The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(2): 305-310, 2025 www.thebioscan.com

Natural Management Strategies for Jassids in Agriculture Systems: A Comprehensive Review

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DOI: 10.63001/tbs.2025.v20.i02.pp305-310

KEYWORDS
Jassids, Natural Management, Botanical Pesticides, Entomopathogens, Biological Control, Natural Enemies, Integrated Pest Management, Sustainable Agriculture

Received on:
20-04-2025

Accepted on:
20-05-2025

Published on:
22-06-2025

ABSTRACT
Jassids (Hemiptera: Cicadellidae) are significant agricultural pests that damage various crops, including legumes, cotton,chili, okra, and eggplant, causing substantial yield losses through direct feeding and the transmission of viruses. However, the use of synthetic pesticides in conventional management has resulted in environmental deterioration and health hazards, including the development of insecticide resistance, adverse effects on non-target organisms, pesticide residue contamination, biodiversity loss, and farmer exposure to toxins. This review synthesizes current research on natural management strategies within integrated pest management (IPM) frame works, evaluating their effectiveness, ecological benefits, and alignment with sustainable agriculture. Natural methods emphasize that biological pesticides, such as those derived from neem (e.g., neem seed kernel extract and neem oil), have consistently demonstrated effectiveness in suppressing jassid populations. Additionally, beneficial fungi, such as *Beauveria bassiana*, *Lecanicillium lecanii*,and *Metarhizium anisopliae*, are recognized for their potential in biological control. Moreover, conserving and enhancing populations of natural enemies, such as various predators (e.g., spiders, lacewings, ladybird beetles, and syrphid flies), plays a crucial role in keeping jassid densities below the Economic Threshold Level (ETL), supporting density-dependent regulation. These approaches decrease dependency on chemical pesticides, reduce soil and water contamination, and protect non-target species, including pollinators. This review underscores the urgent need to transition from chemical-intensive practices to sustainable, natural approaches, ensuring agriculture aligns with long-term health and environmental sustainability goals.

INTRODUCTION
Jassid (*Amrasca devastans/biguttula*), a leafhopper (Hemiptera: Cicadellidae), is a major pest in tropical agriculture, attacking okra, chilli, cotton, brinjal, tomato, potato, groundnut, castor, maize, and legumes (Chaudhary and Dadeech, 1989; Chandrasekaran *et al.*, 2021; Devi *et al.*, 2018). Its infestation occurs at the earliest stages of crop growth and lasts till harvest, depending upon agro-climatic circumstances. The nymphs and adults suck the sap from leaves, leading to phytotoxic symptoms called hopper burn, which causes plants to completely desiccate. (Jayarao *et al.*, 2015; Singh *et al.*, 2014). Kouadio *et al.*, (2024) reported damaging species of jassid such as *Jacobiasca lybica*, *Empoasca papaya*, *Empoasca facialis*, and *Amrasca biguttula* in the Ivory Coast.

Amrasca biguttula venile (jassid) damages juvenile seeds and mature crops, causinga 50% reduction in yield (Halder *et al.*, 2016). In Turkey, jassids are major pests of cotton that reduce cotton yields by 35-55% and cause 35-55% loss in fruiting parts (Atakan, 2009). *Empoascakerri* (jassid) causes a significant reduction in the yield of green gram and other legumes (Raut *et al.*, 2019).The green leafhopper (*Empoascadecipiens*) is an important vegetable pest in European greenhouses, resulting in fruit damage and yellowish staining of leaves (hopperburn) (Tounou *et al.*, 2003; Kodjo *et al.*, 2011).

Traditionally, this pest has been controlled by the large-scale use of synthetic insecticides. Nonetheless, the dependence has led to several ecological and agricultural issues, such as the development of insecticide

resistance, bioaccumulation of chemical residues, environmental pollution, and negative impact on non-target beneficial organisms (Ambethgar, 2009; Bhattacharyya *et al.,* 2022; Kouadio *et al.,* 2024; Naveed, 2023). The overuse of synthetic pesticides not only leads to resistance, also pollutes food, affects natural enemies, and imbalances the ecology (Naveed, 2023; Raghavendra *et al.,* 2016; Ghosh, 2020). Some species, such as *Amrasca bigutula* and *Amrasca devastans*, are proven to be resistant to organophosphates (Ambethgar, 2009). These conditions require an approach to alternatives, safer and sustainable pest management.

Plant-based extracts and compounds have become an attractive option for jassid control due to their various insecticidal, antifeedant, repellent, and insect growth regulatory activities, as well as their biodegradability and fewer harmful environmental effects compared to synthetic chemicals (Ahmad, 2020; Miah *et al.,* 2019).

The entomopathogenic agents, particularly fungi and bacteria, have emerged as potential biocontrol agents for jassids, being target-specific and environmentally safe as compared to chemical pesticides (Ambethgar, 2009; Halder *et al.,* 2021; Singh *et al.,* 2017).Robert and Hajek (1992) said that fungi are distinct from other pathogenic microorganisms that infect directly through the insect cuticle, making them effective against sucking insect pests like leafhoppers. Huffaker *et al.,* (1971) thoroughly examine the theory of natural control, highlighting density-dependent regulation where natural enemies play a crucial role in keeping population levels within certain boundaries. They point out that effective biological control often relies on enemies with high searching ability, strong reproductive capacity, and adaptability to environmental conditions.

