Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2022, Volume 35, Issue 1, Page 138-144

# Bio-intensive management of pest complex of brinjal, *Solanum melongena* L. in an organic environment.

Sushruta Boruah • Mahesh Pathak • Kennedy Ningthoujam • Pranab Dutta • Raghubir Kumar Patidar • N.S Azad Thakur

School of Crop Protection, CPGS-AS, CAU-Imphal, Umiam, Meghalaya

ARTICLE INFO

*Article history*:
Received: 28 December, 2021
Revision: 16 May, 2022
Accepted: 31 May, 2022

*Key words: Bio-pesticide, Chlorantraniliprole, Seed treatment, Soil treatment, Um-Comb.*

ABSTRACT

Field studies were carried out to evaluate eco-friendly management strategies to manage the pest complex of brinjal in Umiam, Meghalaya (India) from April to July, 2021. The treatment combinations in nursery included seed treatment, soil treatment, seed + soil treatment with Um-Comb while in transplanted main field were seed treatment + foliar spray with Um-Comb, soil treatment + foliar spray with Um-Comb, seed + soil treatment + foliar spray with Um-Comb at 21 days interval from the date of transplanting and chemical treatment (Chlorantraniliprole and Dimethoate) when the pest population reached ETL. Um-Comb (bio-pesticide) was prepared by combination of six compatible bio agents (*Trichoderma harzianum, Beauveria bassiana Metarhizium anisopliae, Verticillium leccani* and *Pseudomonas fluorescens*). The results showed that Chlorantraniliprole 18.50 SC was the most effective against brinjal shoot and fruit borer and hadda beetle while Dimethoate 30 EC against the sucking pests (aphids and jassids). The seed and soil treatment and foliar spray with Um-Comb resulted in increase in height of the plant, number of branches and yield. Among the different Um-Comb combinations, seed + soil treatment + foliar sprays were found to be the most effective treatment in managing the major pests. The highest marketable yield was achieved from the chemically treated plots; however the Benefit Cost Ratio (BCR) was highest (2.74:1) in seed + soil treatment + foliar spray with Um-Comb.

## 1. Introduction

India, a country with rich biodiversity and varied agro-climatic regions, favours cultivation of a diverse range of vegetables throughout the year. Apart from the nutritional benefits, vegetables being short duration and a good source of employment generation, constitute an important component of agriculture. Among the various vegetables crops, Brinjal (*Solanum melongena* L.), also referred to as eggplant belongs to the family Solanaceae with 2n=24 chromosome numbers. The fruit is a noble source of vitamins and minerals and has less calories and fat content. West Bengal ranks first in brinjal production in the country with a share of 23.69 % followed by Orissa, Gujarat, Bihar, Madhya Pradesh, Chhattisgarh and Karnataka (Anonymous, 2019). In the North-Eastern states, the productivity of the crop is comparatively lower than the rest of the country. In Meghalaya, it is cultivated in an area of 1.08 thousand ha with production of 15.21 thousand M T and productivity of 14.10 M T $ha^{-1}$ (Anonymous, 2018).

Despite the popularity of the vegetable amongst the poor farmers, growing of the crop mostly requires more inputs, especially insecticides as the crop is ravaged by a large number of insect pests thereby limiting the production and productivity of the crop in spite of its high demand in the market. Brinjal crop is damaged by many species of insect pests from nursery to maturity stage. The important insect pests include- brinjal fruit and shoot borer (*Leucinodes orbonalis* Guen), cotton aphids (*Aphis gossypii* Glover), cotton jassids (*Amrasca bigutulla bigutulla* Ishida), stem borer (*Euzophera perticella* Ragonot), epilachna beetle (*Henosepilachna viginitoctopunctata* Fab.), white fly (*Bemisia tabaci* Genn.), lacewing bug (*Urantitus hystricellus* Dist.) and non-insect pest- red spider mite (*Tetranychus macfurlanei*). In South and South-East Asia, the brinjal fruit and shoot borer (BFSB) is the most damaging one and it

*Corresponding author: sushrutaboruah96@gmail.com

reduces the yield ranging from 37-63% in different parts of India (Dhankar, 1988). Hadda Beetle also cause significant loss to brinjal (Bhagat and Munshi, 2004). Moreover, various sucking pests like aphids, jassids and whitefly persistently cause remarkable losses both in terms of yield and quality of fruits on a consistent basis (Karim *et al.*, 2001).

