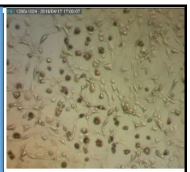
JOBIMB, 2025, Vol 13, No 1, 135-138
https://doi.org/10.54987/jobimb.v13i1.1090

HIBISCUS PUBLISHER

JOURNAL OF BIOCHEMISTRY, MICROBIOLOGY AND BIOTECHNOLOGY

Website: http://journal.hibiscuspublisher.com/index.php/JOBIMB/index



JOBIMB VOL 13 NO 1 2025
Lipid Accumulation Staining

Evaluation of Selected Aqueous Plant Extracts for the Management of *Helicoverpa armigera* (Hubner)

V. Mirunaliniraj[1] and G. Sundararajan[1]*

[1]Department of Botany, Government Arts College, Dharmapuri – 636705, Tamil Nadu, India.

*Corresponding author:
G. Sundararajan,
Department of Botany,
Government Arts College,
Dharmapuri – 636705,
Tamil Nadu,
India.
Email. ID: drgsbotany@gmail.com

History

Received: 20th April 2025
Received in revised form: 21st June 2025
Accepted: 29th July 2025

Keywords

Helicoverpa armigera
Botanical insecticides
Aqueous plant extracts
Integrated pest management (IPM)
Cost–benefit analysis

Abstract

The focus in this study is the investigation of the insecticidal potential of different water-based plant extracts against the pathogen *Helicoverpa armigera*, of which the specific attention is given to LC50 values, suppression of larval population, improved yield in tomato, and overall economic feasibility. It was observed that considerable variation was found both among and within plant species during the experimental trials. It was also found that the strongest activity was in fact recorded for *Azadirachta indica* (LC50 = 0.081%), while *Calotropis gigantea* (LC50 = 3.244%) and *Pongamia pinnata* (LC50 = 3.835%) also exhibited notable toxicity. Observation of the plant parts found that *Pedalium murex* roots were particularly potent. On the other hand, *Vitex negundo* appeared less effective in LC50 assays (4.231%), yet demonstrated high performance under real field conditions. Field experiments provided further confirmation. Treatments with *Ipomoea carnea* and *V. negundo* reduced larval counts per ten tomato plants from 2.43 to 0.52 and 0.59, respectively. When these two species were applied in combination, the reduction was even greater, with larval density dropping to 0.23. The resultant observation has highlighted a synergistic interaction between the species. Results on the yield assessments has revealed crop productivity gains of up to 32%, with *Pteridium aquilinum* and *Homalomena arifolia* showing the strongest positive impact. Economic analyses has reinforced these findings where favorable cost–benefit ratios were achieved, particularly with *C. gigantea* and *V. negundo*. In these plants, returns exceeded 1:1.8. Taken together, the results emphasize the dual agronomic and economic promise of botanical insecticides. The results in this study are similar to a previous observation that recommend their use as part of integrated pest management programs. A further understanding of the mechanistic insights hinted that larval mortality is linked to immune responses triggered in *H. armigera* by phytochemicals present in the extracts.

INTRODUCTION

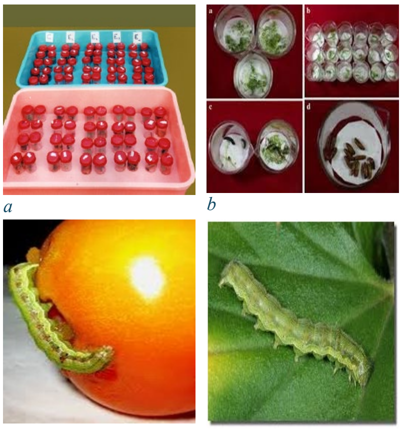
The benefits of botanical or biorational insecticides—including target selectivity, relative safety for non-target organisms (especially mammals), and efficacy at low doses—have driven sustained public–private R&D, with a marked rise over the past five decades and growing integration into IPM programmes [1]. Nevertheless, "natural" insecticidal materials are sometimes stockpiled without clear risk stratification, while many pest problems continue to be evaluated using frameworks developed for conventional synthetics. Given the economic centrality of the pesticide sector and recurring challenges such as resistance, resurgence, and environmental contamination, safer alternatives remain a priority [2,3]. *Helicoverpa armigera* (Noctuidae: Lepidoptera) is a major pest of fruit and vegetables across South and East Asia. Classical accounts and regional syntheses document extensive host ranges and management difficulties [4,5]. Numerous studies report plant-derived interventions and changing susceptibility patterns, including bioactives from Melia dubia and variable organophosphate toxicity, as well as broader resistance signals in regional cropping systems [6–8].

