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Evaluation of Biopesticides for Managing Sucking Insect Pests in Brinjal Crops under Field Conditions

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ABSTRACT

Brinjal (Solanum melongena L.), a major vegetable crop which is considered to be facing major damage from different insects, including whiteflies, jassids, aphids, and thrips. The overuse of synthetic pesticides has led to adverse effects, including environmental pollution, pest resistance, and risks to food safety. Thus, the study intends to investigate how biopesticides function as environmentally benign and sustainable substitutes for maintaining such pests in various field settings. It has been discovered that biopesticides made from natural sources, such as tobacco, neem, and eucalyptus, can successfully lower insect populations while protecting beneficial creatures and guaranteeing environmental safety. Products made from neem have been shown to reduce pest populations by up to 80% for whiteflies and 75% for jassids. Additionally, the study emphasizes how biopesticides can boost crop yields, enhance soil health, and reduce chemical residues in produce. Biopesticides present a viable route towards sustainable pest management and agricultural practices, despite obstacles including slower action and restricted farmer access. To realize their full potential, farmers must receive further training and development.

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INTRODUCTION

One of the most popular vegetable crops is brinjal, often called aubergine or aubergine (Solanum melongena L.), mainly due to its year-round availability and low cost (Behera et al., 2023). The Deccan Plateau and South India's climates are ideal for eggplant, which comes in 15–20 different kinds (Khapte et al., 2024). Additionally, it thrives in hilly regions with temperatures that seldom fall below 5°C.Eggplant is believed to have been domesticated in regions such as India, China, Thailand, Burma, and other parts of Southeast Asia (Riley & Moomaw, 2012). It is cultivated extensively in countries like China, Japan, India, and Pakistan. Notably, China is the largest producer, contributing approximately 68.7% to global brinjal production (Brief, 2019). Historically, eggplant may have been used more for medicinal purposes than culinary ones due to the initial bitterness of its flesh, which has been reduced through centuries of domestication and experimentation (Bhatti et al., 2024). Nutritionally, brinjal is composed of 92.7% water, 1.1% protein, fiber, carbohydrates (0.02%), and no fats. It is also a good source of Vitamins A and B (Jeevitha, 2020). Despite its importance as a staple vegetable, brinjal is vulnerable to a variety of pests throughout its growth cycle, from the nursery stage to harvest (Kumar et al., 2020). These include major insect pests such as the shoot and fruit borer (Leucinodes orbonalis Guenée), whitefly (Bemisia tabaci Gennadius), jassid (Amrasca biguttula biguttula Ishida), aphid (Aphis gossypii Glover), Mexican bean beetle (Epilachna varivestis Mulsant), and red spider mite (Tetranychus urticae Koch). These are the major insects that damage the brinjal crop (Mohapatra, 2023). Among these, sucking pests like whitefly, jassid, aphid, and thrips are particularly problematic, as they attack the plant from the nursery stage to harvest, leading to significant economic losses in marketable yield (Belachew & Jenber, 2024). In Himachal Pradesh, 27 insect species and one mite species have been reported to be associated with the brinjal crop (Singh et al., 2024). These pests cause damage to the plant's shoots and fruits at all stages of growth, resulting in yield losses ranging from 70% to 92% (Overton et al., 2021). Among the various pests, lepidopteran species are particularly destructive, as they attack the shoot tips and fruits, leading to a significant reduction in marketable yield (Ankireddy et al., 2023). Synthetic pesticides are commonly used to control brinjal pests. These chemicals are very expenses; however, excessive reliance on these chemicals poses risks to human health and the environment. than we avoid the chemicals because they are harmful (Ghosh, 2022). This has highlighted the need to develop and adopt environmentally safe, effective, and eco-friendly pest management strategies that we used to biological control (Verma et al., 2023). While chemical pesticides initially mitigated pest-related losses, their overuse has caused soil degradation, groundwater pollution, and nutritional imbalances in agricultural land (Abajue & Gbarakoro, 2023). Additionally, pesticide residues in crops can lead to food safety concerns and hinder the export of agricultural products (Zikankuba et al., 2019). Eco-friendly alternatives, such as biopesticides, offer a sustainable solution. Biopesticides, which include various pest control interventions derived from predatory, parasitic, or chemical relationships in nature, rely on non-toxic mechanisms to manage pests (Thilagam et al., 2023). These substances, derived from plants, are considered safer for human health and the environment (Afonne & Ifediba, 2022). Biopesticides are particularly effective in managing brinjal pests such as shoot and fruit borers, whiteflies, jassids, and aphids, which are the sap sucking insects, by suppressing larval populations and reducing pest infestation levels (Deekshith, 2020). More and more people are realizing the value of plant extracts and botanical insecticides in agriculture. Because they are non-residual, safe for the environment, and reasonably priced, botanical insecticides are a great option for sustainable pest management (Khan, 2021). Neem, asafetida (Ferula assa-foetida), thorn apple (Datura), tobacco, and eucalyptus extracts are among the natural compounds that have shown efficacy against a variety of insect pests (Van, 2015; Khoso et al., 2025). By focusing on the behaviour or growth of pests, they function as repellents, anti-feedants, or population inhibitors (Mohan et al., 2024). Over time, field crop and vegetable pests such as bollworms, fruit borers, aphids, jassids, thrips, whiteflies, leafhoppers, and diamondback moths have been effectively controlled with biopesticides (Ragunathan & Divakar, 2020). These herbal remedies' ability to effectively reduce insect populations indicates their potential for broader use in brinjal farming (Siam et al, 2024). Keeping in view, the present study will be carried out to study evaluation of Biopesticides for Managing Sucking Insect Pests in Brinjal Crops under Field Conditions.