In large scale commercial cultivation of brinjal, farmers use hefty applications of chemicals to subdue the pest population which besides killing the target pests causes unredeemable harm to both human and environment as well as to the non-target organisms like natural enemies, pollinators etc. Owing to the unreasonable and persistent use of chemical pesticides, the issue is further exacerbated due to ecosystem pollution, disruption of ecological balance, pest resurgence, secondary pest breakout, and bio-magnification of residue in brinjal ecosystem. In view of the above facts, manifested by the unfettered and unchecked application of chemicals in brinjal ecosystem and the associated hazards, the present study was undertaken with emphasis on a safer and sustainable mode of management, that is, the use of Bio-pesticides.

## 2. Materials and Methods

The experiment was carried out in randomized block design (RBD) with 4 treatments in nursery and 5 treatments in transplanted field maintaining 4 replications in each case. The var. Pusa Purple Long (PPL) was sown on 20/03/2021 and transplanted after one month of sowing in an area of 100 m$^2$ with spacing of 60 cm (R-R) × 50 cm (P-P). The treatment combinations for nursery (conducted in pot culture) were- $T_1$- Control, $T_2$- Seed Treatment with Um-Comb @ 10 ml kg$^{-1}$ of seed, $T_3$- soil drenching with Um-Comb @ 10 ml l$^{-1}$ of water, $T_4$- Seed treatment @ 10 ml kg$^{-1}$ of seed+ soil drenching with Um-Comb @ 10 ml l$^{-1}$ of water before sowing. The treatments for transplanted crop were- $T_1$- Control, $T_2$- Seed treatment with Um-Comb @ 10 ml kg$^{-1}$ of seed + Foliar Spray (FS) @ 10 ml l$^{-1}$ thrice at 21 days intervals, $T_3$- Treatment of nursery by soil drenching with Um-Comb @ 10 ml l$^{-1}$ of water + FS @ 10 ml l$^{-1}$ thrice at 21 days intervals, $T_4$- Seed treatment @ 10 ml kg$^{-1}$ of seed+ treatment of nursery bed by soil drenching with Um-Comb @ 10 ml l$^{-1}$ of water before sowing + FS @ 10 ml l$^{-1}$ thrice at 21 days intervals and $T_5$- Foliar spray with Chlorantraniprole 18.5% SC @ 40 g a.i. ha$^{-1}$ and Dimethoate 30% EC @ 500 ml ha$^{-1}$ at ETL. The bio-pesticide, Um-Comb was prepared by School of Crop Protection, CPGS-AS, Umiam (Meghalaya) by combination of six compatible bio-control agents (*Trichoderma harzianum, Beauveria bassiana Metarhizium anisopliae, Verticillium leccani* and *Pseudomonas fluorescens*) accompanied by standardized additives (adjuvants, stickers, surfactants, UV protectant). The crop was sprayed thrice with bio-pesticides at 21 days intervals from the date of transplanting (*i.e.* on 11/05/2021, 1/06/2021 and 22/06/2021) by using high volume knapsack sprayer @400 litres of spray solution per hectare. The observations for major insect pests were taken one day before (pre-treatment) and 3,7 and 14 days after first, second and third applications of bio-pesticides and insecticides on five randomly selected plants from each plot (*i.e.* replication). The shoot and fruit borer infestation was recorded by counting the drooped shoots and also the infested fruits. For recording hadda beetle and sucking pests, the reduction in population in each treatment was taken as a criterion to assess the bio-efficiency of different treatments. The data thus collected were subjected to statistical analysis using analysis of variance (ANOVA) to know the significance of differences in the population of various insect pests and Duncan Multiple Range Test (DMRT) (Duncan, 1951) was applied to compare different treatments for their efficacies. Plant growth parameters like plant height, no. of branches, fruit yield and benefit cost ratio of the different treatments of Um-Comb and synthetic pesticides were also worked out to find the effectiveness of the respective treatments.

