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EXPLORING SELECTED MICROBIAL PESTICIEDES AGAINST SUCKING PESTS OF BRINJAL

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ABSTRACT

Brinjal (*Solanum melongena* L.) is one of the most pesticide-intensive vegetable crops in Bangladesh, where excessive insecticides are used to control the brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenée) and sap-sucking pests which poses severe environmental and health risks. To develop an eco-compatible alternative, field experiments were conducted during two consecutive Rabi seasons (2020-2021 and 2021-2022) at the Entomology Research Field, BARI, Gazipur, to evaluate the efficacy of new generation microbial pesticides and some selected insecticides. Significantly the lowest mean population of jassid, thrips and whitefly were received in afidopyropen (Sefina 5 DC) and it was followed by spraying with thiamethoxam (Actara 25 WG). The mean population of jassid, thrips and whitefly were lower in *Metarhizium anisopliae* (Bio Magic 1.15%WP); *Bacillus thuringiensis* var. *kurstaki* (Bio Fighter 2.0%WP), *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP) and *Metarhizium anisopliae* (Lycomax-M 2.0%WP). These treatments have been showed better performance among the microbial pesticides. The mean aphid, jassid and whitefly population was (2.11, 4.52 & 3.02/five leaves, respectively) in Sefina 5 DC and it was followed by Actara 25 WG (2.72, 5.86 & 6.81/five leaves, respectively). In the treatment *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP) the mean aphid, jassid and whitefly population was (3.02, 7.15 & 8.49/five leaves, respectively). However, among them afidopyropen (Sefina 5 DC) resulted the greatest pest suppression, appeared as the best approach providing highest average yield (16.08 t ha^{-1}) whereas *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP) treated plot produced 14.25 t ha^{-1}. The biorational tool offers a robust, residue-free alternative to pesticide-intensive management. Adoption of such bio-intensive strategies can substantially reduce chemical dependency, conserve natural enemies, and promote safer, more sustainable brinjal production systems in Bangladesh and similar agro-ecological regions.

Keywords: Assessment, *Solanum melongena*, jassids, whiteflies, aphids, microbial pesticides

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INTRODUCTION

Brinjal (*Solanum melongena* L.), one of the most widely cultivated and consumed vegetable crops in South and Southeast Asia, holds immense nutritional and economic importance in Bangladesh. It is a vitamin, mineral, phenol, and antioxidant-rich vegetable (Gurbuz *et al.* 2018). This vegetable is cultivated throughout the world because of heat insensitivity, and genetic or morphological diversity (Chapman 2020) with a production of 7,26,000 tons from 54,655 ha area (BBS 2024). Insect pests are the major impediment to the successful cultivation and production of brinjal (Mollah *et al.* 2022a). However, its productivity and quality are severely constrained by a complex of insect pests that infest the crop from the nursery stage to harvest. About 140 species of insect and arachnid pests are reported to infest brinjal throughout the world (Sharma and Tayde 2017). Among these, the brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* Guenée) is considered the most destructive pest, capable of inflicting yield losses exceeding 70-85% in the absence of effective control (Alam *et al*. 2004). In addition, several sap-sucking pests such as the aphid (*Aphis gossypii* Glover), jassid (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius), thrips, and mites have gained considerable importance in recent years due to their increasing infestation and damaging potential (Alam *et al*. 2004, Munde *et al*. 2011). In Bangladesh, green leafhopper (*Amrasca biguttula biguttula*), aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), thrips (*Thrips tabaci*), shoot and fruit borer (*Leucinodes orbonalis* G.), and from arachnid, red spider mite (*Tetranychus macfurlanei*) are most prevalent (Dutta *et al.* 2017). Among these, brinjal shoot and fruit borer (BSFB), leafhopper, whitefly, and mealy bugs are most common, prevalent, and destructive in the summer season (Kapil *et al.* 2022, Mollah *et al.* 2023). These pests not only directly reduce plant vigor by sucking cell sap but also act as vectors of viral diseases, further aggravating yield losses that may exceed 85% under severe infestation in Bangladesh. Both adults and nymphs of leafhoppers and other leaf suckers cause serious damage to leave by sucking cell sap from the lower surface of the leaves causing chlorosis and necrotic spots. Finally, the entire plant turns brown and shows burn symptoms and ultimately the leaves droop off. The indirect effect of leafhoppers includes honey-dew secretion that facilitates fungal growth and interrupts photosynthesis (Bosquee *et al.* 2018).
Meanwhile, prolonged outbreaks of sucking pests can stunt plant growth, especially

