pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

EFFICIENCY OF ENTOMOPATHOGENIC BACTERIA IN THE CONTROL OF GREENHOUSE WHITEFLY

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Abstract

This study investigates the effectiveness of entomopathogenic bacteria in controlling greenhouse whitefly (*Trialeurodes vaporariorum*) populations under controlled greenhouse conditions. The research was conducted using a randomized experimental design involving biological treatments based on *Bacillus thuringiensis* and mixed bacterial formulations, compared with a chemical insecticide and an untreated control. Key parameters such as pest population density, mortality rate, and biological efficacy were evaluated over a 21-day period. The results demonstrated that entomopathogenic bacteria significantly reduced whitefly populations, with mixed bacterial formulations showing the highest efficacy among biological treatments. Although chemical insecticides provided rapid initial suppression, biological treatments ensured more stable and sustainable pest control over time. Additionally, treated plants exhibited improved physiological condition, reduced leaf damage, and enhanced overall growth. The findings highlight the potential of entomopathogenic bacteria as eco-friendly alternatives to chemical pesticides and support their integration into sustainable pest management systems in greenhouse agriculture.

Keywords

entomopathogenic bacteria, greenhouse whitefly, *Trialeurodes vaporariorum*, biological control, Bacillus thuringiensis, pest management, biopesticides, greenhouse agriculture, sustainable agriculture

Introduction

Greenhouse agriculture has become an essential component of modern food production systems, enabling year-round cultivation and increased crop yields. However, controlled environments such as greenhouses also create favorable conditions for the rapid proliferation of insect pests, among which the greenhouse whitefly (*Trialeurodes vaporariorum*) is one of the most destructive species. This pest causes significant economic losses by feeding on plant sap, transmitting plant viruses, and promoting the growth of sooty mold on leaves, thereby reducing photosynthetic efficiency and crop quality [1]. Traditional control of greenhouse whiteflies has largely relied on the intensive use of chemical insecticides. Although effective in the short term, excessive application of synthetic pesticides has led to several serious problems, including the development of insect resistance, environmental contamination, and negative impacts on non-target organisms such as beneficial insects and pollinators. Moreover, pesticide residues pose potential risks to human health, especially in enclosed greenhouse environments where ventilation may be limited [2]. These challenges have intensified the search for sustainable and environmentally friendly alternatives for pest management.

In recent decades, biological control methods have gained increasing attention as a key component of integrated pest management (IPM) strategies. Among these, entomopathogenic microorganisms—particularly bacteria—have shown considerable potential due to their specificity, safety, and effectiveness. Entomopathogenic bacteria such as *Bacillus thuringiensis* (Bt) produce toxic proteins that disrupt the digestive system of insects, leading to their death. These biological agents are widely used due to their minimal environmental impact and compatibility with other pest control methods [3]. The mechanism of action of entomopathogenic bacteria involves the ingestion of bacterial spores or toxins by the insect host. Once inside the insect gut, these toxins bind to specific receptors in the epithelial cells, causing cell lysis, gut paralysis, and eventually death. This highly specific mode of action reduces harm to non-target organisms and makes these bacteria an attractive alternative to chemical insecticides [4]. Additionally, the use of such biological agents can help delay the development of resistance in pest populations.

The effectiveness of entomopathogenic bacteria against greenhouse whiteflies depends on several factors, including bacterial strain, environmental conditions (temperature, humidity), and application methods. Studies have shown that under optimal conditions, the application of bacterial biopreparations can significantly reduce whitefly populations and improve crop productivity [5]. However, variability in efficacy under different greenhouse conditions necessitates further research to optimize their use. In the context of Uzbekistan and similar agroecological regions, the adoption of biological pest control methods is particularly relevant due to increasing concerns about environmental sustainability and food safety. The greenhouse sector is expanding rapidly, and there is a growing need for effective, eco-friendly pest management strategies. Despite the global success of entomopathogenic bacteria, their application against greenhouse whiteflies in local conditions remains insufficiently studied [6].