## 3. Results

### 3.1 Effect of Um-Comb and synthetic pesticide on major insect pests of brinjal

**Aphids (*Aphis gossypii*)**

The results of various treatments on the population of aphids (*Aphis gossypii*) at 3, 7 and 14 days after spraying (DAS) shown in Table 1 revealed that the pre-treatment aphid population was non-significant. However, at 3 DAS the results were significant and the least aphid population was found in T5 treatment followed by T4, T3 and T2. At 7 and 14 DAS, all the treatments were effective in controlling the aphids and were significantly superior over control. Highest reduction in aphid population was noted in T5 followed by T4.

**Jassids (*Amrasca bigutulla bigutulla*)**

The efficiency of different treatments on the population of jassids is presented in Table 2. Though the population at 1 day before spraying was non-significant, the results were significant at 3,7 and 14 DAS, with T5 causing the lowest jassid population followed by T4.

**Hadda beetle (*Henosepilachna vigintiopunctata*)**

The effectiveness of Um-comb and synthetic pesticides on Hadda beetle (*Henosepilachna vigintiopunctata*) population at 3, 7, and 14 DAS is depicted in Table 3. Population at one day prior to spraying was non-significant for all plots whereas at 3, 7 and 14 DAS, T5 brought about the lowest populations.

**BSFB (*Leucinodes orbonalis*)**

Table 4 shows the efficiency of various treatments against *L.*

*orbonalis* in shoots, as measured by average per cent shoot damage at 3, 7, and 14 DAS. The population of shoot and fruit borer larvae recorded one day before spraying was not significant; however T5 treatment caused the maximum per cent reduction of shoot infestation at 3, 7 and 14 DAS, respectively after spraying.

Table 5 shows the data on effectiveness of Um-Comb and pesticide against fruit infestation by BSFB. The observations after each harvest exhibited that the least per cent infestation of BSFB in fruits was noted in T5 treatment followed by T4, T3 and T2 treatments. All the treatment combinations were found notably superior when compared to control.

**3.2 Effect of Um-Comb and synthetic pesticides on growth and yield parameters of brinjal**

**Plant Height**

The maximum plant height (60.27cm) was observed in T4 which was at par with T3 (59.88cm). The lowest plant height (51.52cm) was recorded in T1 treatment (Table 6).

**Primary branches at maturity stage**

The highest number of primary branches (7.10) at maturity stage was observed in T4 which was followed by T5 (6.90). The lowest number of primary branches (6.15) was found in T1 (Table 6).

**Marketable Yield**

The highest marketable yield was recorded in T5 (10.47t $ha^{-1}$) which was followed by T4 treatment (9.80t $ha^{-1}$) and the lowest yield (5.75t $ha^{-1}$) was observed in control plot (T1) (Table 6).

**Total Yield**

The total yield was recorded in T5 (11.30t $ha^{-1}$) followed by T4, T3 and T2 and the lowest yield (7.84t $ha^{-1}$) was obtained in T1 (control) (Table 6).