during dry periods. Despite these challenges, farmers in Bangladesh predominantly depend on repeated applications of synthetic insecticides, often exceeding 80-100 sprays per growing season to achieve blemish-free fruits for the local market. Such indiscriminate pesticide use has led to alarming environmental and health concerns, including pesticide residue accumulation, resurgence of secondary pests, development of insecticide resistance, and disruption of beneficial arthropod populations (Korsak and Sato 1977, Rashid *et al*. 2003, Ulrichs *et al*. 2001). Moreover, the excessive use of insecticides in brinjal (approximately 47% of all vegetable insecticide use in Bangladesh) makes it one of the most pesticide-intensive crops, with an estimated application rate of 1.41 kg or L ha^{-1} (Alam *et al*. 2004). Such practices elevate production costs and pose serious threats to human health and export potential due to pesticide residues (Islam *et al*. 1999). Therefore, the introduction of non-hazardous, plant-based, or microbial-origin bio-insecticides is very essential. Additionally, these are mostly effective, safe for non-target organisms and natural enemies, and target pest-specific, and ecologically sound solutions to pest problems (Mollah *et al.* 2022b). Some commercially formulated microbial or pathogenic bio-insecticides were found effective against the major insect pests of brinjal, brinjal shoot, and fruit borer (Mollah *et al.* 2023) and the sucking insect pests (Gayathri and Geetha 2019). The efficacy of pathogenic or microbial insecticides might come from the combined effect of toxicity (Tobias *et al.* 2018, Mollah *et al.* 2020a), insect host immunity suppression (Mollah *et al.* 2020b, Mollah and Kim 2020), inhibition of immune mediator secretion (Hasan *et al.* 2019, Mollah 2023) and bind with immune proteins (Mollah 2024, Mollah *et al.* 2021). Some botanical insecticides were found effective against the bean pod borer (Mollah *et al.* 2012) and sucking insect pests including aphids of country bean (Mollah *et al.* 2013) and green leafhoppers of brinjal (Kunbhar *et al.* 2018).

For the management of sucking pests use of insecticides is the permanent solution. Recent trend of organic farming and deleterious effect of chemical insecticides on natural enemies has necessitated the alternative approach for economical and eco-friendly management of insect pests. In this context microbial biopesticides attract considerable attention and significant findings have been documented on efficacy of microbial biopesticides in Bt cotton and other various crops (Luo *et al.* 2014, Rajashekhar *et al.* 2017, Chattopadhyay *et al.* 2017). In this context, the paradigm of bio-rational pest management offers a sustainable alternative to sole chemical dependence by integrating multiple eco-compatible components. Among recent advancements, new-generation biorational insecticides including microbial-based products like *Bacillus thuringiensis*, *Beauveria bassiana* and *Metarhizium anisopliae* formulations have shown strong insecticidal potential while preserving ecological safety (Rahman *et al*. 2023, 2025, Rashid *et al*. 2022). These bioactive agents act through unique physiological and behavioral mechanisms, such as feeding inhibition, digestive system disruption, and neuro-modulation, with minimal likelihood of resistance development (Wang *et al*. 2001, Wei *et al*. 2009). However, their field-level integration with conventional management with pesticide remains poorly documented under Bangladesh agro-ecological conditions. A little or no information is available about the efficacy of commercially available microbial insecticides against different sucking pests in the brinjal field.

Therefore, the present study was designed to evaluate and compare the efficacy of new generation commercially formulated microbial pesticides with some selected pesticides, against the sucking insect pests infesting brinjal plants under field conditions during the winter season. The specific objectives were to (i) determine the comparative effectiveness of selected microbial pesticides and insecticides in suppressing sucking pests, (ii) assess their influence on marketable yield and infestation, and (iii) to identify the most economically viable and environmentally safe management strategy. The findings of this research are expected to contribute significantly toward developing a bio-intensive IPM framework for sustainable brinjal production and reducing dependency on hazardous chemical pesticides in Bangladesh.

MATERIALS AND METHODS

Experimental site and duration: Field experiments were conducted for two consecutive winter (*Rabi*) seasons during 2020-2021 and 2021-2022 at the Entomology Research Field of the Bangladesh Agricultural Research Institute (BARI), Gazipur (24°00′N, 90°25′E; elevation 8.4 m above the sea level). The area is characterized by a subtropical climate with distinct dry and cool winters, moderate rainfall, and an average temperature range of 15-30°C. The soil of the experimental site was silty clay loam with pH 6.8 and moderate organic matter content. The experiments were performed under irrigated conditions following standard agronomic practices recommended for brinjal cultivation in central Bangladesh.

