

Plant-Derived Bioinsecticides Against *Helicoverpa armigera*

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Introduction:

Helicoverpa armigera (Hübner), commonly known as the cotton bollworm or tomato fruit worm, is a highly destructive and polyphagous pest of global concern. It induces disease on over 200 economically important crops, such as cotton, chickpea, tomato, pigeon pea, okra and maize (Ali *et al.*, 2021). The larvae attack the reproductive structures of plants with excessive eating and lead to a direct loss of production and an indirect decrease in the quality of crops. *H. armigera* may also lead to the loss of up to 90 and over 50 percent of yields in pulses and cotton and tomato, respectively (Deepti & Pathma, 2023).

H. armigera control has long been achieved through the use of chemical insecticides. Nevertheless, the high level of dependence on synthetic pesticides has resulted in a high level of resistance among their populations (Rahman *et al.*, 2014). Besides the development of resistance, synthetic pesticide use has also been associated with the issues of environmental pollution, food chain contamination and killing of non-target organisms such as pollinators

and natural enemies (Gopalakrishnan *et al.*, 2011). There has therefore been a great impetus over the past few years in the quest of environmentally responsible and ecologically viable pest management options.

The application of botanical insecticides natural plant-derived compounds, having insecticidal properties, antifeedant properties or repellent properties is one of the promising alternatives. These are botanicals, commonly extracted as seeds, leaves, roots or bark, which are active secondary metabolites in their effect on insect behavior and development including alkaloids, flavonoids, terpenoids, and phenolics (Oparaeke *et al.*, 2006; Shah *et al.*, 2013). As an example, the Azadirachta indica (neem) has been referred to due to its azadirachtin content that interferes with feeding and hormonal balance of insects. Neem-based products have demonstrated high efficacy against *H. armigera*, reducing larval populations by up to 65.7% and improving crop yields (Verma *et al.*, 2024).

Multiple plant species have been studied for their insecticidal potential against *H. armigera*, including garlic (*Allium*

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sativum), tobacco (*Nicotiana tabacum*), turmeric (*Curcuma longa*), tulsi (*Ocimum sanctum*), lantana (*Lantana camara*), and mahogany (*Swietenia mahagoni*) (Ali *et al.*, 2021; Rahman *et al.*, 2014; Deepti & Pathma, 2023). These botanicals act through various mechanisms, including feeding deterrence, contact toxicity and growth inhibition. In addition, biowashes made by mixture of botanicals such as *Annona*, *Jatropha* and *Datura* have exhibited synergistic activity in increasing pest mortality besides being compatible with microbial bioagents such as *Metarhizium anisopliae* and *Bacillus thuringiensis* (Gopalakrishnan *et al.*, 2011).

Another solution is the use of botanical insecticides which are biodegradable as compared to synthetic chemicals, therefore making them environmentally friendly, cheap and safe to humans. They also increase their sustainability in agricultural practice because of their compatibility with Integrated Pest Management (IPM) strategies (Oparaeke *et al.*, 2006). Although they have been proved to be effective, botanical pesticides are yet to be adopted because of lack of standardization, poor performance in the field, and a status of little awareness by farmers.

This article is a synthesis of some major findings of research, which shows a holistic review of the various botanicals that

have been tested against the *H. armigera*. The objective of this is to compare their efficacy, mechanisms of action, and applicability in the field so that environmentally friendly pest management methods can be developed to be used in current sustainable agricultural systems.

Why Botanicals Are Important

The increasing concerns over pesticide resistance, environmental degradation, and food safety have accelerated the shift toward botanical pesticides as a key component of sustainable pest management. Particularly for *H. armigera*, a pest known for its polyphagy and rapid adaptation to synthetic insecticides, botanicals provide a viable, effective and environmentally responsible alternative (Verma *et al.*, 2024).

1. Eco-Friendly and Biodegradable

Botanical insecticides, derived from plants such as neem (*Azadirachta indica*), garlic (*Allium sativum*), and lantana (*Lantana camara*), decompose rapidly in the environment. This reduces residual accumulation and minimizes pollution of soil and water ecosystems. Unlike persistent synthetic chemicals, botanicals have a lower ecological footprint and are generally considered safe for beneficial insects, pollinators, and natural enemies (Gopalakrishnan *et al.*, 2011).

2. Resistance Management

Synthetic pesticides usually target specific neural or hormonal pathways, leading to resistance development in pests like *H. armigera*. Botanicals, however, contain a mixture of secondary metabolites such as azadirachtin, nicotine and allicin that act synergistically through multiple mechanisms, including growth inhibition, feeding deterrence and oviposition disruption. This biochemical complexity reduces selection pressure, thereby slowing the evolution of resistance (Ali *et al.*, 2021).