Direct plant-based interventions have shown activity against *H. armigera* under laboratory and field conditions [9,10], and field evaluations indicate that methanolic and aqueous preparations can suppress defoliators in tomato [11–13]. Host-plant resistance and botanicals from several species have also been recommended within IPM toolkits [14–20]. At the same time, resistance to frequently used insecticides is well-documented in India and neighboring regions [21,22].

MATERIALS AND METHODS

Collection and rearing

Late instars of *H. armigera* were collected from tomato fields (TMV-7 variety) in Dharmapuri District, Tamil Nadu, and maintained under controlled temperature and relative humidity with a fixed light–dark regime. A 5 percent vitamin supplement was provided to encourage oviposition; eggs were surface-sanitised with 10 percent formaldehyde before holding (**Fig. 1**).



a b c d

Fig 1. Experimental setup and host plants of *Helicoverpa armigera* (Hubner). (a) Individual larvae maintained in vials with host plant material; (b) multiple vials arranged for treatment; (c) larvae feeding on leaf material within containers; (d) pupal stage after feeding trials; (e) experimental trays containing multiple treatment groups; (f) larva feeding on tomato fruit (host plant); (g) larva feeding on tomato leaf.

Plant material

Healthy specimens (**Fig. 2**) of *Azadirachta indica* A. Juss., *Calotropis gigantea* (L.) R. Br., *Coleus amboinicus* Lour., *Christella parasitica* (L.) H. Lev., *Ipomoea carnea* Jacq. (noted in some sources as *I. cornea*), *Hemionitis arifolia* (Burm.) T. Moore, *Pedalium murex* L., *Pongamia pinnata* (L.) Pierre, *Tephrosia purpurea* (L.) Pers., *Tridax procumbens* L., and *Vitex negundo* L. were harvested in the morning from multiple sites in Dharmapuri and identified using standard floras [23,24].

Aqueous extraction

Shade-dried plant material was powdered; a portion was Soxhlet-extracted in water. Solvent was removed, the crude was stored refrigerated, and stock solutions were prepared. Working concentrations of 0.5, 1.0, 2.0, 4.0, and 6.0 percent were made in distilled water containing 0.1 percent emulsifier (Tween 80), following established procedures for neem-type preparations adapted to the present matrices [25].

Toxicological assays

Fourth-instar larvae were exposed to treated tomato leaves across the concentration range. Controls received solvent and emulsifier only. Mortality was recorded up to 96 hours, corrected using Abbott's formula, and median lethal concentrations (LC50) estimated by probit analysis [26,27]. Field plots included appropriate controls, scheduled applications, and pre- and post-treatment sampling; the cost–benefit ratio was calculated as total profit divided by total cultivation cost.

Azadirachta indica A. Juss *Coleus amboinicus* Lour


Calotropis procera R.Br *Ipomoea carnea* Jacq.,


Hemionitis arifolia (Brun) *Pedalium murex* Linn.,


Pongamia pinnata Pierre, *Tephrosia purpurea* (Linn.),


Tridax procumbens L., *Vitex negundo* Linn.,


Fig. 2. Medicinal and pesticidal plants assessed for their insecticidal activity against *Helicoverpa armigera* (Hubner).

RESULTS AND DISCUSSION

In this study, we evaluated the various aqueous plant extracts against the pathogen *Helicoverpa armigera* were evaluated, focusing on LC_{50} values, reduction in larval population, tomato yield improvement, and economic viability. The results of these findings align with various prior works, which highlight the importance of plant-based biopesticides in sustainable pest management strategies [1,2]. Marked interspecific and intraspecific variability was observed in LC50 values (**Table 1**). *Azadirachta indica* leaf extract demonstrated strong larvicidal activity with a notably low LC_{50} of 0.081%, confirming prior observations on azadirachtin's potency [15, 25]. The results are consistent with those of SenthilNathan et al. [25], who reported a similar effectiveness of the plant neem against the pathogen *Nilaparvata lugens*. In a similar vein, *Calotropis gigantea* (LC50 = 3.244%) and *Pongamia pinnata* (LC50 = 3.835%) exhibited a considerable toxicity effect, which aligns with earlier bioefficacy reports of *Melia dubia* and *P. pinnata* against *H. armigera* [6, 16]. Of the plant parts of *Pedalium murex* tested, the root extract was found to be more toxic (LC50 = 2.736%) than the leaf (3.768%) or fruit (4.394%) extracts. This suggests a part-specific phytochemical concentration. The leaf extract of Vitex negundo, although found to be less toxic in LC50 assays (4.231%), displays strong performance in field work results, which suggests potential systemic or synergistic effects in ecological settings. Similar efficacy discrepancies between lab and field environments were also discussed in Sahayaraj and Paulraj [10]. Field trials further substantiated lab findings.