**Table 1.** Effect of Um-Comb and synthetic pesticide on aphid (*Aphis gossypii*) population

| Treatments | No. of aphids/plant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Spray | | | | 2nd Spray | | | 3rd Spray | | |
| | 1 DBS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS |
| T1 | 2.55 | 2.98$^{a}$ | 3.15$^{a}$ | 4.25$^{a}$ | 5.9$^{a}$ | 7.15$^{a}$ | 7.85$^{a}$ | 10.50$^{a}$ | 11.42$^{a}$ | 11.37$^{a}$ |
| T2 | 2.3 | 1.85$^{b}$ | 1.82$^{b}$ | 1.95$^{b}$ | 3.45$^{b}$ | 4.02$^{b}$ | 3.55$^{b}$ | 5.35$^{b}$ | 5.35$^{b}$ | 4.82$^{b}$ |
| T3 | 2.37 | 1.95$^{b}$ | 1.72$^{b}$ | 2.05$^{b}$ | 3.32$^{b}$ | 1.65$^{c}$ | 3.70$^{bc}$ | 5.40$^{b}$ | 5.00$^{bc}$ | 4.57$^{b}$ |
| T4 | 2.17 | 1.68$^{b}$ | 1.55$^{bc}$ | 1.85$^{b}$ | 3.22$^{b}$ | 3.55$^{d}$ | 3.16$^{c}$ | 4.82$^{b}$ | 4.65$^{c}$ | 4.05$^{c}$ |
| T5 | 2.45 | 1.13$^{c}$ | 1.22$^{c}$ | 1.67$^{b}$ | 1.55$^{c}$ | 2.22$^{e}$ | 2.65$^{d}$ | 2.22$^{c}$ | 2.87$^{d}$ | 3.50$^{d}$ |
| SE.(m) | - | 0.12 | 0.13 | 0.14 | 0.16 | 0.11 | 0.16 | 0.20 | 0.12 | 0.13 |
| CD (p=0.05) | NS | 0.37 | 0.40 | 0.42 | 0.48 | 0.32 | 0.50 | 0.62 | 0.36 | 0.41 |

*Data represented by alphabet were calculated by DMRT Data followed by same alphabets are statistically at par, DBS- Day before spraying DAS- Days after spraying

**Table 2.** Effect of Um-Comb and synthetic pesticide on jassid (*Amrasca bigutulla bigutulla*) population

| Treatments | No. of jassids/plant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Spray | | | | 2nd Spray | | | 3rd Spray | | |
| | 1 DBS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS |
| T1 | 3.05 | 3.25$^{a}$ | 4.00$^{a}$ | 3.62$^{a}$ | 5.15$^{a}$ | 6.10$^{a}$ | 5.17$^{a}$ | 4.35$^{a}$ | 5.15$^{a}$ | 4.95$^{a}$ |
| T2 | 2.60 | 2.09$^{b}$ | 2.37$^{b}$ | 1.97$^{b}$ | 3.07$^{b}$ | 3.45$^{b}$ | 2.72$^{b}$ | 2.50$^{b}$ | 2.56$^{bc}$ | 2.32$^{bc}$ |
| T3 | 2.50 | 2.07$^{b}$ | 2.20$^{bc}$ | 1.85$^{bc}$ | 3.10$^{b}$ | 3.30$^{bc}$ | 2.56$^{b}$ | 2.45$^{b}$ | 2.69$^{b}$ | 2.40$^{b}$ |
| T4 | 2.22 | 1.92$^{b}$ | 2.00$^{c}$ | 1.70$^{cd}$ | 2.91$^{b}$ | 3.05$^{c}$ | 2.35$^{bc}$ | 2.32$^{b}$ | 2.31$^{c}$ | 2.05$^{cd}$ |
| T5 | 2.97 | 1.15$^{c}$ | 1.50$^{d}$ | 1.45$^{d}$ | 1.65$^{c}$ | 2.07$^{d}$ | 2.02$^{c}$ | 1.17$^{c}$ | 1.62$^{d}$ | 1.75$^{d}$ |
| SE.(m) | - | 0.15 | 0.12 | 0.09 | 0.12 | 0.11 | 0.13 | 0.12 | 0.10 | 0.10 |

| CD (p=0.05) | NS | 0.46 | 0.36 | 0.27 | 0.38 | 0.35 | 0.39 | 0.35 | 0.31 | 0.29 |
|---|---|---|---|---|---|---|---|---|---|---|