3. Human and Animal Safety

Botanicals are known for their lower mammalian toxicity. For instance, neem-based products have long been used in traditional medicine and are regarded as non-toxic to humans at typical field application rates (Shah *et al.*, 2013). This makes them particularly valuable in smallholder farming systems, where safety precautions are often minimal and residues on consumable crops pose significant public health risks.

4. Cost-Effective and Locally Available

A major advantage of botanicals lies in their easy availability. Plants such as neem, garlic and turmeric can be sourced locally, allowing farmers to prepare their own extracts without relying on costly commercial formulations (Rahman *et al.*, 2014). This is especially critical in low-resource settings,

where chemical inputs may be economically unfeasible.

5. Compatibility with IPM

Botanicals are highly compatible with Integrated Pest Management (IPM) programs. Because they exhibit selective toxicity and degrade quickly, they do not interfere with the action of biological control agents such as parasitoids and entomopathogenic fungi. Studies have shown that combinations of botanicals and microbial biopesticides, like *Bacillus thuringiensis* and *Metarhizium anisopliae*, maintain or enhance control efficacy without harming beneficial species (Deepthi & Pathma, 2023).

6. Supports Sustainable Agriculture

Adoption of botanical insecticides aligns with the global movement toward sustainable and organic farming. By replacing or supplementing synthetic pesticides, botanicals reduce chemical load in agroecosystems and support biodiversity conservation (Oparaeke *et al.*, 2006). Their integration in field trials has demonstrated substantial reductions in pest populations alongside yield improvements, confirming their role in long-term agroecological sustainability.

Conclusion

Botanical insecticides offer a viable, eco-friendly and cost-effective solution for

Botanicals Used Against *Helicoverpa armigera*

S. No	Botanical Name (Common Name)	Plant Part Used	Dosage / Conc.	Preparation Method	Mode of Action	Efficacy (% Mortality, Yield, etc.)
1	<i>Azadirachta indica</i> (Neem)	Seed kernel, oil	2.5–5%	Crushed seeds soaked in water; filtered; applied as spray	Antifeedant, repellent, growth disruptor	65.7% larval reduction; 31.6% yield increase; 22.29% fruit infestation
2	<i>Allium sativum</i> (Garlic)	Cloves	5% (50 g/L)	Crushed garlic soaked in water; filtered and sprayed	Repellent, neurotoxic	Moderate larval control; 18.4 kg/plot yield
3	<i>Nicotiana tabacum</i> (Tobacco)	Leaves	5% (50 g/L)	Leaves boiled in water with detergent and lime; cooled and filtered	Nicotine-based neurotoxicant	27.7% fruit infestation; 28.6% infestation reduction; 15.95 t/ha yield
4	<i>Curcuma longa</i> (Turmeric)	Rhizome	3.5–5%	Turmeric powder mixed in water; soaked overnight	Antimicrobial, feeding deterrent	15.4% fruit damage; 6.03 t/ha yield
5	<i>Tinospora cordifolia</i> (Giloy)	Leaves	5% (50 g/L)	Leaf extract prepared in water; filtered	Feeding deterrent	Food ingestion reduced to 0.944g/day; delayed death at 6.25 days
6	<i>Swietenia mahagoni</i> (Mahogany)	Seed, oil	Oil: 4 ml/L; Seed: 5%	Oil diluted directly; seed extract boiled with lime and detergent	Feeding inhibitor	30.1% infestation reduction; 18.1 t/ha yield
7	<i>Ocimum sanctum</i> (Tulsi)	Leaves	5%	Aqueous extract, filtered	Antifeedant	Food ingestion reduced to 1.038g/day from 2.297g
8	<i>Lantana camara</i> (Lantana)	Leaves	5%	Aqueous extract, filtered	Repellent, oviposition deterrent	0.985g/day food ingestion vs. 2.297g control
9	<i>Annona</i> , <i>Jatropha</i> , <i>Datura</i> spp. (Biowash combo)	Leaves/seeds	5%	Vermicompost-derived "biowash" + crude extracts	Synergistic larvicidal, ingestion suppressor	81–93% larval mortality, 73–91% weight reduction
10	<i>Eucalyptus</i> + <i>Lemongrass</i>	Leaves	10% + 10%	Combined aqueous extract (equal parts); sprayed at weekly intervals	Synergistic antifeedant	Significant pest reduction in cowpea pods and floral areas

managing *H. armigera*. From widely known botanicals like neem and garlic to regionally potent herbs and essential oils, these natural products not only minimize pest damage but also promote sustainable agriculture. As resistance to synthetic pesticides escalates, integrating botanicals into pest management strategies is no longer optional- it's essential.

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