International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 05-01-2026, Accepted: 04-02-2026, Published: 19-02-2026
Volume 11, Issue 1, 2026, Page No. 355-358

Development, field evaluation, and stability studies of a herbal insecticide for effective mealybug control

Tushar R Patade[1], Shubham S Pachorkar[2], Pranav S Pajai[1], Atharv Nimse[1], Dr. M R N Shaikh[3]
[1] Department of Pharmaceutical Sciences, MET BKC institute of D pharmacy, Nashik, Maharashtra, India
[2] Assistant Professor, MET BKC Institute of D pharmacy, Nashik, Maharashtra, India
[3] Principal, MET BKC Institute of D pharmacy, Nashik, Maharashtra, India

Abstract
Mealybugs are known agricultural pests that seriously harm crops by consuming plant sap, which results in secondary illnesses, slowed growth, and decreased production. The overuse of synthetic insecticides to eliminate mealybugs has sparked concern about pesticide resistance, environmental toxicity, and negative impacts on organisms that are not the intended target. The purpose of this study was to develop and evaluate a herbal pesticide utilising a fermentation-based method that included pyrethrin extract, green chilli, cow urine, neem, karanj, nirgundi, and drumstick leaves. The formulation's stability, field effectiveness, and physicochemical characteristics were evaluated. Multiple fields tests revealed a 95% mealybug mortality rate within 21 days of application, as well as a notable decrease in crop loss and an improvement in plant health. The constant nature of the formulation's colour, odour, and pH under various storage settings was confirmed by stability studies. These findings demonstrate the potential of herbal insecticides as efficient and environmentally friendly alternatives for synthetic pesticides. The study supports the application of plant-based compounds for agriculture's sustainable pest control.

Keywords: Mealybugs, herbal insecticide, formulation, evaluation, stability studies

Introduction
Mealybugs (*Hemiptera*: *Pseudococcidae*) are tiny, soft-bodied insects that feed on plants. They are members of the second-largest scale insect family, *Pseudococcidae*, which has about 2000 species spread across 300 genera. The waxy substance that covers the body of adult females is the source of their common name [1, 2].

Fig 1: Mealybug

Mealybugs (*Pseudococcidae*) are infamous agricultural pests that cause critical harm to a wide extend of crops by sucking plant sap, driving to hindered growth, leaf yellowing, and decreased yield. These bugs moreover emit honeydew, which advances the development of dingy mold, encourage breaking down plant wellbeing. Conventional management methodologies for mealybugs basically depend on synthetic insecticides, which, whereas effective, posture a few concerns, counting natural harmfulness, pesticide resistance, and hurtful impacts on non-target living beings, counting useful insects and soil microbiota [3, 4, 5].

With developing awareness of sustainable farming and the unfavorable effects of chemical pesticides, there is an expanding demand for eco-friendly pest management solutions. Plant-based insecticides, derived from medicinal and aromatic plants, have gained consideration as practical choices due to their biodegradability, low toxicity to people, and ecologically safe nature. Different plant extracts and essential oils contain bioactive phytochemicals such as alkaloids, flavonoids, terpenoids, and saponins, which show insecticidal, repellent, and anti-feeding properties against agricultural pests, counting mealybugs [6, 7, 8].

The present study centers on the development and field evaluation of a herbal insecticide defined from plant extracts with known pesticidal action. The study points to evaluate its efficacy against mealybugs under real farming conditions, determine its impact on crop wellbeing, and compare its effectiveness with conventional manufactured insecticides. By conducting field trials over numerous farms, this research seeks to contribute to the development of a natural, cost-effective, and economical pest control methodology for mealybug management.

Materials & Methods
Each herb was purchased at the Nashik local market. Water was used to extract pyrethrin.

Methods

Extraction of Pyrethrin

After being sun-dried to eliminate moisture, chrysanthemum flowers were then crushed into a fine powder. The flower powder was put in a container then extracted using warm water. The final solution, which was ready for use, was obtained by filtering the mixture after it had stood for two days.

Formulation of Insecticide

All ingredients were placed in a container and extracted with a solvent. The container was sealed tightly to ensure an airtight environment. Fermentation was allowed for 15 to 20 days, after which the solution was filtered and transferred to a suitable container. Pyrethrin extract was then added, completing the formulation, which was stored in a well-closed container.