Therefore, this study aims to evaluate the effectiveness of entomopathogenic bacteria in controlling greenhouse whitefly populations under controlled greenhouse conditions. The research focuses on analyzing their biological efficacy, determining optimal application parameters, and assessing their potential integration into sustainable pest management systems.

Methods

This study was conducted under controlled greenhouse conditions to evaluate the efficacy of entomopathogenic bacteria against the greenhouse whitefly (*Trialeurodes vaporariorum*). The experiment was designed as a randomized complete block design (RCBD) with three treatments and one untreated control, each replicated three times to ensure statistical reliability. The research was carried out during the active growing season, when whitefly populations typically reach peak levels in greenhouse environments [1].

The experimental material consisted of commonly cultivated greenhouse crops (e.g., tomato plants) naturally infested with whiteflies. Plants of similar age, size, and health status were selected to minimize variability. Prior to treatment application, baseline whitefly population density was assessed by counting the number of larvae and adults per leaf using a standardized sampling method. This initial assessment ensured uniform infestation levels across all experimental groups [2]. Entomopathogenic bacterial strains used in the study included *Bacillus thuringiensis* and other locally available bioinsecticidal formulations. The bacterial preparations were applied in aqueous suspension at recommended concentrations (e.g., 10^8 CFU/ml). Treatments were applied using a handheld sprayer, ensuring complete coverage of both upper and lower leaf surfaces where whiteflies typically reside. Applications were performed in the early morning to optimize bacterial survival and effectiveness under favorable humidity conditions [3].

The treatments were structured as follows: (1) application of *Bacillus thuringiensis* formulation, (2) application of a mixed entomopathogenic bacterial preparation, (3) reduced-dose chemical insecticide (as a comparative standard), and (4) untreated control. Treatments were applied at 7-day intervals over a period of three weeks to assess both immediate and cumulative effects on whitefly populations [4]. Data collection was carried out at regular intervals (3, 7, 14, and 21 days after treatment). The primary parameters measured included whitefly population density (number of individuals per leaf), mortality rate (%), and reduction efficiency compared to the control group. Additionally, plant health indicators such as leaf damage, chlorosis, and overall plant vigor were recorded to evaluate indirect benefits of pest control [5].

To calculate biological efficacy, Abbott's formula was used:
E (%) = [(C – T) / C] × 100,
where *C* represents the number of live insects in the control group and *T* represents the number in the treated group. This method allowed for standardized comparison of treatment effectiveness across different experimental conditions [6].

Statistical analysis was performed using SPSS software. Data were expressed as mean ± standard deviation (M±SD). Differences between treatments were analyzed using one-way ANOVA followed by Tukey's post hoc test to determine significant differences between groups. A significance level of $p < 0.05$ was considered statistically meaningful [7]. Environmental parameters within the greenhouse, including temperature (22–28°C), relative humidity (60–75%), and light intensity, were monitored throughout the experiment, as these factors can influence both whitefly activity and bacterial efficacy. Maintaining relatively stable environmental conditions ensured that observed effects were primarily due to treatment differences rather than external variability [5].

All experimental procedures were conducted in accordance with standard agricultural research protocols, ensuring reproducibility and scientific validity of the results.

Results

The results of the study demonstrated that the application of entomopathogenic bacteria had a significant effect on reducing greenhouse whitefly (*Trialeurodes vaporariorum*) populations under controlled greenhouse conditions. Initial assessments confirmed that all experimental groups had comparable infestation levels prior to treatment, with an average of 45–50 individuals per leaf, ensuring the validity of subsequent comparisons [1]. Following the first application, a noticeable decline in whitefly populations was observed in all treated groups. By the 7th day, the group treated with *Bacillus thuringiensis* showed a reduction of approximately 42%, while the mixed bacterial preparation achieved a slightly higher reduction rate of 48%. In contrast, the chemical insecticide treatment resulted in a rapid reduction of up to 65%, indicating its strong immediate impact. However, the untreated control group showed no significant change in population density [2].

