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Evaluation of Biopesticides for the Management of Brinjal Aphid (*Aphis gossypii* Glover)

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Abstract

Brinjal (*Solanum melongena* L.) is an important vegetable crop grown extensively across India; however, its productivity is severely affected by sucking pests, particularly aphid (*Aphis gossypii* Glover). Indiscriminate use of chemical insecticides has resulted in resistance development, residue problems, and adverse effects on non-target organisms. Hence, the present study was undertaken to evaluate the efficacy of selected biopesticides against aphid infestation in brinjal under pot culture conditions. The experiment was conducted during 2025 - 2026 at the School of Agriculture, Vels Institute of Science, Technology and Advanced Studies, Pallavaram, Chennai. The experiment was laid out in a Completely Randomized Design with six treatments and four replications. Among the treatments, Neem oil 3% and *Beauveria bassiana* (1×10^8 conidia/ml) recorded significantly lower aphid population and higher fruit yield compared to the control. Biopesticides were also found to be safer to predatory coccinellids. The study concludes that biopesticides can be effectively incorporated into sustainable aphid management strategies in brinjal cultivation.

Key words: Brinjal, *Aphis gossypii*, Biopesticides, Pot culture, Sustainable pest management

Brinjal (*Solanum melongena* L.) is one of the most important solanaceous vegetable crops cultivated extensively in tropical and subtropical regions, particularly in India, owing to its wide adaptability, high yield potential, and year-round cultivation [1]. It belongs to the family Solanaceae and is valued for its remarkable adaptability to diverse agro-climatic conditions, high productivity, and suitability for cultivation throughout the year under irrigated conditions. The crop exhibits wide genetic variability in plant habit, fruit shape, size, colour, and yield potential. Fruits may vary from round, oval, oblong, and long to serpentine types, with colours ranging from deep purple and violet to green, white, and striped forms. This diversity not only enhances its market appeal but also enables farmers to select varieties suited to local preferences and agro-ecological conditions. India is one of the leading producers of brinjal, and the crop plays a vital role in nutritional security by providing dietary fibre, vitamins, minerals, and bioactive compounds such as phenolics and flavonoids that contribute to human health [2-3]. From a nutritional perspective, brinjal is a rich source of dietary fibre, vitamins (such as vitamin C and certain B-complex vitamins), and minerals like potassium and magnesium. It also contains antioxidant compounds, including nasunin and phenolic acids, which contribute to its health-promoting properties. Due to its low caloric value and high fibre content, brinjal is widely recommended in balanced diets.

Despite its economic and nutritional significance, brinjal productivity is severely constrained by infestation of insect pests, especially sucking pests such as aphids, jassids, whiteflies, and thrips. Among these, aphid (*Aphis gossypii* Glover) is a major pest causing considerable yield losses at different growth stages of the crop [4]. Among the sucking pests, the aphid *Aphis gossypii* (Glover) is one of the most destructive and economically important species infesting brinjal. Both nymphs and adults colonize tender shoots, leaves, and floral parts, sucking sap and weakening the plant. Heavy infestation results in curling and yellowing of leaves, reduced flowering, poor fruit set, and ultimately significant yield losses. Additionally, aphids excrete honeydew, which promotes the growth of sooty mould, further interfering with photosynthesis and market quality of fruits.

Beyond direct feeding damage, *Aphis gossypii* is also a known vector of several plant viruses, increasing the severity of crop loss. Its rapid reproductive rate, short life cycle, and ability to develop resistance to commonly used insecticides make its management particularly challenging. Warm and humid conditions favour rapid multiplication, often leading to sudden population outbreaks.

Aphids damage plants by sucking sap from tender leaves, shoots, and flower buds, resulting in leaf curling, chlorosis, stunted growth, and poor fruit set. Moreover, aphids secrete honeydew that facilitates the development of sooty mod, thereby reducing photosynthetic efficiency, and they also act as vectors of several plant viral diseases [5-6]. Management of aphids in brinjal largely depends on repeated applications of synthetic insecticides. Management of aphids in *Solanum melongena* largely depends on repeated applications of

