Krishi Netra
ISSN : 3048-5207

"Winning the Battle: Successful Biological Control of Invasive Insect Pests in India"

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Manuscript No: KN-V3-03/007

Abstract

Invasive insect pests pose a significant threat to India's agriculture, causing severe crop losses and economic distress. Biological control, using natural enemies like parasitoids, predatory insects, and microbial agents, has emerged as a sustainable solution to manage these pests. Success stories, such as the control of Eucalyptus Gall Wasp, Fall Armyworm, and South American Tomato Pinworm, highlight the effectiveness of eco-friendly pest management. By reducing reliance on chemical pesticides, biological control ensures long-term agricultural sustainability and protects farmers' livelihoods.

Keywords: Invasive insect pests, biological control.

Introduction

Invasive species cause enormous financial losses and are one of the biggest and fastest-growing dangers to forests, livelihoods, human and animal health, and agricultural biodiversity. Insect pests classified as invasive are exotic or non-native species that exist outside of their natural environment and potential for dissemination. But when invasive insect pests are purposefully or inadvertently brought into new locations where they have the capacity to establish, invade, and outcompete native species, they become invasive. The International Union for Conservation of Nature and Natural Resources (IUCN) defines an invasive insect pest as one that threatens native biological diversity by establishing itself in natural or seminatural ecosystems or habitat. Invasive species can be found all over the world in a variety of environments. International agricultural trade has expanded as a result of globalization, and the flow of seeds and planting materials has raised the possibility that invasive insect pests may be introduced into India. These insect pests have the capacity to increase significantly and harm crop plants and other economically significant plant species. The lack of natural enemies and favorable environmental conditions causes invasive insect pests to spread to newly introduced areas. Through legislative measures, the National Plant Protection Organizations (NPPO) have reduced the unintentional or deliberate spread of plant pests into more recent regions.

Biological Control

The utilization of an organism's natural enemies to lower its population density is known as biological control. This strategy has been acknowledged as one of the most successful, economical, and long-term methods for controlling invasive species. The host population can be reduced by natural enemies such as parasites, herbivores, predators, and viruses; the quantity of the host also affects the natural enemies' population levels. All of the main taxonomic groups—viruses, fungus, ferns, algae mosses, higher plants, invertebrates, fish, amphibians, reptiles, birds, and mammals—have invasive alien species. The traits of invasive species include hardiness, longevity, voracity, aggressive widespread distribution, rapid growth, resilience, a broad diet, long-distance mobility, and prolific reproduction. These are non-native or exotic creatures that exist outside of their naturally occurring habitat and potential for spread. However, when intentionally or accidentally transported outside of their natural habitats into new places where they have the ability to invade, establish, and outcompete local species, some invasive insect pests turn become invasive species. Through legislative measures, the National Plant Protection Organizations (NPPO) have reduced the deliberate, unintentional, or accidental introduction of plant pests into more recent locations.

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Successful Biological Control of Eucalyptus Gall Wasp in India

The Eucalyptus Gall Wasp (Leptocybe invasa), a serious pest affecting eucalyptus seedlings and coppices, was first detected in India in 2001. This invasive pest caused significant economic damage to eucalyptus plantations, severely impacting the paper industry. In response, ICAR-NBAIR, with support from the Indian Paper Manufacturers Association (IPMA), initiated a classical biological control program. Between 2008 and 2010, three parasitoid species—Quadrastichus mendeli, Megastigmus viggiani, and Selitrichodes kryceri—were imported from Israel and introduced into affected areas. Within two years of their release, an estimated 80,000 hectares of eucalyptus plantations showed significant recovery. These parasitoids effectively suppressed the gall wasp population by targeting suitable stages of galls for oviposition, particularly in young infestations. As a result, Leptocybe invasa, once a major threat, has now been reduced to a minor pest. This successful biological control effort has helped restore eucalyptus plantations, ensuring the sustainability of the paper industry in India.

Biological Control of Rugose Spiraling Whitefly in India

The Rugose Spiraling Whitefly (Aleurodicus rugioperculatus), a highly polyphagous invasive pest, was first reported in India on coconut plantations in Pollachi, Tamil Nadu, in 2016 by scientists from ICAR-NBAIR, Bengaluru. This pest quickly spread across multiple states, including Kerala, Andhra Pradesh, Karnataka, Telangana, Assam, Goa, West Bengal, Maharashtra, and Gujarat, infesting a wide range of crops such as banana, sapota, maize, oil palm, mango, and cashew, along with various ornamental plants. Initially, chemical control methods proved ineffective against this pest, leading researchers to explore biological control solutions. The introduction of the parasitoid Encarsia guadeloupae and the entomopathogenic fungus Isaria fumosorosea has successfully managed whitefly populations in farmers' fields. This environmentally friendly approach has helped curb the damage caused by RSW, ensuring sustainable pest management for affected crops across the country.