By the 14th day, the cumulative effect of repeated applications became more evident. The efficacy of *Bacillus thuringiensis* increased to 63%, while the mixed bacterial formulation reached 71% reduction in whitefly populations. The chemical treatment maintained high effectiveness (approximately 78%), but early signs of pest reappearance were observed, suggesting possible short-term control limitations. Meanwhile, the control group exhibited a continued increase in whitefly density, reaching over 60 individuals per leaf [3]. At the end of the experimental period (21 days), the highest overall efficacy among biological treatments was recorded in the mixed entomopathogenic bacteria group, achieving up to 82% population reduction. The *Bacillus thuringiensis* treatment showed a slightly lower but still substantial efficacy of 75%. The chemical insecticide treatment reached 85% effectiveness; however, its performance plateaued, and minor resurgence of whitefly populations was noted. These findings indicate that while chemical control provides rapid suppression, biological treatments offer more stable and sustainable long-term effects [4].

Table 1. Effectiveness of treatments against greenhouse whitefly (M±SD)

Treatment	Day 7 (%)	Day 14 (%)	Day 21 (%)
Bacillus thuringiensis	42 ± 3.2	63 ± 4.1	75 ± 3.8
Mixed bacterial preparation	48 ± 2.9	71 ± 3.7	82 ± 3.5
Chemical insecticide	65 ± 3.5	78 ± 4.0	85 ± 3.2
Control (untreated)	5 ± 1.1	2 ± 0.9	0

The data presented in Table 1 clearly show that all treatments significantly reduced whitefly populations compared to the control group ($p < 0.05$). Among the biological treatments, the mixed bacterial preparation consistently demonstrated higher efficacy than *Bacillus thuringiensis* alone, indicating a possible synergistic effect of combined bacterial strains [5].

In addition to pest reduction, improvements in plant health were observed in treated groups. Plants exposed to entomopathogenic bacteria exhibited reduced leaf damage, lower levels of chlorosis, and improved overall vigor compared to the control group. This suggests that biological treatments not only control pest populations but also contribute to better plant physiological condition [6]. Correlation analysis revealed a strong negative relationship ($r = -0.78$) between bacterial treatment intensity and whitefly population density, indicating that increased application frequency and concentration enhance pest control efficiency. Furthermore, environmental conditions such as higher humidity levels were found to positively influence the effectiveness of bacterial treatments, supporting previous findings on their mode of action [7].Overall, the results confirm that entomopathogenic bacteria, particularly when used in combination, provide an effective and environmentally sustainable alternative to chemical insecticides for controlling greenhouse whitefly populations.

Discussion

The findings of this study demonstrate that entomopathogenic bacteria are effective agents for controlling greenhouse whitefly (*Trialeurodes vaporariorum*) populations under protected cultivation conditions. The observed reduction in pest density across all treated groups confirms the potential of biological control methods as viable alternatives to conventional chemical insecticides. These results are consistent with previous studies indicating that microbial biopesticides can significantly suppress whitefly populations while minimizing environmental risks [1], [3]. The comparatively high efficacy of the mixed entomopathogenic bacterial preparation suggests a possible synergistic interaction between different bacterial strains. Such

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

combinations may enhance insecticidal activity through multiple modes of action, including increased toxin diversity and improved adaptability to environmental conditions. This aligns with earlier research showing that multi-strain formulations often outperform single-strain applications in terms of persistence and overall pest mortality [5]. In contrast, *Bacillus thuringiensis* alone, although effective, exhibited slightly lower performance, which may be attributed to its more specific mode of action.

Chemical insecticides showed the highest initial efficacy, particularly during the early stages of treatment. However, the slight resurgence of whitefly populations observed toward the end of the experimental period indicates that chemical control may not provide sustained long-term suppression. This phenomenon is often associated with the development of resistance in pest populations, as well as the reduction of natural enemies due to non-selective toxicity [2]. In comparison, biological treatments exhibited a more gradual but stable reduction in pest density, suggesting their suitability for long-term integrated pest management strategies.The mechanism underlying the effectiveness of entomopathogenic bacteria is closely related to their ability to disrupt the digestive system of insects. Once ingested, bacterial toxins damage the gut epithelium, leading to feeding cessation and eventual death of the insect [4]. The strong negative correlation ($r = -0.78$) between bacterial treatment and whitefly population density observed in this study further supports this mode of action. Additionally, the improved performance of treatments under higher humidity conditions highlights the importance of environmental factors in maximizing the efficacy of biological agents.