Experimental design and crop establishment: The experiment was laid out in a randomized complete block design (RCBD) with nine treatments and an untreated control with three replications. Each plot measured 8.0 m × 2.5 m with 1.0 m spacing between plots and 1.5 m between blocks to prevent cross-interference of treatments. Brinjal variety *BARI Begun-8* was used as the test crop. Thirty-day-old healthy seedlings were transplanted at a spacing of 75 cm × 60 cm during the last week of October in both years. The recommended fertilizer doses were applied at 20 t ha^{-1} cow dung, 120 kg N, 100 kg P_2O_5, 100 kg K_2O, and 15 kg S per hectare. Standard irrigation, weeding, and mulching operations were performed as required to maintain uniform crop growth across all treatments and untreated control.

Treatments applied in the experiment: Seven microbial insecticides and two chemical insecticides were tested in this study (Table 1).

Table 1. Details of microbial pesticides and chemical insecticides applied in the experiment

Treatments	Active ingredient	Dose
T_1= Bio Catch	*Verticillum lecani* (1.15% WP- 2 x 10^8 cfu g^{-1})	6.0 g L^{-1} of water
T_2= Bio Magic	*Metarhizium anisopliae* (1.15% WP- 2 x 10^8 cfu g^{-1})	6.0 g L^{-1} of water
T_3= Bio Power	*Beauveria bassiana* (1.15% WP- 2 x 10^8 cfu g^{-1})	6.0 g L^{-1} of water
T_4= Bio Fighter	*Bacillus thuringiensis* var. *kurstaki* (1.15% WP- 2 x 10^8 cfu g^{-1})	2.5 g L^{-1} of water
T_5= Biocure	*Bacillus thuringiensis* var. *kurstaki* (2.0% WP- 2 x 10^8 cfu g^{-1})	1.0 g L^{-1} of water
T_6= Lycomax-M	*Metarhizium anisopliae* (2.0% WP- 2 x 10^8 cfu g^{-1})	1.0 g L^{-1} of water
T_7= Lycomax-B	*Beauveria bassiana* (2.0% WP- 2 x 10^8 cfu g^{-1})	1.0 g L^{-1} of water
T_8= Sefina 5 DC	Afidopyropen	2.0 ml L^{-1} of water
T_9= Actara 25 WG	Thiamethoxam	0.2 g L^{-1} of water
T_{10}= Untreated control (Water spray)	N/A	N/A

A total of five foliar sprays were applied for each treatment, starting at the initial detection of pest infestation and continued at 7-day intervals. Applications were made using a hand-operated knapsack sprayer calibrated for uniform droplet size.

Data collection

Sucking pest population: Observations on aphids, jassids, thrips, and whiteflies were recorded from five randomly selected plants per plot. From each plant, five leaves were examined (one from the lower canopy, two from the middle, and two from the upper canopy). The number of live insects per leaf was counted from the abaxial surface using a 10× hand lens. Data were expressed as mean insect population per five leaves.

The reduction in pest population over the untreated control was calculated using the following formula:

$$\text{Percent reduction over control} = \frac{\text{Mean population in untreated control - Mean population in treatment}}{\text{Mean population in untreated control}} \times 100$$

Yield: Healthy fruits were harvested periodically from each plot, and total marketable yield (t ha^{-1}) was calculated.

Statistical analysis: All data were subjected to analysis of variance (ANOVA) using R statistical software (version 4.3.1). Treatment means were separated by the least significant difference (LSD) test at a 5% probability level ($p \leq 0.05$). Data expressed in percentages were arcsine-transformed before analysis to ensure homogeneity of variance.

RESULTS AND DISCUSSION

Seasonal incidence and pest pressure: During both cropping seasons (2020-2021 and 2021-2022), brinjal fields were infested by several insect pests, including the shoot and fruit borer (*Leucinodes orbonalis* Guenée), aphids (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), and whiteflies (*Bemisia tabaci* Gennadius). The populations of thrips and epilachna beetles remained negligible throughout the experiment, while predatory ladybird beetles (Coccinellidae) were frequently observed, indicating the conservation of natural enemies under bio-insecticides regimes. Pest populations began to increase from 30-40 days after transplanting (DAT), peaked between 65-90 DAT under warm and dry weather conditions, and gradually declined thereafter. This population trend closely followed fluctuations in temperature and relative humidity, corroborating previous findings by Khan *et al*. (2023) and Saikia *et al*. (2020), who highlighted that climatic factor play a critical role in pest proliferation in brinjal ecosystems.