This review assesses eco-friendly jassid management techniques,such as the applicationof botanical insecticides, entomopathogenic fungi, and management through natural enemies. The objective is to minimize dependence on synthetic pesticides through the provision of an integrated approach for sustainable jassid management in agriculturalsystems.

BOTANICAL APPROACHES

Botanical products have emerged as attractive biopesticides that offera low-cost natural alternative to synthetic insecticides and reduced environmental impact, being less toxic to non-target organisms. Sakthivel *et al.,* (2012) found that neem oil (3%), FORS (fish oil rosin soap) (2%) and pongamia oil (3%) were the only botanicals that exhibited a reduction in jassid population of 48.73, 46.88 and 42.49%, respectively, whereas NSKE (neem seed kernel extract) (5%) had the minimum reduction on jassids 33.59% at 1 DAS (days after spray). The maximum reduction, 72.64% was found in the synergistic effect of neem oil + FORS, followed by neem oil + pongamia oil (60.16%) and pongamia oil + FORS (62.81%). Biswas (2015) also reported a 65.07% reduction in jassid populations on groundnut crops by combining detergent with crude neem seed mixture (NSM). Rehman *et al.,* (2015) evaluated the efficacy of neem oil at different concentrations (1% to 5%) against jassids on eggplant. Based on the study, the greatest decrease in jassid populations (88.48%) occurs at 3%, 4%, and 5% neem oil concentrations. Siddiqua *et al.,* (2016) reported a significant reduction in jassid population on a cotton field using nine botanicals, including black paper powder, chilli powder, coriander powder, turmeric powder, neem leaf extract, garlic extract, *Eucalyptus* oil, mahogany oil, and neem oil. These botanical treatments were also safe for natural enemies such as ants, spiders, and ladybird beetles. Miah *et al.,* (2019) reported that leaf extract of allamanda, basil, neem, chilli powder, coriander powder, garlic extract, mahogany oil, and neem oil were effective treatments for the control of jassid populations in okra fields. Arshad *et al.,* (2019) reported high efficacy of *Azadirachtaindica* (70–80%) and *Meliaazedarach* (35–40%) on Bt cotton. Raut *et al.,* (2019) reported that neem oil, datura leaf extract, *Eucalyptus* oil, karaj oil, and madar leaf extract were significantly effective against jassids (*Empoascakerri*) in green gram fields.

Ahmad (2020)evaluated the effectiveness of botanicals against the jassid population in okra crops. Results revealed that *Azadirachta indica, Nicotiana tabacum, Cassia fistula, Citrus aurantium,* and*Acacia nilotica* control 70% jassid populations. Kumar *et al.,* (2021) found that neem oil 3% (30ml/l)reduced the jassid population 65-82% in an okra field. Khadka *et al.,* (2023) used some natural insecticides like cow urine, mugwort, agri-spray oil (99% EC), *Eucalyptus*, tobacco, and neemoil to control the jassid population in an okra field. The greatest percentage of population reduction over control of Jassids was seen in agri-spray oil (74.27%), followed by tobacco (62.57%) and neem oil (59.69%). Bali *et al.,* (2022) recorded that neem oil, garlic oil, and pongamia oil were significantly effective against jassids (*Amrascabiguttla*) on cluster bean, achieving a 32.67% reduction. Naveed *et al.,* (2023) evaluate the efficacy of botanical extract against jassids in an okra field. The study found that *Nicotianatabacum* achieved the highest jassid mortality (78%), followed by *Ferula assafoetida* (77%) and *Citrulluscolocynthis* (63%), demonstrating their potential as sustainable biopesticides. Aktar and Banu (2024) found that garlic extract, neem oil, mustard seed extract,tobacco leaf extract, and papaya leaf extract were efficient against leafhoppers on brinjal crops. Neem oil and tobacco reduced jassid populations by 57.73% and 50.83%, respectively. Thakar *et al.,* (2024) stated that the application of *Azadirachtin* and *Lecanicilliumlecanii* brought down the jassid population to 1.82 per leaf; both the neem seed kernel extract (NSKE) alone and NSKE along with cow urine also gave good control. Ghosh and Charkroborty (2015) assessed the extract of *Pongamiapinnata* and *Polygonumhydropiper* on the jassid population on

ladyfinger. *Polygonum* extract reduced 60% while *Pongamiapinnata* reduced 50% jassid population. All of these studies demonstrated a significant potential of botanicals in the management of jassid populations.