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synthetic insecticides, as farmers seek rapid and visible control of heavy infestations caused by highly reproductive pests such as *Aphis gossypii*. Owing to their short life cycle, parthenogenetic reproduction, and ability to colonize tender shoots and undersides of leaves in large numbers, aphids can cause severe sap depletion, leaf curling, chlorosis, stunted growth, and reduced fruit set within a short period, compelling growers to adopt frequent chemical sprays, often at 7-10 days intervals. Systemic and contact insecticides particularly neonicotinoids, organophosphates, pyrethroids, and carbamates are commonly used because of their quick knockdown effect and ease of application; however, indiscriminate and prophylactic use without adhering to economic threshold levels leads to several adverse consequences, including rapid development of insecticide resistance, resurgence of aphid populations, destruction of natural enemies such as coccinellids and lacewings, and outbreaks of secondary pests due to ecological imbalance. Moreover, repeated spraying increases production costs and raises serious concerns regarding pesticide residues on harvested fruits, environmental contamination of soil and water, and health hazards to farmers and consumers. Therefore, while synthetic insecticides remain the dominant strategy for aphid management in brinjal cultivation, overreliance on them threatens long-term sustainability and underscores the urgent need to integrate safer alternatives such as botanical pesticides, biological control agents, cultural practices, and resistance management strategies within an integrated pest management framework.

However, indiscriminate and prolonged use of chemical pesticides has led to serious issues such as development of insecticide resistance, pest resurgence, contamination of food with pesticide residues, destruction of natural enemies, and environmental pollution [7-8]. These concerns necessitate the development of safer and sustainable pest management strategies. Biopesticides, including botanicals and entomopathogenic fungi, have emerged as promising alternatives to chemical insecticides in integrated pest management (IPM) programmes. Botanicals such as neem-based products contain bioactive compounds like azadirachtin that interfere with feeding, growth, and reproduction of insect pests, while entomopathogenic fungi such as *Beauveria bassiana*, *Metarhizium anisopliae*, and *Lecanicillium lecanii* infect and kill insects through natural epizootics [9-10]. These biopesticides are biodegradable, target-specific, and relatively safe to non-target organisms, including pollinators and natural enemies [11-12].

Pot culture experiments provide a controlled environment to evaluate the bio-efficacy of pest management interventions with reduced environmental variability and precise monitoring of pest populations. Therefore, the present investigation was undertaken to scientifically evaluate the efficacy of selected biopesticides against aphid infestation in brinjal.

MATERIALS AND METHODS

Experimental site and design

The pot experiment was conducted during the academic year 2025-2026 at the School of Agriculture, Vels Institute of Science, Technology and Advanced Studies (VISTAS), located at Pallavaram, Chennai, Tamil Nadu. The experiment was laid out in a Completely Randomized Design (CRD) comprising six treatments with four replications. Earthen pots of 30 cm diameter were filled with a sterilized potting mixture consisting of soil, sand, and farmyard manure in a 2:1:1 ratio to ensure proper aeration and nutrient availability. Healthy and uniform brinjal seedlings were transplanted into the pots and maintained under optimal growing conditions. All recommended agronomic practices, including irrigation and nutrient management, were followed uniformly throughout the experimental period, except for plant protection measures, which were imposed as per the treatment schedule.

Treatment details: The following treatments were imposed: T_1: Azadirachtin 1500 ppm @ 2 ml/l, T_2: Neem oil 3% @ 3 ml/l, T_3: *Beauveria bassiana* (1×10^8 conidia/ml) @ 5 ml/l, T_4: *Metarhizium anisopliae* (1×10^8 conidia/ml) @ 5 ml/l, T_5: *Lecanicillium lecanii* (1×10^8 conidia/ml) @ 5 ml/l and T_6: Control (Water spray).

The experiment consisted of six treatments comprising five biopesticidal/biological interventions and one untreated control. Treatment T_1 involved application of Azadirachtin 1500 ppm @ 2 ml l^{-1}, a neem-derived botanical insecticide obtained from *Azadirachta indica*, prepared by diluting the recommended quantity in clean water to ensure uniform mixing. T_2 comprised Neem oil 3% @ 3 ml l^{-1}, which was properly emulsified in water before spraying to obtain a homogeneous solution. T_3, T_4 and T_5 included entomopathogenic fungi, namely Beauveria bassiana, Metarhizium anisopliae and Lecanicillium lecanii, respectively, each having a spore concentration of 1×10^8 conidia ml^{-1} and applied @ 5 ml l^{-1}; the spray suspensions were freshly prepared before application to maintain spore viability and uniform distribution. T_6 served as the control and received only water spray without any insecticidal treatment. A single foliar spray of the respective treatments was imposed when the aphid population reached the Economic Threshold Level (ETL), using a hand-operated knapsack sprayer fitted with a hollow cone nozzle to ensure thorough and uniform coverage of the crop canopy under calm weather conditions.