*Data represented by alphabet were calculated by DMRT Data followed by same alphabets are statistically at par, DBS- Day before spraying DAS- Days after spraying

**Table 3.** Effect of Um-Comb and synthetic pesticide on hadda beetle (*Henosepilachna vigintiopunctata*) population

| Treatments | No. of hadda beetle/plant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Spray | | | | 2nd Spray | | | 3rd Spray | | |
| | 1 DBS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS |
| T1 | 0.90 | 0.92a | 1.00a | 1.30a | 1.50a | 2.07a | 1.92a | 2.62a | 2.57a | 2.05a |
| T2 | 0.82 | 0.60b | 0.60b | 0.67b | 0.87b | 1.05b | 0.90b | 1.45b | 1.27b | 0.93b |
| T3 | 0.80 | 0.62b | 0.58b | 0.65b | 0.92b | 1.02b | 0.86b | 1.37b | 1.25b | 0.90b |
| T4 | 0.75 | 0.56b | 0.55b | 0.60b | 0.80b | 0.92cd | 0.82b | 1.32b | 1.15b | 0.80bc |
| T5 | 0.95 | 0.32c | 0.38c | 0.55b | 0.45c | 0.72d | 0.75c | 0.62c | 0.72c | 0.71c |
| SE.(m) | - | 0.04 | 0.04 | 0.04 | 0.06 | 0.07 | 0.06 | 0.04 | 0.05 | 0.06 |
| CD (p=0.05) | NS | 0.12 | 0.13 | 0.13 | 0.18 | 0.22 | 0.17 | 0.12 | 0.15 | 0.18 |

*Data represented by alphabet were calculated by DMRT. Data followed by same alphabets are statistically at par, DBS- Day before spraying DAS- Days after spraying.

**Table 4.** Effect of Um-Comb and synthetic pesticide on shoot infestation due to BSFB (*Leucinodes orbonalis*)

| Treatments | Percent shoot infestation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Spray | | | | 2nd Spray | | | 3rd Spray | | |
| | 1 DBS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS | 3 DAS | 7 DAS | 14 DAS |
| T1 | 4.6 | 6.17a | 7.82a | 15.07a | 20.39 | 15.89a | 8.06a | 6.34a | 4.01a | 3.12a |
| | (12.38) | (14.38) | (16.24) | (22.84) | (26.84) | (23.49) | (16.49) | (14.58) | (11.55) | (10.17) |
| T2 | 4.26 | 4.5b | 4.43b | 6.22b | 13.57b | 8.18b | 3.5b | 3.9b | 2.12b | 1.38b |
| | (11.91) | (12.26) | (12.15) | (14.44) | (21.61) | (16.61) | (10.78) | (11.38) | (8.37) | (6.74) |
| T3 | 4.19 | 4.26bc | 4.13bc | 6.00bc | 13.80b | 8.07b | 3.2bc | 4.05b | 2.35b | 1.55b |
| | (11.81) | (11.91) | (11.72) | (14.17) | (21.80) | (16.50) | (10.30) | (11.60) | (8.81) | (7.15) |
| T4 | 3.84 | 3.92bc | 3.64c | 5.55bc | 12.16b | 7.62b | 3.02bc | 3.55b | 2.09b | 1.35bc |
| | (11.30) | (11.41) | (10.99) | (13.62) | (20.40) | (16.02) | (10.00) | (10.86) | (8.31) | (6.67) |
| T5 | 4.98 | 2.1c | 2.85c | 4.55c | 5.54c | 5.01c | 2.5c | 2.05c | 1.56c | 1.15c |
| | 12.89 | (8.33) | (9.71) | (12.31) | (13.61) | (12.93) | (9.09) | (8.23) | (7.17) | (6.12) |
| SE.(m) | - | 0.18 | 0.26 | 0.39 | 0.57 | 0.47 | 0.27 | 0.23 | 0.16 | 0.07 |
| CD (p=0.05) | NS | 0.55 | 0.8 | 1.19 | 1.76 | 1.44 | 0.84 | 0.70 | 0.49 | 0.22 |

*Data represented by alphabet were calculated by DMRT Data followed by same alphabets are statistically at par, DBS- Day before spraying DAS- Days after spraying. Data in parenthesis are angular transformed.