LITERATURE REVIEW

Importance of Brinjal

A popular vegetable in the Solanaceae family, eggplant (Solanum melongena) is often referred to as brinjal or aubergine (Ayub & Chopra, 2024). It is prized for its many culinary uses, nutritional advantages, and therapeutic qualities and has been cultivated for generations (Hadidi et al., 2024). With broad leaves and eye-catching fruits that come in purple, white, green, and striped variations, the plant usually reaches a height of 60 to 100 cm (Maas et al., 2025). Warm temperatures are necessary for the best growth of eggplant, which grows best in fertile, well-drained soils (Nyasapoh et al., 2024). China, India, and a number of African and Mediterranean nations are major eggplant growers (Ali, 2020; Manzoor et al., 2020).

Aubergine's high vitamin, mineral, and fiber content contributes to a number of health advantages. It is a great option for weight management because it is low in calories (Ataguba & Orji, 2025). It also has notable levels of potassium, foliate, vitamin K, and vitamin C (Hoque, 2023). Anthocyanins, strong antioxidants that aid in preventing inflammation and oxidative stress, are responsible for the purple pigmentation of the skin (Ibrahim et al., 2021; Khan et al., 2022). By lowering cholesterol, eggplant's high dietary fiber content also promotes cardiovascular health and facilitates digestion (Guil-Guerrero et al., 2019).

In terms of cooking, aubergine is a common component of many international cuisines, such as Middle Eastern, Asian, and Mediterranean cuisines (Ruhlman, 2006). It is an essential ingredient in classic recipes like moussaka, baba ghanoush, and aubergine Parmesan, and it may be prepared in a variety of ways, including grilling, frying, baking, and stuffing (Berman, 2024). Furthermore, it is occasionally turned into pickled goods, jams, and sauces (Suresh & Kumar, 2020).

Sucking Insect Complex in Eggplant and Its Impact on Yield

By interfering with physiological functions, including photosynthesis and food intake, sucking insect pests have a major effect on aubergine production (Zheng et al., 2024). These insects, which include jassids (Amrasca biguttula biguttula), whiteflies (Bemisia tabaci), and aphids (Aphis gossypii), drain plant sap and inject toxic saliva, causing leaf chlorosis and decreased photosynthetic efficiency (Prabakar et al., 2016). Long-term feeding causes nutritional depletion, which impairs fruit quality and formation. As a result, plants develop more slowly, harvest later, and produce less overall (Rai et al., 2019; Chaudhary et al., 2020).

The sucking pest complex has significant economic ramifications, particularly in regions where aubergine is the main crop (Rani et al., 2020). These pests cause yield losses of 20% to 50%, with the greatest losses happening during times of peak infestation (Yadav et al., 2017). Chemical pesticides are commonly used by farmers to control these pests; however, this strategy has resulted in long-term health and environmental issues (Jiang & Wang, 2025). Pests have become more resistant as a result of ongoing pesticide use, making pest control more difficult (Venkatesan et al., 2019; Basha et al., 2021).

