sex pheromone(S. P.) | 12.61c | 34.70 | 10.35c | 27.22 |
| A.V. +Neem seed spray(N. S.) | 13.38c | 30.71 | 13.41abc | 5.70 |
| A.V. +Chemical spray(C. S.) | 13.22c | 31.54 | 12.45abc | 12.44 |
| A.V. +M.C.+ Soluk | 22.32ab | +15.58 | 18.39a | +29.32 |
| A.V. +M.C.+ S. P | 12.46c | 35.47 | 12.85abc | 9.63 |
| A.V. +M.C.+ N. S. | 16.31abc | 15.53 | 12.32bc | 13.36 |
| A.V. +M.C.+C.S. | 14.38bc | 25.53 | 13.34abc | 6.19 |

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level by DMRT. Values are means of three replications.

Table 1.7. Effect of different IPM packages on the biology of brinjal shoot and fruit borer and their larval parasitization during winter 2005.

| IPM packages | Total no. of BSFB pupae collected | Total no. of adult emerged | | Parasitization (%) | Parasitization reduction over control (%) |
|---|---|---|---|---|---|
| | | BSFB | Parasitoid | | |
| Antixenotic variety(A.V.) (Control) | 240 | 196 | 21 | 9.67 | |
| A.V. +Mechanical control(M.C. | 122 | 96 | 9 | 8.57 | 11.38 |
| A.V. +Umbellifer (Soluk) | 198 | 163 | 16 | 8.94 | 7.55 |
| A.V. +Sex pheromone(S. P.) | 103 | 88 | 8 | 8.33 | 13.85 |
| A.V. +Neem seed spray(N. S.) | 150 | 122 | 11 | 8.27 | 14.48 |
| A.V. +Chemical spray(C. S.) | 32 | 24 | 2 | 7.69 | 20.48 |
| A.V. +M.C.+ Soluk | 180 | 146 | 16 | 10.95 | +13.23 |
| A.V. +M.C.+ S. P | 88 | 68 | 7 | 9.33 | 3.52 |
| A.V. +M.C.+ N. S. | 110 | 84 | 9 | 9.67 | 0.00 |
| A.V. +M.C.+C.S. | 26 | 15 | 1 | 6.25 | 35.37 |