**Table 5.** Effect of Um-Comb and synthetic pesticides on fruit infestation due to BSFB

| Treatments | Percent fruit infestation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of Harvests | | | | | | | | % protect-ion over control |
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | Mean | |
| T1 | 20.35d | 28.57c | 33.92c | 38.85d | 25.84d | 20.34d | 18.21d | 26.58 | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (26.81) | (32.31) | (35.62) | (38.55) | (30.55) | (26.80) | (25.26) | | |
| **T2** | 16.40$^{c}$ | 12.98$^{b}$ | 13.95$^{b}$ | 16.26$^{c}$ | 13.31$^{c}$ | 12.06$^{c}$ | 11.06$^{c}$ | 13.71 | 48 |
| | (23.88) | (21.04) | (21.93) | (23.78) | (21.39) | (20.32) | (19.42) | | |
| **T3** | 12.62$^{b}$ | 14.39$^{b}$ | 12.20$^{b}$ | 12.87$^{b}$ | 11.90$^{bc}$ | 12.28$^{bc}$ | 13.78$^{b}$ | 12.86 | 52 |
| | (20.80) | (22.29) | (20.44) | (21.02) | (20.17) | (20.51) | (21.79) | | |
| **T4** | 8.21$^{a}$ | 10.12$^{a}$ | 11.87$^{b}$ | 12.02$^{b}$ | 10.14$^{b}$ | 10.14$^{b}$ | 9.69$^{ab}$ | 10.31 | 61 |
| | (16.65) | (18.54) | (20.15) | (20.28) | (18.56) | (18.56) | (18.13) | | |
| **T5** | 6.16$^{a}$ | 9.43$^{a}$ | 6.68$^{a}$ | 8.61$^{a}$ | 5.84$^{a}$ | 6.59$^{a}$ | 8.15$^{a}$ | 7.35 | 72 |
| | (14.37) | (17.88) | (14.97) | (17.06) | (13.98) | (14.87) | (16.58) | | |
| **SE.(m)** | 0.80 | 0.94 | 0.65 | 1.03 | 0.74 | 0.69 | 0.57 | | |
| **CD (p=0.05)** | 2.46 | 2.89 | 2 | 3.17 | 2.29 | 2.12 | 1.76 | 2.38 | |

*Data represented by alphabet were calculated by DMRT Data followed by same alphabets are statistically at par, DBS- Day before spraying DAS- Days after spraying. Data in parenthesis are angular transformed.

**Table 6.** Effect of Um-Comb and synthetic pesticides on growth and yield parameters of brinjal

| **Treatment** | **Plant height (cm) at maturity stage** | **Primary branches at maturity stage (no.)** | **Marketable Yield (t $ha^{-1}$)** | **Total Yield ($t\ ha^{-1}$)** | **B:C ratio** |
|---|---|---|---|---|---|
| **T1** | 51.52 | 6.15 | 5.75 | 7.84 | 1.68 |
| **T2** | 55.78 | 6.30 | 7.73 | 8.96 | 2.26 |
| **T3** | 59.88 | 6.42 | 8.66 | 9.93 | 2.62 |
| **T4** | 60.27 | 7.10 | 9.80 | 10.93 | 2.74 |
| **T5** | 57.82 | 6.90 | 10.47 | 11.30 | 2.64 |
| **SE.(m)** | 5.75 | 0.62 | 0.58 | 0.63 | - |
| **CD (p=0.05)** | 1.86 | 0.20 | 1.79 | 1.98 | - |

**Benefit Cost Ratio (BCR) ratio**

While computing the cost and benefits of the production of brinjal associated with the experiment, the highest B:C ratio (2.74: 1) was observed in T4 treatment, which was followed by T5 treatment (2.64:1). The B:C ratios of the 5 treatments were in the following order- T4<T5<T3<T2<T1 (Table 6).