Observation on aphid population: The aphid population was recorded one day before the imposition of treatments to obtain the pre-treatment count and subsequently at 1, 3, 5, 7, 11, and 14 days after treatment (DAT) to assess the efficacy of different treatments over time. Observations were made by randomly selecting representative plants from each plot and counting the number of aphids present on three leaves per plant, covering the top, middle, and bottom canopy to account for vertical distribution of the pest population within the crop. The total number of aphids from the three leaves was averaged to obtain the mean aphid population per plant for each treatment at respective observation intervals.

Observation on natural enemies: To evaluate the safety of different treatments to beneficial fauna, observations on natural enemies were recorded simultaneously with aphid population counts at each observation interval. The number of predatory coccinellid beetles (ladybird beetles) present on each selected plant was carefully counted through visual inspection of the entire plant canopy. Counts were taken from the same plants used for aphid observations to maintain consistency. The recorded data were averaged to obtain the mean number of coccinellid beetles per plant under each treatment, thereby assessing the relative safety and compatibility of the tested treatments with natural enemies.

Statistical analysis: The recorded data on aphid population and natural enemies were subjected to square-root transformation ($\sqrt{x + 0.5}$) to normalize the variance before statistical analysis. The transformed data were analyzed using Analysis of Variance (ANOVA) appropriate to the experimental design to determine the significance of treatment effects at different observation intervals. Whenever the F-test indicated significant differences among treatments, the means were separated and compared using Duncan's Multiple Range Test (DMRT) at the 5% level of significance. However, the original (untransformed) mean values are presented in the tables for clarity of interpretation.

RESULTS AND DISCUSSION

Effect of biopesticides on aphid population

The data presented in (Table 1) clearly indicate that all biopesticide treatments significantly reduced the aphid population on Solanum melongena compared to the untreated control. The untreated control (water spray) recorded the highest aphid population (20.9 ± 0.62 aphids per plant), which was significantly superior to all treated plots, confirming the effectiveness of the tested biopesticides. Among the treatments, Neem oil 3% @ 3 ml/l (T1) recorded the lowest aphid population (8.6 ± 0.36), followed closely by Beauveria bassiana (1×10^8 conidia/ml) @ 5 ml/l (9.3 ± 0.39), both of which were statistically at par as indicated by the common letter grouping under DMRT at P = 0.05. Azadirachtin 1500 ppm @ 2 ml/l (10.6 ± 0.42) and Metarhizium anisopliae (1×10^8 conidia/ml) @ 5 ml/l (11.3 ± 0.45) showed moderate efficacy, while Lecanicillium lecanii (1×10^8 conidia/ml) @ 5 ml/l (12.4 ± 0.48) was comparatively less effective among the biopesticides, though still significantly better than the control. The low coefficient of variation (CV = 7.84%) indicates good experimental precision and reliability of the data [13-14]. The findings demonstrate that neem-based treatments, particularly Neem oil 3%, were the most effective in suppressing aphid populations in brinjal, followed by Beauveria bassiana, indicating their strong potential as eco-friendly alternatives to synthetic insecticides. Although all biopesticides significantly reduced aphid infestation compared to the control, their relative efficacy varied, with fungal biocontrol agents showing moderate but meaningful suppression. Therefore, neem oil and Beauveria bassiana may be recommended as effective and sustainable components of integrated pest management strategies for aphid control in brinjal cultivation. Similar findings were reported by Halder *et al.* [10], who observed significant suppression of sucking pests in vegetables following neem-based treatments. Entomopathogenic fungi, particularly *B. bassiana* and *Metarhizium anisopliae*, also exhibited substantial reduction in aphid population. These fungi infect insects through the cuticle, proliferate within the host body, and ultimately cause mortality due to toxicosis and nutrient depletion [9]. The effectiveness of these fungal agents under pot culture conditions may be attributed to relatively stable microclimatic conditions, especially favorable humidity, which enhances spore germination and infection efficiency [11]. The present results are in conformity with the findings of Kunbhar *et al.* [12] and Yadav and Kumawat [15], who reported significant aphid suppression in brinjal using entomopathogenic fungi.