H. armigera larvae treated with *Ipomoea carnea* and *Vitex negundo* were found to be significantly reduced by the treatment (**Table 2**). *I. carnea* was found to reduce infestation to a level of 0.52 larvae discovered per 10 plants, while *V. negundo* exhibited a better suppression at 0.59 larvae per 10 plants. When compared to controls (2.43 larvae per 10 plants), these reductions were statistically significant ($P < 0.05$), corroborating the findings of earlier trials on *V. negundo*'s bioactivity [13,18]. Raman et al. [11] have documented a similar notable suppression of S. litura populations in tomato using plant extracts, which reinforced the utility of such treatments under field studies. A co-application of *V. negundo* with *I. carnea* shows a synergistic interaction, where a reduction of larval density further to 0.23 larvae per 10 plants (Table 3) was observed. The co-application achieved a 76.67% reduction in population. The results reported in this study reflect better than individual treatments and align well with findings from Kalyanasundaram et al. [20], who emphasized the benefits of integrating botanicals for pest suppression.

Yield data also reflected the effectiveness of treatments. Plots that is treated with *Pteridium aquilinum* produced the highest yield (1400 kg/ha). This is followed closely by *H. arifolia* (1370 kg/ha) and *I. carnea* (1312.50 kg/ha), far exceeding the untreated controls (ranging from 1060.50 to 1120 kg/ha). These yield improvements, ranging between 16% to 32%, demonstrate the agronomic value of botanical insecticides beyond pest suppression. Interestingly, while *V. negundo* had lower toxicity in lab assays, its field efficacy and impact on yield (1270.50 kg/ha) were pronounced, highlighting its practical value. Similar field-level effectiveness of *V. negundo* has been reported by Sahayaraj and Ravi [13]. In their study, the broad-spectrum activity improved pest management in tomato ecosystems.

Economic evaluations showed that botanical treatments are not only biologically effective but also economically feasible. *C. gigantea* had the highest cost–benefit ratio at 1:2.0, which is followed by *P. aquilinum* (1:1.79), *H. arifolia* (1:1.76), *V. negundo,* and *P. pinnata* (both at 1:1.8) (**Table 3**). The resultant ratios do suggest a substantial return on investment, particularly with *C. gigantea* and *V. negundo*, making them suitable for inclusion in integrated pest management (IPM) programs in resource-limited settings. Rosell et al. [1] exhibit similar cost-effectiveness of biorational insecticides in reducing the dependency on synthetic chemicals while at the same time maintaining the profitability for smallholders. In addition, Sahayaraj [12] also demonstrated the economic sustainability through the integration of botanical insecticides with predators like *Rhynocoris marginatus*, emphasizing a broader ecological strategy.

Previous studies have also shown similar results, where the observed mortality has been linked to cell-mediated immune responses, which are triggered in *H. armigera* and *Spodoptera litura* following exposure to botanical toxins [28]. Sahayaraj et al. [28] demonstrated that phytoecdysteroids from ferns induced cellular immune responses. These steroids potentially impair larval development and feeding behavior. This mechanistic pathway provides explanatory value for the high mortality observed in extracts such as *C. gigantea* and *V. negundo*. These studies also support the integration of plant-based interventions with entomopathogenic agents.

Table1.Impact of aqueous extracts of plants on the LC_{50}values of*Helicoverpa armigera*fourth instar.