## 4. Discussion

In the present investigation, Chlorantraniliprole 18.5 SC was found to be the most effective against brinjal shoot and fruit borer and brinjal hadda beetle whereas Dimethoate 30 EC was most effective in controlling the population of the sucking pests *i.e.* jassids and aphids. When efficacy of bio-pesticides was considered, seed and soil treatment with Um-Comb was the most effective in reducing the population of the pest complex. This might be due to inclusion of both seed and soil inoculation with the bio-pesticide Um-Comb in T4 treatment. Rajeshwari *et al.* (2019) also recorded lower populations of aphid after two sprays of spinosad 45 SC @ 0.2 ml/l followed by Dimethoate 30 EC @ 1.6 ml/l. Nawaz *et al.* (2020) reported that *Trichoderma sp.* caused population reduction of the aphid to a great extent (87%) when applied at 7 DAS at the maximum concentration, which supports the present findings. Similarly, Kharade *et al.* (2018) observed that after Imidaclorprid, Dimethoate was most effective in reducing the population of jassid in brinjal and Devi *et al.* (2015) obtained the most effective control of shoot and fruit infestation by brinjal shoot and fruit borer with Chlorantraniliprole. Tripura *et al.* (2017) also found *Beauveria bassiana* and *Metarhizium anisoplae* to be relatively efficient bio-pesticides against BSFB.

The maximum plant height was observed in T4 *i.e.* seed + soil treatment with Um-Comb which was at par with T3. These results indicated that beneficial microbes in Um-Comb possibly helped in solubilisation of nutrients from soil and also produced Indole Acetic Acid (IAA) which promoted plant growth as Patten and Glick (1996) noticed that majority of bacteria isolated from the rhizosphere of diverse crops (80%) could synthesize and release auxins as secondary metabolites. Windham *et al.* (1986) reported that *T. harzianum* promoted root growth and plant development, which was linked to the fungus's unknown growth-regulating components. Highest yield was recorded in the plots treated with chemical pesticides (T5) *viz.* Dimethoate for sucking pests and Chorantraniprole for hadda beetle and BSFB, followed by the plots treated with seed+ soil treatment (T4) of Um-Comb. These findings are in accord with those of Sajjan and Raffe (2015), who found that synthetic chemical Chlorantraniliprole was the most effective against BSFB in eggplant and produced the highest fruit yield. Tripura *et al.* (2017) also reported highest marketable yield in the Chlorantraniliprole treated plots. Prithiva *et al.* (2017) reported that Imidachlopride and Dimethoate were most effective in controlling sucking pests in tomato and produced higher yield, followed by *Beauveria bassiana.* When evaluating the cost benefit ratio, it was observed that T4 had the greatest B:C ratio (2.67:1), followed by T5 treatment (2.64:1). These results are supported by Upamanya *et al.* (2020) who obtained highest B:C ratio of 3.99:1 from treatments comprising seed + seed bed treatment in nursery with consortia of bio control agent, root dip treatment of seedling with consortia of bio-fertilizer, soil treatment in main field and spraying with consortia of bio-control agent.

## 5. Conclusion

Chemical treatment with Chlorantraniprole 18.5 SC and Dimethoate 30 EC was most effective in controlling major insect pests of brinjal and producing the highest marketable yield. However, among the different Um-Comb treatments, seed and soil treatment was found to be the most effective in reducing the pest population along with producing highest BCR and increase in growth and yield parameters.

## 6. References


Anonymous (2018). Horticultural Statistics at a Glance. Horticulture Statistics Division Department of Agriculture, Cooperation & Farmers' Welfare Ministry of Agriculture and Farmers' Welfare Government of India Available: http://agricoop.nic.in/sites/default /files/Horticulture%20Statistics%20at%20a %20Glance-2018.pdf. Accessed on 15.03.2021.