Effect of different treatments on sucking pest suppression: Application of different treatments significantly reduced the population densities of major sucking pests such as aphids, jassids, and whiteflies compared to the untreated control ($p \leq 0.05$) during both cropping seasons (2020-2021 and 2021-2022). In Rabi 2020-21 season; the mean aphid, jassid, and whitefly populations were the lowest in Sefina® 5 DC treated plot and it was followed by Actara® 25 WG recording 2.06, 4.29 & 3.08 individuals per five leaves, respectively. The Actara® 25 WG treated plot had received aphid, jassid, and whitefly populations 2.67, 5.70 & 7.69 per five leaves, respectively. The mean population of jassid, thrips and whitefly showed lower in *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0% WP) @ 1.0 g L^{-1} of water and *Metarhizium anisopliae* (Lycomax-M 2.0%WP) @ 1.0 g L^{-1} of water than that of the other microbial pesticides. These two treatments have been showed better performance among the microbial pesticides. In T_5 treatment i.e., *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP); the mean aphid, jassid and whitefly population was (3.79, 8.47 & 9.67 per five leaves, respectively) and it was performed better than that of the other microbial pesticide. These values were statistically comparable to other microbial pesticides treatment. In contrast, the chemical pesticide treatments (Sefina® 5 DC and Actara® 25 WG); the microbial pesticide treatments showed moderate suppression, while the untreated control recorded the highest pest densities 12.51, 25.93 & 27.42 per five leaves, respectively (Table 2). From Table 3 it was revealed that the highest reduction in aphid, jassid, and whitefly populations over untreated control showed by Sefina® 5 DC (83.53%, 83.46%, and 88.77%, respectively), followed by Actara® 25 WG (78.66%, 78.02%, and 72.02%).

Similar trend of results was also found in Rabi 2021-22 seasons. The mean aphid, jassid, and whitefly populations were the lowest in Sefina® 5 DC and it was followed by Actara® 25 WG recording 2.11, 4.52 & 3.02 individuals per five leaves, respectively. The Actara® 25 WG treated plot showed aphid, jassid, and whitefly populations of 2.72, 5.86 & 6.81per five leaves, respectively. The control treatment had significantly highest population in respect of all the pest viz. aphid, jassid & whitefly (11.95, 27.83, and 29.68/five leaves, respectively). Thus, the maximum reduction of aphid, jassid & whitefly over untreated control was achieved from Sefina® 5 DC (82.34%, 83.76%, and 89.82%, respectively), followed by Actara® 25 WG (81.00%, 78.94%, and 77.06%). Similarly, applications of microbial pesticides have also reduced the mean aphid, jassid & whitefly pest population but not likely to chemical pesticide application. Among the microbial pesticides, *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0% WP) @ 1.0 g L^{-1} of water and *Metarhizium anisopliae* (Lycomax-M 2.0% WP) @ 1.0 g L^{-1} of water have been showed better than that of the other microbial pesticides. The minimum percent pest population over control was also obtained from these microbial pesticides (Tables 2-3).

The result was found in this study could not be compared with any other findings since these combinations were newly introduced first time in this study. Although chemical control is the common practice to manage the sucking pests, nowadays different microbial native insecticides, microbes or plant-based bioinsecticides are being applied. Raghunandan *et al.* (2018) reported that the population of sucking pests viz. aphid, jassid, whitefly and thrips reduced significantly in the in Bt cotton plots treated with microbial biopesticide. *Lecanicillium lecanii* was the most effective followed by *Beauveria bassiana* and *Metarhizium anisopliae*. Ajith *et al.* (2023) also observed that entomopathogenic fungi, *Lecanicillium lecanii* and *Beauveria bassiana* was most effective for sucking insect pest *viz*., aphid, whitefly and thrips population of chilli. Previous studies reported, where integration of biorationals and physical controls effectively suppressed sucking pests in brinjal (Dutta *et al*. 2012, Aparna and Dethe 2011). The superior efficacy of Afidopyropen and Matrine can be attributed to their novel biochemical modes of action on chordotonal organs and feeding inhibition (Kandasamy *et al*. 2017), while Spinosad provided additional ingestion toxicity with minimal harm to beneficial insects. These results confirm that new-generation microbial pesticides can serve as sustainable alternatives to synthetic pesticides in vegetable IPM systems as well as other crops.