Table 1: Prepared herbal formulation

Sr. No.	Ingredient	Use	Quantity (%)
1	Neem Leaves (*Azadirachta indica*)	Acts as a natural insecticide, containing azadirachtin, which disrupts insect growth and feeding.	25
2	Karanj Leaves (*Pongamia pinnata*)	Contains flavonoids and karanjin, which have insecticidal and antifungal properties.	15
3	Nirgundi Leaves (*Vitex negundo*)	Provides larvicidal and repellent properties against pests.	10
4	Drumstick Leaves (*Moringa oleifera*)	Rich in bioactive compounds that enhance insecticidal potency and plant defense.	10
5	Green Chilli (*Capsicum annuum*)	Contains capsaicin, which acts as an irritant and repellent for insects.	5
6	Cow Urine	Acts as a natural solvent, fermentation enhancer, and bio-enhancer for plant-based insecticides.	25
7	Pyrethrin Extract (from *Chrysanthemum cinerariaefolium*)	A potent natural insecticide that targets the nervous system of pests.	5
8	Water	Aids in extraction of bioactive compounds from plant material.	5

Evaluation

Physiochemical evaluation

The prepared formulation's organoleptic qualities, including colour, odour, and appearance, were examined visually. A digital pH meter was used to measure its pH. The results are displayed in Table No. 2.

Field Study design

Selection of Farms and Crop Types

To provide a thorough assessment, field tests were carried out on farms in various agroclimatic zones. The study's chosen crops included tomato, brinjal, grapes, and bhindi, all of which are frequently impacted by mealybugs. To evaluate the applicability of the herbal pesticide, farms with varying soil types, irrigation techniques, and climates were used.

Experimental Design

The treated and untreated plots were compared using a randomised block design (RBD). Each farm was split into three sections: the positive control plot received a commercial synthetic insecticide treatment, the treated plot received the herbal insecticide formulation, and the negative control plot was kept untreated to monitor the levels of natural infestation. Replication and plot size were chosen in accordance with accepted field research practices.

Application Method

A knapsack sprayer was used to apply a foliar spray of the herbal insecticide at a predefined concentration. Early morning or late evening spraying was done to increase effectiveness and reduce evaporation losses. Depending on the intensity of the infestation, applications were repeated at regular intervals (every 7–10 days).

Data Collection and Monitoring

Prior to the initial application, the initial population of mealybugs was documented. At 3, 7, 14, and 21 days after application, post-treatment observations were made to measure the mealybug mortality rate, crop damage reduction, and plant health improvement. A clear indicator of the insecticide's efficacy was provided by the percentages out of 100 for each outcome. The results are displayed in Table No. 4,5,6.

Stability Studies

The CIPAC procedure (No. 46.3, 2000) was followed in conducting the storage stability test. According to CIPAC MT46.3, 2000, the formulation was exposed to accelerated storage for 14 days at three distinct temperatures (4, 25, and 54 2 ○C). This is comparable to a two-year shelf-life at room temperature (27 2 ○C). The formulation was visually inspected for colour changes fourteen days after storage. Three replicate sets of the produced formulation's storage stability tests were conducted at three distinct temperatures. (9) The results are displayed in Table No. 7.

Results

Physiochemical evaluation

Table 2: Physiochemical evaluation of formulation

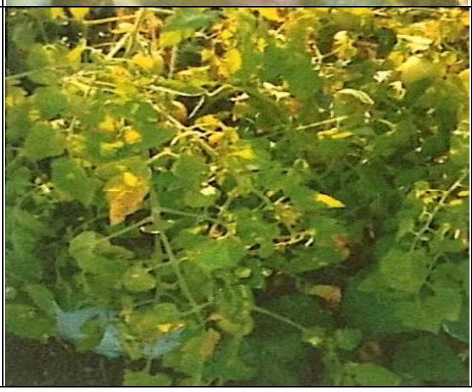
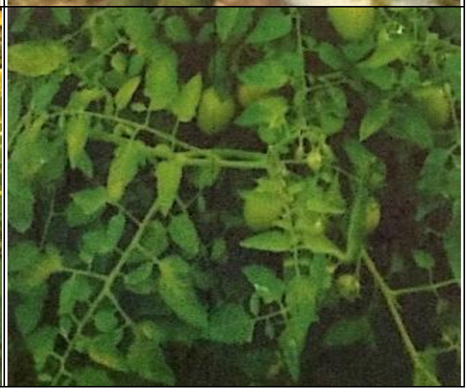
Sr. No.	Parameter	Result
1	Colour	Greenish yellow
2	Odour	Ammonic musk
3	pH	5 to 6.2

Field Study

Within 21 days of treatment, field tests showed a significant mortality rate of up to 95% in grapes and over 90% in other crops. Crop damage was greatly reduced, with up to 90% protection, while plant health improved, with up to 88%

greater growth compared to untreated crops. Results of the herbal formulation on a few selected plants are as follows:

Table 3: Untreated and plants treated with formulation

Plant	Untreated	Treated
Grapes		
Brinjal (Eggplant)		
Bhindi (Okra)		
Tomato		

Mealybug Mortality Rate (%)