Anonymous (2019). National Horticultural Board. Ministry of Agriculture and Farmers' Welfare Government of India Available: http://nhb.gov.in/StatisticsViewer.aspx?enc=MWo UJibk35dW2g36TUJWAoZqESmAYFi7h2irlsmjlI NTcFl1rG/kLbq8ZQbWUvuM. Accessed on 20.05.2021.

Bhagat KC, Munshi SK (2004). Host preference of spotted leaf eating beetle, *Henosepilachna vigintioctopunctata* (Fabr.) on different brinjal varieties. *Pest Manag Econ Zool.* 12 : 77-81.

Devi LL, Ghule TM, Chatterjee ML, Senapati AK (2015). Effectiveness of biorational insecticides for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee and on yield. *Ecol Environ Conserv.* 21(2) : 783-788.

Dhankhar BS (1988). Progress in resistance studies in the eggplant (*Solanum melongena* L.) against shoot and fruit borer (*Leucinodes orbonalis* Guen.) infestation. *Trop Pest Manag.* 34(3) :343-354.

Duncan DB (1951). A significant test for differences between ranked treatment means in an analysis of variance. *Virgin J Sci.* 2 : 171–189.

Karim KS, Das BC, Khalequzzaman M (2001). Population dynamics of *Aphis gossypii* Glover (Homoptera: Aphididae) at Rajshahi, Bangladesh. *Online J Biol Sci.* 1 : 492-495.

Kharade VG, Mutkule DS, Sakhare VM (2018). Bio-efficacy of newer insecticides against sucking insect-pests on brinjal (*Solanum melongena* L.). *J Entomol Zool Stud.* 6(4) : 162-166.

Kodandaram MH, Halder J, Rai, AB (2014). New insecticide molecules and entomopathogens against Hadda beetle, *Henosepilachna vigintioctopunctata* infesting vegetable cowpea. *Indian J Plant Prot.* 42(4) : 333-337.

Nawaz A, Gogi MD, Naveed M, Arshad M, Sufyan M, Binyameen M, Islam SU, Waseem M, Ayyub MB, Arif MJ, Ali H (2020). In vivo and in vitro assessment of *Trichoderma* species and *Bacillus thuringiensis* integration to mitigate insect pests of brinjal (*Solanum melongena* L.). *Egypt J Biol Pest Control.* 30 : 1-7.

Patten CL, Glick BR (1996). Bacterial biosynthesis of indole-3-acetic acid. *Can J Microbiol.* 42(3) : 207–220.

Prithiva JN, Ganapathy N, Jeyarani S (2017). Efficacy of different formulations of *Beauveria bassiana* (Bb 112) against *Bemisia tabaci* on tomato. *J Entomol Zool Stud.* 5 : 1239-1243.

Rajeshwari G, Sridhar V, Chakravarthy AK, Kumar SM (2019). Studies on efficacy of biorational insecticides against major sucking pests, *Amrasca biguttula biguttula* (Ishida), *Bemisia tabaci* (Genn.) and *Aphis gossypii* (Glov.) on brinjal.7(1) : 584-588.

Sajjan AA, Rafee CM (2015). Efficacy of insecticides against shoot and fruit borer, *Leucinodes orbonalis* (Guen.) in brinjal. *Karnataka J Agric Sci.* 28(2) : 284-285.

Tripura A, Chatterjee ML, Pande R, Patra S (2017). Biorational management of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) in mid hills of meghalaya. *J Entomol Zool Stud.* 5(4) : 41-45.

Upamanya GK, Bhattacharyya A, Dutta P (2020). Consortia of entomo-pathogenic fungi and bio-control agents improve the agro-ecological conditions for brinjal cultivation of Assam. *Biotech.* 10(10) : 1-19.

Windham MT, Elad Y, Baker R (1986). A mechanism for increased plant growth induced by *Trichoderma* spp. *Phytopathology*, 76 : 518-521.