Table 2. Effect of different treatments on the mean population of sucking pests in brinjal over two cropping seasons

Cropping season	Treatments	Number of Aphid /5 leaves	Number of Jassid /5 leaves	Number of Thrips /5 leaves	Number of Epilachna /5 leaves	Number of Whitefly /5 leaves
2020-21	Bio Catch 1.15% WP	4.24 b	10.51 c	-	-	9.00 c
	Bio Magic 1.15% WP	4.18 b	10.50 c	-	-	11.09 bc
	Bio Power 1.15% WP	4.85 b	12.90 b	-	-	12.08 b
	Bio Fighter 1.15% WP	4.57 b	10.98 c			12.75 b
	Biocure 2.0% WP	3.79 b	8.47 d	-	-	9.67 c
	Lycomax-M 2.0%WP	4.05 b	8.50 d	-	-	9.75 c
	Lycomax-B 2.0%WP	4.74 b	9.32 c	-	-	10.41 bc
	Sefina 5 DC	2.06 c	4.29 e	-	-	3.08 d
	Actara 25 WG	2.67 c	5.70 e	-	-	7.69 c
	Untreated control	12.51a	25.93 a	-	-	27.42 a
2021-22	Bio Catch 1.15% WP	4.59 b	11.39 b	-	-	10.05 c
	Bio Magic 1.15%WP	3.07 c	9.43 c	-	-	10.02 b
	Bio Power 1.15% WP	4.91 b	12.27 b	-	-	12.29 b
	Bio Fighter 1.15% WP	3.12 c	9.24 c			10.33 b
	Biocure 2.0% WP	3.02 c	7.08 d	-	-	8.49 c
	Lycomax-M 2.0%WP	3.18 c	7.15 d	-	-	8.62 c
	Lycomax-B 2.0%WP	4.81 b	9.86 c	-	-	11.27 b
	Sefina 5 DC	2.11 d	4.52 e	-	-	3.02 e
	Actara 25 WG	2.72 d	5.86 e	-	-	6.81 d
	Untreated control	11.95a	27.83 a	-	-	29.68 a

Means within the same column for a crop growing season that share the same letter are not significantly different at P > 0.05 according to the LSD test.

Table 3. Percent reduction of major sucking pest populations over untreated control in brinjal under different treatments across two cropping seasons

Treatments	Percent pest population reduction over untreated control					
	2020-21			2021-22		
	Aphid	Jassid	Whitefly	Aphid	Jassid	Whitefly
Bio Catch 1.15% WP	66.11	59.46	67.18	61.59	59.07	66.14
Bio Magic 1.15%WP	66.59	59.51	59.56	74.30	66.12	66.24
Bio Power 1.15% WP	61.23	50.26	55.94	58.92	55.91	58.60
Bio Fighter 1.15% WP	63.47	57.66	54.00	73.89	66.80	65.20
Biocure 2.0% WP	69.70	67.34	64.73	74.73	74.70	71.39
Lycomax-M 2.0%WP	67.63	67.21	64.44	73.39	74.31	70.96
Lycomax-B 2.0% WP	62.11	64.06	62.04	59.75	64.57	62.03
Sefina 5 DC	83.53	83.46	88.77	82.34	83.76	89.82
Actara 25 WG	78.66	78.02	72.02	81.00	78.94	77.06
Untreated control	-	-	-	-	-	-

Effect of microbial pesticides and insecticides on pest infestation in brinjal plant: The percent plant infestation and reduction over untreated control was presented in Figure 1. The highest percent reduction of plant infestation by aphids, jassid, and whitefly over untreated control was attained from the treatment T_8, Sefina® 5 DC @ 2.0 ml L^{-1} of water (73.05%) and it was statistically similar with spraying with T_9 (Actara 25® WG) @ 0.2 g L^{-1} of water (71.48%) which was followed by T_5 (Biocure 2.0% WP), T_6 (Lycomax-M 2.0% WP) & T_7 (Lycomax-B 2.0% WP) where plant infestation over control (67.59%, 67.10% & 66.61%, respectively). The lowest percent reduction of plant infestation by aphids, jassid, and whitefly population over control was obtained from T_3 (Bio Power) treatment (61.20%).