Successful Biological Control of Invasive Fall Armyworm in India

The Fall Armyworm (Spodoptera frugiperda), a highly invasive and polyphagous pest, was first detected in India in 2018 in maize fields in Karnataka. Since then, it has rapidly spread across the country, affecting major crops such as maize, sorghum, finger millet (ragi), pearl millet (bajra), sugarcane, rice, cotton, and wheat, with varying damage intensities. The infestation has been severe in Karnataka (44-100%), Maharashtra (4-100%), Andhra Pradesh (4-30%), Gujarat (20-25%), Rajasthan (5-10%), and Punjab (10-25%). The widespread damage to staple and cash crops posed a significant threat to India's agricultural economy, necessitating urgent and sustainable pest management solutions.

To combat this invasive pest, ICAR-NBAIR developed an integrated biological control strategy. Monitoring through pheromone traps (10 traps per acre) helps in early detection, while the release of the egg parasitoid Trichogramma chilonis (100,000 adults per hectare, with 2-3 releases at weekly intervals) effectively suppresses FAW populations. Additionally, microbial insecticides such as Bacillus thuringiensis (Bt) (2g/L) and Metarhizium anisopliae (5g/L) have proven effective in controlling larval stages. The application of entomopathogenic nematodes (Heterorhabditis indica NBAIR H38) as whorl sprays (4kg/acre) further aids in reducing pest populations. These eco-friendly measures have played a crucial role in mitigating FAW infestations, demonstrating the success of biological control in managing invasive insect pests in India. By adopting these sustainable pest management practices, farmers can protect their crops while minimizing reliance on chemical pesticides, ensuring long-term agricultural productivity.

Biological Control of Thrips parvispinus in India

India's agriculture faces a growing threat from invasive insect pests, which cause severe crop losses and

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economic distress for farmers. Among these, Thrips parvispinus, an invasive species of quarantine significance, has wreaked havoc on chili cultivation across Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, and Maharashtra. Though first reported in India in 2015, its outbreak in October 2021 led to widespread damage, affecting all chili cultivars. Infested plants exhibited reddish-brown lower leaves, yellowing upper surfaces, upward leaf curling, and severe flower desiccation, ultimately leading to reduced fruit set and drastic yield losses.

Recognizing the urgency of sustainable management solutions, ICAR-NBAIR introduced biological control agents to curb the spread of Thrips parvispinus. Several strains of beneficial microbes and fungi were evaluated, including Pseudomonas fluorescens (NBAIR-PFDWD), Metarhizium anisopliae (NBAIR Ma4), Beauveria albus (NBAIR-BATP), and Beauveria bassiana (NBAIR Bb5a). Additionally, a consortium of PFDWD and BATP was tested for enhanced effectiveness. Field trials conducted in Chintamani, the University of Agricultural Sciences (UAS) Raichur, and Anand Agricultural University (AAU) in Anand demonstrated remarkable success, achieving a 50–80% reduction in thrips populations.

Biological Control of South American Tomato Pinworm

The South American Tomato Pinworm (Tuta absoluta), an invasive pest, was first reported in India in 2014 and has since caused severe damage to tomato crops. This pest is notorious for its ability to destroy up to 90% of the yield by tunneling into leaves, stems, and fruits, leading to significant economic losses for farmers. Given its rapid spread and resistance to chemical pesticides, an effective and sustainable management strategy was urgently needed.

To combat this destructive pest, biological control methods have been successfully implemented. The egg parasitoid Trichogramma pretiosum has been introduced to target and parasitize the pest's eggs, preventing further infestations. Additionally, the predatory bug Nesidiocoris tenuis has been used to feed on Tuta absoluta larvae, reducing their population naturally. The application of Bacillus thuringiensis (Bt), a microbial insecticide, has further helped suppress larval development without harming beneficial organisms. These eco-friendly solutions have proven highly effective in managing Tuta absoluta infestations in tomato-growing regions of India, offering farmers a sustainable alternative to chemical pesticides while ensuring better crop protection and yield stability.

Conclusion:

Biological control offers a sustainable and eco-friendly solution to managing invasive insect pests in India, reducing dependence on harmful chemical pesticides. By harnessing the power of natural enemies, farmers can protect their crops, improve yields, and ensure long-term agricultural stability. Continued research and collaboration among scientists are crucial for refining these strategies and addressing ecological challenges. With large-scale implementation, biocontrol can help safeguard India's agriculture, promoting a healthier environment and a more resilient farming community.

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ISSN : 3048-5207

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Source: www.nbair.res.in