Table 4: Results of mealybug mortality rate

Days post-application	Grapes	Brinjal (Eggplant)	Bhindi (Okra)	Tomato
3%	50%	45%	48%	47%
7%	70%	68%	72%	69%
14%	85%	82%	86%	83%
21%	95%	92%	94%	91%

Reduction in Crop Damage (%)

Table 5: Results of reduction in crop damage

Days post-application	Grapes	Brinjal (Eggplant)	Bhindi (Okra)	Tomato
3%	25%	20%	22%	21%
7%	50%	45%	48%	46%
14%	75%	70%	73%	72%
21%	90%	88%	89%	87%

Plant Health Improvement (%)

Table 6: Results of plant health improvement

Days post-application	Grapes	Brinjal (Eggplant)	Bhindi (Okra)	Tomato
3	20%	18%	19%	17%
7	45%	40%	42%	38%
14	70%	65%	67%	63%
21	88%	85%	86%	82%

Stability Studies

Table 7: Results of stability studies

Storage conditions after 14 days	Colour	Odour	pH
4^0C $\underline{+}1$	Greenish yellow	Ammonic musk	5.8
25^0C $\underline{+}1$	Greenish yellow	Ammonic musk	6.1
54^0C $\underline{+}1$	Greenish yellow	Ammonic musk	5.5

Conclusion

The formulated herbal insecticide shown noteworthy efficacy in controlling mealybug infestations whereas keeping up stability and bioactivity. The combination of neem, karanj, nirgundi, drumstick leaves, green chili, cow urine, and pyrethrin extract given a synergistic insecticidal effect, successfully disturbing mealybug growth and survival. Field trials demonstrated a high mortality rate of up to 95% in grapes and over 90% in other crops within 21 days of application. A significant decrease in crop damage was observed, with up to 90% protection, whereas plant wellbeing progressed significantly, showing up to 88% better growth compared to untreated crops. Physicochemical evaluations confirmed the stability of the formulation, with consistent pH, color, and odor beneath different storage conditions. These findings suggest that plant-based insecticides can serve as a reasonable, eco-friendly alternative to synthetic pesticides, decreasing natural toxicity whereas ensuring effective bug control. The fermentation-based formulation improves potency, stability, and bioavailability of the active ingredients, making it a promising solution for sustainable farming. Further research on long-term storage stability, large-scale field trials, and integration with pest management techniques might offer assistance optimize its effectiveness and commercial viability. This study supports the adoption of herbal insecticides as a cost-effective and environmentally sustainable approach for bug control in agriculture.

References

1. Miller DR, Williams DJ. A new species of mealybug in the genus Pseudococcus (Homoptera: *Pseudococcidae*) of quarantine importance. Proceedings of the Entomological Society of Washington,1997:99:305-311.
2. Downie DA, Gullan PJ. Phylogenetic analysis of mealybugs (*Hemiptera: Coccoidea: Pseudococcidae*) based on DNA sequences from three nuclear genes, and a review of the higher classification. Systematic Entomology,2004, 29, 238-259.
3. Industries P. Mealybug. Business Queensland, 2021. https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/biosecurity/plants/insects/field-crop/mealybug
4. Strategies for effective mealybug management in greenhouses. Strategies for effective mealybug management in greenhouses, 2023. https://www.hortidaily.com/article/9532039/strategies-for-effective-mealybug-management-in-greenhouses/
5. Mamoon-ur-Rasheed, Bushra S, Tariq M. Use and impact of insecticides in mealybug control. International Journal of Advances in Biology (IJAB), 2014, 1(2). https://airccse.com/ijab/papers/1214ijab01.pdf
6. Isman MB. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu Rev Entomol,2006:51:45-66. https://doi.org/10.2174/2772574X14666230804102104
7. Ayilara MS, Adeleke BS, Akinola SA, Fayose CA, Adeyemi UT, Gbadegesin LA, *et al*. Biopesticides as a promising alternative to synthetic pesticides: A case for microbial pesticides, phytopesticides, and nanobiopesticides. Frontiers in Microbiology, 2023, 14. https://doi.org/10.3389/fmicb.2023.1040901
8. Rajput S, Sharma P, Malviya R. Utilization of herbal components as insecticidal and repellent effects. Recent Advances in Food Nutrition & Agriculture,2023:14(3):144–154. https://doi.org/10.2174/2772574x14666230804102104
9. Dobrat W, Martijn A. CIPAC MT 46.3, 2000. Accelerated storage procedure. In: Dobrat W, Martijn A. CIPAC Handbook J. Physico-Chemical Methods for Technical and Formulated Pesticides, 2000, 128. Collaborative International Pesticides Analytical Council Ltd, Harpenden, England.