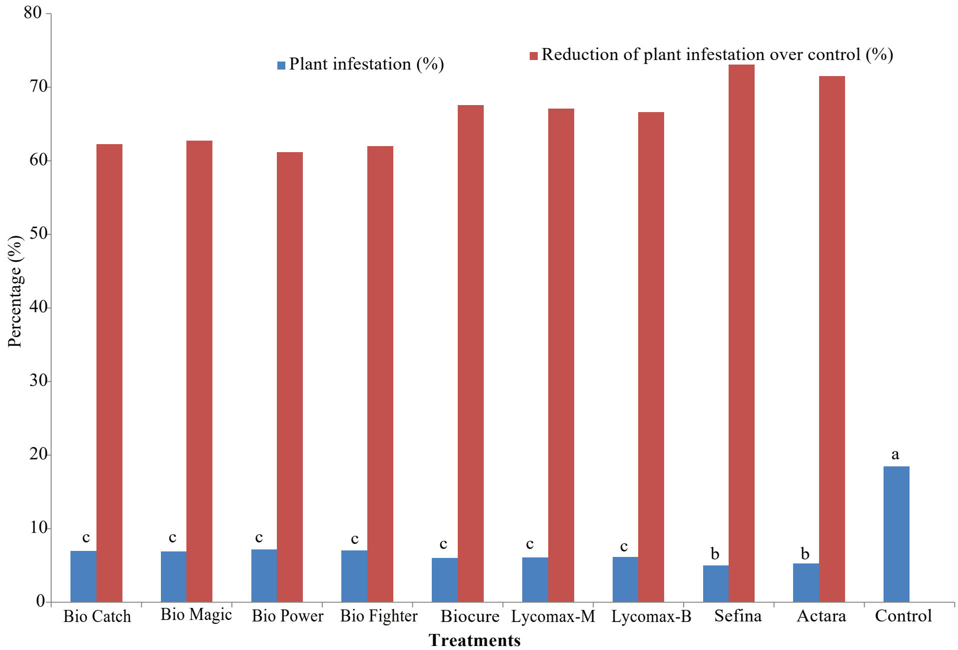

Fig. 1. Percent reduction of plant by aphid, jassid and whitefly population over control in brinjal as influenced by different treatments

Effect of different management options on the yield of brinjal: The principal objective of this research was to determine the comparative effectiveness of selected microbial pesticides and chemical insecticides in suppressing sucking pests as well as its impact on brinjal shoot and fruit borer (BSFB) infestation. The brinjal shoot and fruit borer (BSFB) remained the dominant pest throughout the cropping period. If no intervention was done for the management of BSFB that cause the marketable fruit yield loss of brinjal. More or less a poor yield was obtained due to severe infestation of BSFB. The marketable fruit yield was bit higher in chemical pesticides treatment plot than that of microbial pesticides plot. It might be the effect of chemical pesticides on BSFB population than that of microbial pesticides. From Table 4 it was revealed that significant differences in marketable fruit yield among the treatments ($p \leq 0.05$) during both cropping seasons (2020-2021 & 2021-2022). In the Rabi 2020-21 cropping season the highest marketable fruit yield (16.45 t ha^{-1}) was recorded in afidopyropen (Sefina® 5 DC) followed by spraying with thiamethoxam (Actara® 25 WG) where the yield was 14.98 t ha^{-1}. However, the lowest yield was obtained from untreated control plot (9.02 t ha^{-1}). In contrast, the microbial treatment *Bacillus* thuringiensis var. *kurstaki* (Biocure 2.0%WP) received 13.97 t ha^{-1} yields which were at par with the treatment *Metarhizium anisopliae* (Lycomax-M 2.0%WP) and *Beauveria bassiana* (Lycomax-B 2.0%WP). Similarly, the highest yield increase over control was calculated from afidopyropen (Sefina® 5 DC) treated plots (82.37%) followed by spraying with thiamethoxam (Actara® 25 WG) which was 66.08%. *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP) treated plot had 54.88% yield increase over control followed by *Metarhizium anisopliae* (Lycomax-M 2.0%WP) which was 53.99%.