Environmental Factors Influencing Population Fluctuations of Sucking Insect Pests

Temperature, humidity, precipitation, and natural predators are some of the environmental elements that affect the population dynamics of sucking insect pests in eggplant fields. The intensity and length of insect infestations are greatly influenced by these variables (Singh & Yadav, 2019). The development, reproduction, and survival of sucking insect pests are all greatly impacted by temperature. Higher temperatures have been shown to speed up growth and boost reproductive output in species like whiteflies and aphids (Subedi et al., 2023). Extreme heat, however, can have a detrimental effect on fecundity and survival. Aphid populations, for example, flourish in temperatures between 20°C and 30°C, declining above 35°C (Elbasyoni & Elbana, 2017). The distribution of whiteflies is also impacted by differences in development across climatic zones (Suleman et al., 2017).

The dynamics of insect populations are also significantly influenced by humidity. Particularly in tropical and subtropical regions, high humidity levels promote the growth of plants and the introduction of pests (Shafiq et al., 2024). High relative humidity, for instance, increases the survival and reproduction rates of aphids and whiteflies (Rodríguez et al., 2020). On the other hand, extended drought conditions can cause water stress, which lowers insect populations and causes seasonal variations in pest populations (Belewu et al., 2018). Additionally, wind can affect how sucking pests spread, enabling species like aphids and whiteflies to quickly move across diverse geographic areas (Chanchala, 2025). When climatic conditions are favorable, wind-assisted dispersal helps cause abrupt increases in pest populations (Matinga et al., 2018). Seasonal variations also affect pest numbers; in temperate regions, colder winter temperatures reduce populations, while warmer growing season temperatures encourage rapid insect multiplication (Morris et al., 2021; Horton & Gowda, 2018).

Comparative Effectiveness of Botanical vs. Synthetic Pesticides

Aphids, whiteflies, and jassids are among the sucking insect pests that seriously threaten aubergine output, leading farmers to implement a variety of pest management techniques (Mandal, 2019). Synthetic chemical pesticides, which are the mainstay of conventional approaches, are effective but have sparked worries about their effects on the environment, pesticide resistance, and potential health risks to humans (Khan et al., 2020). Because of their natural nature and lower toxicity to organisms that are not their intended target, botanical pesticides have thus drawn attention as sustainable alternatives (Isman, 2021).

By means of neurotoxic and metabolically disruptive actions, synthetic insecticides manage sucking pests (Kougias, 2018). In aubergine farming, common chemical groups including pyrethroids and organophosphates are frequently utilised (Hussain et al., 2020). Yet, an over-dependence on these chemicals has caused key pests to develop pesticide resistance, endangering beneficial insects and compromising water and soil supplies (Georghiou, 2022; Riley et al., 2021).

An environmentally beneficial substitute for chemical pesticides is botanical pesticides, which are made from plants that contain bioactive components (Dalavayi Haritha et al., 2021). Alkaloids, terpenoids, flavonoids, and essential oils are examples of bioactive compounds that have insecticidal, repellant, or growth-inhibitory qualities (Duraimurugan et al., 2021). Garlic oil, chilli pepper extract, and neem (Azadirachta indica) have all demonstrated effectiveness in controlling sucking insects. Because azadirachtin is a crucial bioactive ingredient, neem-based formulations in particular have been thoroughly researched for their capacity to interfere with insect development and reproduction (Schmutterer, 2002).

Botanical pesticides have shown similar outcomes when incorporated into pest management strategies, despite the fact that synthetic pesticides offer quicker pest control. Neem oil and garlic extract dramatically decreased aubergine aphid populations, according to a study by Ayyadurai et al. (2018). Their efficacy was comparable to that of synthetic pyrethroids. However, under varying environmental conditions, botanical pesticides may be less consistent and have a tendency to work more slowly (Koul et al., 2020). Botanicals decompose more quickly and are generally safer for biodiversity and human health than synthetic pesticides, which carry the dangers of residue buildup and environmental contamination (Lima et al., 2019).