ENTOMOPATHOGENIC APPROACH

Entomopathogenic fungi act as natural control agents by infecting Jassids by penetrating their cuticles.It grows in humid tropical weather. According to Singh et al. (2017), entomopathogenic fungi such as *Beauveriabassiana* have a wide host range and efficiently target arachnids like mites and ticks as well as insects like wasps, fire ants, bark beetles, and mole crickets. Through conidiogenesis and cuticle penetration, the fungus infects all stages of development, including eggs, larvae, pupae, nymphs, and adults, generating extracellular enzymes that break down insect tissues.Jugno *et al.,* (2018) demonstrated that *Metarhiziumanisopliae* and *Bacillusthuringiensis* significantly reduced the jassid population in brinjal crops. *M. anisopliae* showed an 85% reduction in jassid populations. Halder *et al.,* (2021) found combination of the entomopathogenic fungi such as *Beauveriabassiana*, *Metarhiziumanisopliae*, and *Lecanicilliumlecanii* with neem oil showeda 65.15% reduction in jassid populations in an okra field.Yun et al. (2009) reported that the continuous spraying of *Verticilliumlecanii* effectively reduced 80% of the leafhopper population from peach trees. Robert and Hajek (1992) effectively used *Zoophthoraradicans* to control leahopper populations in the United States and Brazil. Bali *et al.,* (2022) observed that *Beauveriabassiana*, *Metarhiziumanisopliae*, and *Bacillusthuringiensis* reduced 30-40% of the jassid population in the cluster bean field. Kodjo *et al.,* (2011) found that *Beauveriabassiana*, *P. fumosoroseus*, *Metarhiziumanisopliae*, and*Verticilliumlecanii*cause 60-98% mortality to nymphs of leafhoppers. Ibrahim *et al.,* (2021) state that *M. anisopliae* efficiently controls the nymph and the adult stages of green leafhoppers. Upamanya *et al.,* (2023) observed that *Beauveriabassiana* and *Metarhiziumanisopliae* reduced the jassid population by 51.74% and 57.74 % respectively.

NATURAL ENEMIES

Natural enemies are essential in reducing jassid populations because they provide a long-lasting and self-sustaining control strategy. Wagan *et al.,* (2015) reported spiders, ladybird beetles, ants (*Solenopsis geminata*), and green lacewings (*Chrysoperla carnea*) as the main jassid predators on okra. Spider populations were highest (3.52/spot) at the 10th week, which corresponded with increases in jassid populations, while ladybird beetles and ants reached 2.16 and 2.81 per spot, respectively. Patel and Radadia (2018) studied about natural enemies of jassid *(Amrasca biguttula*) in cotton at Bharuch, India, during kharif season 2015–16 and 2016-17, and found ladybird beetles, spiders, and *Chrysopids* (lacewings) as the important predators, ladybird beetles and spiders were found to reduce jassid population in cotton, and their density was positively related to the presence of the pest, indicating density-dependent predation. Kumar *et al.,* (2018) also recorded spiders, ladybird beetles, green lacewings, and syrphid flies as natural enemies in the brinjal field. Borkakati et al., (2018) found five species of *Coccinellid* predators on brinjal crops, including *Coccinellatransversalis*, which is a dominant and significant predator of leafhoppers and aphids.Kumari *et al.,*(2023) documented seven key natural enemies: ladybird beetles (*Coccinella septempunctata*), syrphid flies (*Syrphus corollae*), rove beetles (*Paederus fuscipes*), black ants (*Lasius niger*), green lacewings (*Chrysoperla carnea*), praying mantids (*Mantis religiosa*), and spiders *(Neozona theisi).* All natural enemieswere effective in suppressing sucking pest populationsin brinjal crops.

Lal *et al.,* (2019) demonstrated the positive effects of farmscaping (e.g., planting marigolds) in enhancing the abundance of generalist predators (e.g., ladybird beetles, syrphid flies, and predacious wasps), which can lead to the overall suppression of insect pests. Huffaker et al., [1971] stated that natural enemies are the most controllable aspect of natural control, and Jonsson et al., [2017] advocated for the conservation of the biodiversity of natural enemies to improve biological control, especially as a safeguard against the effects of climate change. Natural enemies are essential for controlling jassid populations, and their abundance is a key factor in regulating these populations. Therefore, conserving and enhancing them is an important part of natural control.

CONCLUSION

This review concluded that jassid is one of the main pests of cotton and okra, causing significant yield loss by sucking plant sap and leading to hopper burn. Various plant extracts, including neem, tobacco, *Acacia nilotica, Ferula assafoetida, Citrullus colocynthis,* garlic, *Adhatoda vasica, Calotropis gigantea, Lantana camara, Pongamia pinnata, Vitex negundo,* and *Parthenium hysterophorus,* have shown significant insecticidal and antifeedant activities. The entomopathogenic fungi *Beauveria bassiana, Lecanicillium lecanii (formerly Verticillium lecanii), Metarhizium anisopliae,* and *Bacillus thuringiensis* are effective microbial agents, and their combination with botanicals offers synergistic effects that increase jassid mortality. Importantly, these natural methods cause minimal harm to beneficial natural enemies such as spiders, ladybird beetles, and lacewings, which are vital for natural pest control. Incorporating these botanical, entomopathogenic, and natural enemy-based approaches into an IPM program can ensure sustainable and effective control of jassids, reducing reliance on chemicals and promoting healthy agro ecosystems.

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