In the *Rabi* 2021-22 cropping season the highest yield (15.71 t ha^{-1}) was also recorded in afidopyropen (Sefina® 5 DC) followed by spraying with thiamethoxam (Actara® 25 WG) which was (14.88 t ha^{-1}). However, the lowest yield was obtained from control plot (9.01 t ha^{-1}). Similarly, the highest yield increase over untreated control was intended from afidopyropen (Sefina® 5 DC) treated plots (74.36 %) followed by spraying with thiamethoxam (Actara® 25 WG) which was 65.15%. *Bacillus thuringiensis* var. *kurstaki* (Biocure 2.0%WP) treated plot received 61.15% yield increase over control followed by *Metarhizium anisopliae* (Lycomax-M 2.0%WP) which was 57.49%.

Table 4. Effect of different treatments on the marketable yield of brinjal in two cropping seasons at BARI, Gazipur

Crop growing season	Treatments	Marketable yield (t/ha)	Yield increase over control (%)
2020-2021	Bio Catch 1.15% WP	13.17 d	46.00
	Bio Magic 1.15%WP	13.32 d	47.67
	Bio Power 1.15% WP	12.05 d	33.59
	Bio Fighter 1.15% WP	12.65 d	40.24
	Biocure 2.0% WP	13.97 c	54.88
	Lycomax-M 2.0%WP	13.89 c	53.99
	Lycomax-B 2.0%WP	13.78 c	52.77
	Sefina 5 DC	16.45 a	82.37
	Actara 25 WG	14.98 b	66.08
	Untreated control	9.02 e	-
	CV %	4.48	-

Crop growing season	Treatments	Marketable yield (t/ha)	Yield increase over control (%)
2021-2022	Bio Catch 1.15% WP	12.85 d	42.62
	Bio Magic 1.15%WP	14.06 c	56.05
	Bio Power 1.15% WP	12.22 d	35.63
	Bio Fighter 1.15% WP	13.97 cd	55.05
	Biocure 2.0% WP	14.52 c	61.15
	Lycomax-M 2.0%WP	14.19 c	57.49
	Lycomax-B 2.0%WP	13.05 d	44.84
	Sefina 5 DC	15.71 a	74.36
	Actara 25 WG	14.88 b	65.15
	Untreated control	9.01e	-
	CV %	5.01	-

Means within the same column for a crop growing season that share the same letter are not significantly different at $P > 0.05$ according to the LSD test.

Ecological and practical implications: The novel biopesticides such as Matrine, D-limonene, Sodium lauryl ether sulphate, *Celastrus angulatus* extract, azadirachtin preparation, *Saccharopolyspora spinosa* and *Bacillus thuringiensis* var. *kurstaki* both mixture preparation, potassium salt of fatty acid preparation and *Bacillus thuringiensis* var. *kurstaki* alone were demonstrated the efficacy of multi component strategies for sustainable brinjal pest management very recently at Entomology Division, BARI, Gazipur and the findings were very promising. The findings of this newly designed research with microbial pesticides have been played a vital role for the management of sucking pests of other high value vegetable crops such as country bean, okra, chilli, yard long been, cabbage, cauliflower etc. Unlike conventional programs relying on repetitive synthetic insecticide applications, these biorational interventions operate through diverse biochemical modes of action, thereby reducing the risk of pest resistance and preserving natural enemy populations. Moreover, they minimize environmental contamination, safeguard beneficial arthropods, and enhance ecological stability within brinjal ecosystems. The study highlights a paradigm shift toward ecologically synchronized pest management, where adoption of multi component packages can substantially reduce pesticide dependency, lower production costs, improve fruit quality, and support safer, more sustainable vegetable production systems in Bangladesh and other South Asian agro ecological regions.

CONCLUSION

The present study demonstrated that the new-generation biorational insecticide provides an effective, eco-friendly, and economically viable approach for the sustainable management of sucking pests of brinjal. All the treatments significantly reduced the populations of sucking pests (aphid, jassid, and whitefly). Among the tested treatments, chemical pesticides exhibited the highest suppression of pest populations and plant infestation, coupled with superior marketable yields. The efficacy of microbial pesticides was also upright and successfully managed the sucking pests of brinjal. This integrated strategy can substantially reduce pesticide dependency in intensive vegetable systems, aligning with the national goal of promoting safe, residue-free vegetables for domestic and export markets. Due to unavailability of some newer microbial pesticides price, economic evaluation has not been done. Future research should focus on the long-term ecological impacts, compatibility with natural enemies, and optimization of these biorational IPM components under varying agro-climatic conditions for broader adoption by smallholder farmers.

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