METHODOLOGY

The field experiment was conducted at the Department of Plant Protection, Sindh Agriculture University, Tandojam, under semi-arid climatic conditions favorable for brinjal cultivation. A Randomized Complete Block Design (RCBD) was employed with six treatments, including neem oil (3%), neem seed kernel extract (5%), tobacco extract (3%), eucalyptus extract (3%), a synthetic pesticide (standard chemical control), and an untreated control, each replicated thrice in plots measuring 4 × 3 meters with appropriate plant spacing. Biopesticides preparations involved diluting neem oil and NSKE with water and a few drops of liquid soap, soaking 500 g of tobacco leaves in 10 liters of water for 24 hours, and boiling crushed eucalyptus leaves, followed by filtration. All treatments were sprayed early in the morning using a knapsack sprayer, applied weekly for six weeks post pest infestation. Insect pest populations (whiteflies, jassids, aphids, and thrips) were monitored weekly from five randomly selected plants per plot using a hand lens and leaf tap method. Pest reduction percentage was calculated by comparing treated and control populations. Yield parameters such as the number of marketable fruits per plant and total yield per plot (kg) were recorded, along with a cost-benefit analysis. The collected data were analyzed using ANOVA, and treatment means were compared using the Least Significant Difference (LSD) test at a 5% significance level through statistical software.

RESULT AND DISCUSSION

Sucking Insect Pests of Brinjal

By removing plant sap, sucking insect pests like aphids (Aphis gossypii), jassids (Amrasca biguttula biguttula), whiteflies (Bemisia tabaci), and thrips endanger brinjal crops by weakening the plants, halting growth, and lowering yield quality (Rani et al., 2020). To make matters worse, these pests are also carriers of viral illnesses such as tomato yellow leaf curl virus (Kammara et al., 2023). Brindal is impacted by root knot nematodes, which infest roots and cause galls to form. Their population dynamics are influenced by temperature and humidity, with warmer and somewhat humid circumstances encouraging their growth (Malik et al., 2024). Several insect species have developed resistance as a result of an over-reliance on chemical pesticides, and implementing integrated pest management (IPM) techniques is necessary (Wang et al., 2024). These strategies have demonstrated promise in lowering pest populations and minimizing yield losses sustainably. They include the use of resistant brinjal types, biological controls like natural predators and parasitoids, and environmentally benign techniques like neem-based sprays (Mandal, 2019).

Effectiveness of Biopesticides

For the management of illnesses and sucking insect pests, biopesticides, which are made from natural sources such as plant extracts, microbes, and their metabolites, offer a sustainable and efficient substitute for chemical pesticides (Ayilara et al., 2023). These natural chemicals minimise damage to beneficial insects and non-target species while being very effective against pests like aphids, thrips, jassids, and whiteflies (Khursheed et al., 2022). Products made from neem, like those that include azadirachtin, hinder the feeding and reproduction of pests, which helps to lower their numbers. Furthermore, microbial agents such as Beauveria bassiana and Bacillus thuringiensis have demonstrated efficacy in controlling and eradicating these pests while maintaining cost-effectiveness (Thakur et al., 2020).

In addition to addressing the growing problem of pest resistance and avoiding toxic chemical pesticides, the use of biopesticides encourages sustainable farming practices by lowering hazards to the environment, human health, and animals (Fenibo et al., 2022). Biopesticides have greatly increased crop health and yield while preserving environmental integrity in pest-prone areas such as South Asia (Beehag et al., 2016).

Neem-Based Biopesticides

Extracts from neem (Azadirachta indica), including neem oil and neem seed kernel extract (NSKE), are known to be useful in the sustainable management of agricultural pests (Sharma & Kole, 2019). Neem contains the bioactive chemical azadirachtin, which is very effective against pests including aphids, jassids, and whiteflies, since it interferes with their feeding, growth, and reproduction (Adhikari et al., 2020). Products made from neem have been demonstrated to disrupt the life cycles of pests by lowering fertility and preventing moulting (Rahal et al., 2019). According to Ara and Haque (2021), these devices are also environmentally friendly because they kill destructive sucking insects while causing little harm to beneficial insects like pollinators and natural predators. Field applications of neem extracts have demonstrated significant success, with reductions in whitefly and jassid populations reaching up to 80% and 75%, respectively (Mohapatra et al., 2024). Additionally, neem integrates well with other pest control strategies, enhancing its role in sustainable agriculture and integrated pest management systems, where it contributes to healthier crops and reduced reliance on synthetic chemicals (Samanta et al., 2024).