Plants	Family	Plant parts	LC_{50}
*Azadirachta indica*A.Juss.	Meliaceae	Leaves	3.898
Calotopi sgigantia	Asclepiadaceae	Leaves	0.693
Vitex negundo	Verbenaceae	Leaves	1.332
Pongiamia pinnata	Papilionaceae	Leaves	4.547
Tridax procumbens	Asteraceae	Leaves	2.833
*Pedalium murex*Linn	Pedaliaceae	Leaves	3.768
*Pedalium murex*Linn	Pedaliaceae	Root	2.736
*Pedalium murex*Linn	Pedaliaceae	Fruits	4.394

Table 2.Various plant products water extracts on the incidence and population reduction (in %) of *H.armigera* and tomato production (Kg/ha).

Treatment	Mean population	Population reduction	Production
C.parasitica	1.45	52.51	1250
P.aquilinum	1.32	56.73	1400
H.arifolia	1.45	53.00	1370
Control	3.10	-	I120
A.indica	1.42	69.27	1260
C.gigantea	1.26	61.64	1304
P.pinnata	1.11	54.15	1154
Control	2.05	-	1177
V.negundo	0.59	77.63	1270.50
I.cornea	0.52	68.42	1312.50
Control	0.76	-	1060.50

Table 3. Water extracts of various plants on the incidence and reduction (in %) of *H. armigera*and cost benefit ratio.

Plants	Incidence	Population Reduction	Cost benefit ratio
C.parasitical	1.00	41.15	1:1.63
P.aquilinum	0.80	32.92	1:1.79
H.arifolia	0.82	33.74	1:1.76
Control	2.43	-	1:1.48
C.gigantea	1.1	55.00	1:2.0
P.pinnata	0.9	45.00	1: 1.8
V.negundo	1.0	50.00	1: 1.8
Control	2.0	-	1: 1.2
V.negundo	0.23	76.67	1:1.71
I.cornea	0.22	73.33	1:1.76
Control	0.30	-	1:1.43

CONCLUSION

The findings of this study have revealed that simple water-based extracts from common plants can act as effective natural remedies for managing *Helicoverpa armigera*, a destructive pest in tomato cultivation. In controlled laboratory trials, extracts of neem (*Azadirachta indica*), *Calotropis gigantea*, and Tephrosia purpurea demonstrated strong larvicidal activity. Under field conditions, however, extracts from *Vitex negundo* and *Ipomoea carnea* provided the most reliable control, resulting in sharp declines in pest numbers. The resultant reductions in pest populations were directly reflected in farm-level benefits. Crop yields were found to be significantly improved, while a cost–benefit analysis showed highly favorable returns, with some treatments achieving more than 1.8 times the initial investment. The results further suggested that the effectiveness of control depends on the plant part selected, and that combining extracts can enhance potency. The resultant flexibility has provided farmers with the direct possibility of tailoring pest control strategies to their own conditions. Support from earlier studies strengthens these observations, as past research has shown that certain plant-based compounds can disrupt insect immunity and reduce their survival rates. Aside from the efficacy produced, the extracts also carry additional advantages, including being environmentally safe, affordable for smallholders, and helping to reduce dependence on synthetic pesticides that often lead to resistance problems. Taken together, all the evidence shown in this study supported the inclusion of botanical extracts as essential tools within integrated pest management (IPM) systems. By adopting such approaches, farmers can safeguard their crops sustainably, increase yields, and mitigate the long-term risks associated with chemical pesticide use. Looking ahead, further work should prioritize the isolation of active compounds, the refinement of extraction and formulation methods, and the evaluation of long-term stability across multiple cropping cycles.