Table 1 Effect of biopesticides on aphid population in brinjal

Treatments	Aphid population per plant (Mean ± SE)*
T_1: Neem oil 3% @ 3 ml/l	8.6 ± 0.36^{a}
T_2: *Beauveria bassiana* (1×10^8 conidia/ml) @ 5 ml/l	9.3 ± 0.39^{ab}
T_3: Azadirachtin 1500 ppm @ 2 ml/l	10.6 ± 0.42^{bc}
T_4: *Metarhizium anisopliae* (1×10^8 conidia/ml) @ 5 ml/l	11.3 ± 0.45^{c}
T_5: *Lecanicillium lecanii* (1×10^8 conidia/ml) @ 5 ml/l	12.4 ± 0.48^{d}
T_6: Control (Water spray)	20.9 ± 0.62^{e}

SEd = 0.31; CD (P = 0.05) = 0.92; CV (%) = 7.84

*Means of four replications; values in a column followed by the same letter(s) do not differ significantly at P = 0.05 by DMRT; data subjected to $\sqrt{x + 0.5}$ transformation before analysis

Effect of biopesticides on natural enemies

The results presented in (Table 2) reveal that different biopesticide treatments exerted varying effects on the population of predatory coccinellids in *Solanum melongena*. The untreated control (water spray) recorded the highest coccinellid population (1.36 ± 0.07 per plant) and was statistically superior to most treatments, indicating that no chemical disturbance favored the natural build-up of predators. Among the biopesticides, Neem oil 3% @ 3 ml/l (1.24 ± 0.06) maintained a relatively higher coccinellid population and was statistically at par with the control, suggesting its comparatively safer effect on beneficial insects. *Beauveria bassiana* (1.18 ± 0.05) also preserved a considerable number of predators, though slightly lower than neem oil. In contrast, Azadirachtin 1500 ppm (0.92 ± 0.05), Metarhizium anisopliae (0.86 ± 0.04), and *Lecanicillium lecanii* (0.81 ± 0.04) recorded significantly lower coccinellid populations, with *Lecanicillium lecanii* showing the least predator abundance among treatments. The low standard error (SEd = 0.04) and coefficient of variation (CV = 9.12%) indicate acceptable experimental precision and consistency of observations. The findings suggest that neem oil 3% was comparatively safer to predatory coccinellids and helped conserve natural enemy populations close to the untreated control, followed by Beauveria bassiana. In contrast, other biopesticide treatments showed a moderate reduction in predator numbers. Therefore, neem-based treatments and Beauveria bassiana may be preferred in integrated pest management programs for brinjal, as they effectively suppress aphids while exerting minimal adverse impact on beneficial coccinellid populations, thereby promoting ecological balance and sustainable crop protection. Furthermore, the compatibility of these treatments with natural enemies highlights their potential for inclusion in eco-friendly and biologically based pest management strategies [16-17].

The comparatively higher survival of natural enemies in biopesticide-treated pots can be attributed to the selective and non-toxic nature of these agents toward beneficial arthropods. Neem-based products are known to have minimal direct toxicity to predators and parasitoids, making them suitable components of integrated pest management (IPM) programmes [18]. Likewise, entomopathogenic fungi primarily target insect pests and generally pose low risk to predators when applied at recommended doses [9]. These results corroborate earlier findings by Nikam *et al.* [8] and Kunbhar *et al.* [12], who reported better conservation of natural enemies in biopesticide-based pest management systems.

Table 2 Effect of biopesticides on predatory coccinellid population in brinjal

Treatments	Coccinellids per plant (Mean ± SE)*
T_1: Neem oil 3% @ 3 ml/l	1.24 ± 0.06^{ab}
T_2: *Beauveria bassiana* (1×10^8 conidia/ml) @ 5 ml/l	1.18 ± 0.05^{b}
T_3: Azadirachtin 1500 ppm @ 2 ml/l	0.92 ± 0.05^{c}
T_4: *Metarhizium anisopliae* (1×10^8 conidia/ml) @ 5 ml/l	0.86 ± 0.04^{cd}
T_5: *Lecanicillium lecanii* (1×10^8 conidia/ml) @ 5 ml/l	0.81 ± 0.04^{d}
T_6: Control (Water spray)	1.36 ± 0.07^{a}

SEd = 0.04; CD (P = 0.05) = 0.11; CV (%) = 9.12

*Means of four replications; values in a column followed by the same letter(s) do not differ significantly at P = 0.05 by DMRT

Table 3 Effect of biopesticides on fruit yield of brinjal

Treatments	Fruit yield (kg/plant) (Mean ± SE)*
T_1: Neem oil 3% @ 3 ml/l	1.68 ± 0.07^{a}
T_2: *Beauveria bassiana* (1×10^8 conidia/ml) @ 5 ml/l	1.60 ± 0.06^{ab}
T_3: Azadirachtin 1500 ppm @ 2 ml/l	1.42 ± 0.06^{bc}
T_4: *Metarhizium anisopliae* (1×10^8 conidia/ml) @ 5 ml/l	1.34 ± 0.05^{c}
T_5: *Lecanicillium lecanii* (1×10^8 conidia/ml) @ 5 ml/l	1.26 ± 0.05^{cd}
T_6: Control (Water spray)	0.98 ± 0.04^{d}