Table 1. Pest Reductions %

Treatment	Pest Reduction
Neem oil (3%)	75
NSKE (5%)	72
Synthetic Pesticide	85

The data above indicates that neem biopesticides are almost as effective as synthetic chemicals but with fewer risks to the environment.

Eucalyptus and Tobacco Extracts

Extracts from eucalyptus (Eucalyptus globulus) and tobacco (Nicotiana tabacum) are also effective in harmful insect pest management (Abdelkhalek et al., 2020; Khoso et al., 2025). Eucalyptus oil, rich in eucalyptol, deters pests by disrupting their feeding behavior and meting thrips while nicotine in tobacco affects pest nervous systems (Ntalli et al., 2022). Field trials revealed that these extracts reduced thrip populations by approximately 65% (Munyoki et al., 2024).

Comparative Analysis of Biopesticides and Synthetic Pesticides

A comparison between synthetic pesticides and biopesticides shows that while synthetic options work quickly, the biopesticides work slowly, they contribute to pest resistance, environmental toxicity, and harm to non-target organisms. Biopesticides, on the other hand, offer gradual but sustainable pest control (Daraban et al., 2023).

Table 2. Parameter Synthetic Pesticide Biopesticides

Parameter	**Synthetic Pesticides**	**Biopesticides**
Speed of Action	Fast	Moderate
Residual Toxicity	High	Low
Pest Resistance	Common	Rare
Environmental Safety	Poor	Excellent
Cost	Moderate to High	Low to Moderate

Impact on Yield and Economic Feasibility

Biopesticides play a crucial role in improving crop yields and ensuring economic sustainability in agriculture (Hezakiel et al., 2024). Their application promotes ecologically friendly practices, supports soil health, and improves pest management (Singh et al., 2024). According to experiments carried out in various locations, applying biopesticides increased brinjal yields by 25% to 30% and reduced sucking insect assaults, proving their efficacy in comparison to traditional pesticides (Ravindra et al., 2021). Despite the greater initial cost, biopesticides are a cost-effective choice because of their long-term advantages, which include decreased pest reappearance, increased soil microbial activity, and compliance with food safety regulations (Vermelho et al., 2024). Furthermore, by reducing pesticide residues in crops, biopesticides increase crop yield marketability and satisfy export regulations (Lengai et al., 2022). By lowering input costs and preserving ecological balance, biopesticides further increase economic returns when combined with sustainable agricultural practices like crop rotation and the use of natural predators (Baker et al., 2020). These benefits establish biopesticides as a crucial element in attaining sustainable farming systems and increased agricultural output (Fusar & Fontefrancesco, 2024).

Challenges and Future Directions

Biopesticides have drawbacks despite their benefits, including slower action, varying effectiveness in various settings, and restricted access for farmers in some regions (Mounaimi et al., 2024). More study is required to improve their formulations, increase their stability, and expand their availability. For example, farmer education programs and former field schools may be able to promote the use of biopesticides (Constantine et al., 2020).

CONCLUSIONS AND RECOMMENDATIONS

Considering the results, the study concludes that Neem, asafetida, thorn apple, eucalyptus, and tobacco-based natural biopesticides are useful instruments for controlling sucking insect pests in brinjal crops. They offer a healthier, more environmentally friendly substitute for artificial chemicals, boosting productivity and safeguarding ecosystems. Synthetic pesticides provide quick fixes, but their long-term drawbacks highlight the need to switch to sustainable pest management techniques. Their wider usage will be greatly aided by developments in biopesticides, farmer field schools, and farmer training.

With regards to the literature and the results, the study recommends that biopesticides should be applied for pest control as such pesticides are eco-friendly and are less or no more means of harmful to farming communities, specifically for brinjal crops. Since biopesticides are less economical as well as easier to apply. Besides that, the policy measures and protective measures should be taken for sustainable development.

FURTHER STUDY

This research still has limitations, so it is still necessary to conduct further research on the topic.

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