REFERENCES

1. Rosell G, Quero C, Coll J, Guerrero A. Biorational insecticides in pest management. J Pestic Sci. 2008;33(2):103–21.
2. Desai SD, Desai BD. Studies on insecticidal properties of some plants. Shashpa. 2000;7(1):85–8.
3. Dhaliwal GS, Singh B, editors. Pesticides: Ecological Impact in Developing Countries. New Delhi: Commonwealth Publishers; 1999. p. 30–50.
4. Chari MS, Patel NG. Cotton leaf worm Heliothis, its biology and integrated control measures. Cotton Dev. 1983;13:7–8.
5. Ranga Rao G, Rabindra RJ, Nandagopal V, Rameswar Rao. *Spodoptera litura* (Fab.). In: Nandagopal V, Gunathilagaraj K, editors. Tomato Entomology. New Delhi: Satish Serial Publ House; 2008. p. 65–99.
6. Koul O, Multani JS, Singh G, Wahab S. Bio-efficacy of toosendanin from Melia dubia against *Helicoverpa armigera* (Hübner). Curr Sci. 2002;83(11):1387–91.
7. Kodandaram MH, Dhingra S. Variation in the toxicity of organophosphate insecticides to field populations of *H. armigera*. Indian J Plant Prot. 2007;35(1):53–6.
8. Ahmad M, Arif MI, Ahmad M. Occurrence of insecticide resistance in field populations of *Spodoptera litura* in Pakistan. Crop Prot. 2007;26(6):809–17.
9. Sahayaraj K. Antifeedant effect of some plant extracts on *Spodoptera litura* (F.). Curr Sci. 1998;74(6):523–6.
10. Sahayaraj K, Paulraj MG. Screening the relative toxicity of some plant extracts to *Spodoptera litura* Fab. Fresen Environ Bull. 1998;7(9–10):557–60.
11. Raman GV, Srinivasa Rao M, Venkateswarlu B, Srirmannarayana G. Field evaluation of custard apple extracts in tomato crop against *Spodoptera litura* (Fab.). Indian J Plant Prot. 2007;35(1):64–7.
12. Sahayaraj K. Field bioefficacy of a reduviid predator *Rhynocoris marginatus* and plant products against *Aproaerema modicella* on tomato. Indian J Entomol. 2002;64(3):292–300.
13. Sahayaraj K, Ravi C. Evaluation of reduviid predators and plant products against chosen tomato pests. Arch Phytopathol Plant Prot. 2007;40(4):281–90.
14. Bajpai NK, Sehgal VK. Efficacy of neem, karanj and tobacco formulations against *Helicoverpa armigera* (Hübner) in chickpea crop. Int Chickpea Pigeonpea Newsl. 2000;7:21–3.
15. Gujar GT. Biological effects of azadirachtin and plumbagin on *Helicoverpa armigera*. Indian J Entomol. 1997;59(4):415–22.
16. Kulat SS, Nandanwar VN, Zade NN, Tirthkar SS. Evaluation of some indigenous plant products for the management of *Helicoverpa armigera* Hub. on chickpea. J Appl Zool Res. 2001;12(2–3):96–8.
17. Sahayaraj K, Paulraj MG. Impact of *Tridax procumbens* leaf extract on *Spodoptera litura* Fab. behavior and biometry. Insect Environ. 2000;5(4):149–50.
18. Sundararajan G, Kumuthakalavalli R. Effect of leaf extracts of selected plants against the larvae of *Helicoverpa armigera* (Hübner). Environ Ecol. 2000;18(1):10–2.
19. Sundararajan G, Kumuthakalavalli R. Antifeedant activity of aqueous extract of *Gnidia glauca* and *Toddalia asiatica* on *Helicoverpa armigera*. J Environ Biol. 2001;22(1):11–4.
20. Kalyanasundaram M, Dhandapani N, Swamiappan M, Sundarababu PC, Jeyaraj S. A study on the management of some pests of tomato with biocontrol agents. J Biol Control. 1994;8(1):1–4.
21. Dhingra S, Phokela A, Mehrotra KN. Cypermethrin resistance in the populations of *Helicoverpa armigera* (Hübner). Natl Acad Sci Lett. 1998;21(2):123–5.
22. Patel CC, Koshiya DJ. Insecticidal resistance to *Helicoverpa armigera* (Hübner) in Gujarat. Indian J Entomol. 1999;61(2):121–6.
23. Gamble JS. Flora of the Presidency of Madras. 2 vols. London: Allard & Co; 1936. Reprinted 1956.
24. Matthew KM. An Excursion Flora of Central Tamil Nadu. New Delhi: Oxford & IBH Publ Co Pvt Ltd; 1991. p. 647–51.
25. SenthilNathan S, Choi MY, Paik CH, Seo HY, Kim JD, Kang SM. The toxic effect of neem extract and azadirachtin on the brown planthopper, Nilaparvata lugens. Chemosphere. 2007;67:80–8.
26. Abbott WS. A method of computing the effectiveness of an insecticide. J Econ Entomol. 1925;18:265–7.
27. Finney DJ. Probit Analysis. 3rd ed. New York: Cambridge University Press; 1971. p. 333.
28. Sahayaraj K, Selvaraj P, Balasubramanian R. Cell-mediated immune response of *Helicoverpa armigera* and *Spodoptera litura* to fern phytoecdysone. J Entomol. 2007;4(4):289–98.