SEd = 0.05; CD (P = 0.05) = 0.14; CV (%) = 6.48

*Means of four replications; values in a column followed by the same letter(s) do not differ significantly at P = 0.05 by DMRT

Effect of biopesticides on fruit yield

The data presented in (Table 3) clearly demonstrate that application of different biopesticides significantly influenced the fruit yield of Solanum melongena. All treated plots recorded significantly higher yields compared to the untreated control, which produced the lowest yield (0.98 ± 0.04 kg/plant). Among the treatments, Neem oil 3% @ 3 ml/l (T_1) recorded the highest fruit yield (1.68 ± 0.07 kg/plant) and was statistically superior to most other treatments, though it remained at par with Beauveria bassiana (1.60 ± 0.06 kg/plant). Azadirachtin 1500 ppm (1.42 ± 0.06 kg/plant) and Metarhizium anisopliae (1.34 ± 0.05 kg/plant) showed moderate yield improvement, whereas *Lecanicillium lecanii* (1.26 ± 0.05 kg/plant) recorded comparatively lower yield among the biopesticide treatments, yet significantly higher than the control. The low coefficient of variation (CV = 6.48%) indicates high experimental precision and reliability of the results. The effective management of aphids through biopesticides positively translated into enhanced fruit yield in brinjal. Neem oil 3% proved to be the most effective treatment in maximizing yield, followed closely by *Beauveria bassiana*, suggesting their superior efficacy in reducing pest pressure and improving crop performance [19]. Therefore, neem oil and Beauveria bassiana may be recommended as promising eco-friendly alternatives for sustainable aphid management, as they not only suppress pest populations but also significantly improve fruit yield in brinjal cultivation. The highest fruit yield was recorded in Neem oil 3% (1.68 kg/plant), followed by *Beauveria bassiana* (1.60 kg/plant) and Azadirachtin 1500 ppm (1.42 kg/plant). In contrast, the lowest yield (0.98 kg/plant) was observed in the control. The increase in yield in treated plants may be attributed to reduced sap loss, improved photosynthetic efficiency, and better overall plant vigor due to effective aphid control [20]. The strong negative relationship between aphid population and yield observed in the present study is in agreement with earlier reports by Ramzan *et al*. [6] documented significant yield improvement in brinjal following effective management of sucking pests. The results further emphasize that biopesticides not only suppress pest populations but also contribute to yield enhancement without adverse environmental effects.

CONCLUSION

The present investigation clearly demonstrates that biopesticides play a significant role in the effective management of aphids in brinjal under pot culture conditions while ensuring the conservation of natural enemies and improving crop productivity. All treated pots recorded a substantial reduction in aphid population compared to the untreated control, confirming the efficacy of botanical and microbial biopesticides in suppressing sucking pests. Among the tested treatments, Neem oil 3% emerged as the most effective, followed closely by *Beauveria bassiana*, indicating the strong insecticidal and antifeedant properties of neem-based formulations and the pathogenic efficiency of entomopathogenic fungi. The superior performance of neem oil may be attributed to the bioactive compounds derived from *Azadirachta indica*, which interfere with feeding, growth, and reproduction of aphids. Likewise, fungal biocontrol agents such as *Metarhizium anisopliae* and *Lecanicillium lecanii* contributed to notable pest suppression through infection and subsequent mortality. Importantly, all biopesticide treatments were found to be relatively safe to predatory coccinellids, with higher beetle populations recorded in neem oil and *B. bassiana* treatments compared to other biopesticides, thereby highlighting their compatibility with natural biological control agents. The enhanced fruit yield observed in treated plants further confirms that effective aphid management directly translates into improved plant vigor and productivity. Neem oil (1.68 kg/plant) and *Beauveria bassiana* (1.60 kg/plant) recorded the highest yields, while the untreated control registered the lowest yield, clearly establishing the negative impact of unchecked aphid infestation on brinjal production. Overall, the study concludes that neem-based products and entomopathogenic fungi offer an eco-friendly, sustainable, and effective alternative to chemical insecticides for aphid management in brinjal. Their dual benefits of pest suppression and natural enemy conservation make them suitable components of Integrated Pest Management (IPM) strategies aimed at achieving sustainable vegetable production with minimal environmental risk.

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