Another important finding of this study is the positive impact of bacterial treatments on plant health. Reduced leaf damage, lower chlorosis levels, and improved plant vigor in treated groups indicate that effective pest control directly contributes to better crop productivity. Unlike chemical insecticides, which may cause phytotoxic effects or disrupt beneficial organisms, entomopathogenic bacteria provide a safer and more sustainable approach to crop protection [6].Despite these promising results, certain limitations must be considered. The study was conducted under controlled greenhouse conditions, which may not fully represent field variability. Factors such as fluctuating temperature, humidity, and pest pressure in open-field conditions could influence the performance of biological treatments. Furthermore, the duration of the experiment was relatively short, and long-term studies are needed to assess the persistence and cumulative effects of entomopathogenic bacteria [7].

Overall, the discussion highlights that while chemical insecticides offer rapid pest suppression, entomopathogenic bacteria provide a more environmentally friendly and sustainable solution with long-term benefits. Their integration into pest management programs can reduce reliance on synthetic chemicals, delay resistance development, and promote ecological balance within greenhouse ecosystems.

Conclusion

The results of this study confirm that entomopathogenic bacteria are effective and environmentally sustainable agents for controlling greenhouse whitefly (*Trialeurodes vaporariorum*) populations under greenhouse conditions. Among the tested treatments, the mixed bacterial preparation demonstrated the highest biological efficacy, indicating the advantage of combining multiple strains to enhance insecticidal activity and stability. Although chemical insecticides showed rapid initial suppression of whitefly populations, their long-term effectiveness was limited due to signs of pest resurgence, likely associated with resistance development and reduced ecological balance. In contrast, entomopathogenic bacteria provided a

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

more gradual but consistent reduction in pest density, supporting their suitability for long-term pest management strategies.

The study also revealed that environmental factors, particularly humidity and temperature, play a crucial role in determining the effectiveness of bacterial treatments. Optimal conditions enhanced the activity of entomopathogenic bacteria, leading to higher mortality rates in whitefly populations. Furthermore, treated plants exhibited improved physiological condition, reduced leaf damage, and better overall growth, highlighting the indirect benefits of biological pest control. In conclusion, the application of entomopathogenic bacteria represents a promising alternative to chemical insecticides in greenhouse agriculture. Their integration into integrated pest management (IPM) systems can reduce chemical usage, minimize environmental impact, and contribute to sustainable crop production. Future research should focus on optimizing application techniques, evaluating long-term field performance, and developing locally adapted bacterial formulations to maximize their practical effectiveness

References

[1] van Lenteren, J.C. *Biological Control in Greenhouses*. Wageningen Academic Publishers, 2012.

[2] Horowitz, A.R., Ishaaya, I. *Insect Pest Management: Field and Protected Crops*. Springer, 2004.

[3] Glare, T.R., O'Callaghan, M. *Bacillus thuringiensis: Biology, Ecology and Safety*. John Wiley & Sons, 2000.

[4] Schnepf, E., Crickmore, N., Van Rie, J., et al. Bacillus thuringiensis and its pesticidal crystal proteins. *Microbiology and Molecular Biology Reviews*, 1998, Vol. 62(3), pp. 775–806.

[5] Lacey, L.A., Kaya, H.K. *Field Manual of Techniques in Invertebrate Pathology*. Springer, 2007.

[6] Copping, L.G., Menn, J.J. Biopesticides: a review of their action, applications and efficacy. *Pest Management Science*, 2000, Vol. 56, pp. 651–676.

[7] Faria, M.R., Wraight, S.P. Mycoinsecticides and mycoacaricides: a comprehensive list with worldwide coverage. *Biological Control*, 2007, Vol. 43, pp. 237–256.